RESPOND BASKET 2021

RESPOND & AI

Capacity Building Programme Office

ISRO HQ, Bengaluru

RESPOND BASKET 2021

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Capacity Building Programme Office
ISRO HQ, Bengaluru

Technical Guidance

Dr. M A Paul
Associate Director
RESPOND & AI, ISRO HQ

Technical Support and Compilation

Smt. Nirupama Tiwari
Sci/Engr SE, CBPO, ISRO HQ

Shri K Mahesh
Sr. Asst, CBPO, ISRO HQ

For any queries please contact

Director,
Capacity Building Programme Office (CBPO)
Indian Space Research Organisation HQ
Department of Space
Government of India
Antariksh Bhavan
New BEL Road
Bangalore-560094
E-mail: dir.cbpo@isro.gov.in

Associate Director,
RESPOND & Academic Interface
Indian Space Research Organisation HQ
Department of Space
Government of India
Antariksh Bhavan
New BEL Road
Bangalore-560094
E-mail: respond@isro.gov.in

भारतीय अन्तरिक्ष अनुसंधान संगठन
अन्तरिक्ष विभाग
भारत सरकार
अन्तरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूर – 560 231, भारत
दूरभाष : +91-80-2341 5241 / 2217 2333
फैक्स : +91-80-2341 5328

Indian Space Research Organisation
Department of Space
Government of India
Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India
Telphone: +91-80-2341 5241 / 2217 2333
Fax : +91-80-2341 5328
e-mail : chairman@isro.gov.in

डॉ.कै. शिवन / Dr K. SIVAN
अध्यक्ष / Chairman

MESSAGE

With the advent of upcoming challenging missions, ISRO is focusing on R&D endeavors with greater emphasis on development of advanced technology, missions and capacity building.

With this ever-growing demand, ISRO needs to strengthen the involvement of academia for a more focused and output oriented research directly feeding to the ISROs R&D requirements.

ISRO/DOS Centre/Units have identified around 180 most urgent research problems which will cater to their immediate R&D requirements. These research problems are encapsulated in the **"RESPOND BASKET"** document generated and compiled by RESPOND, Capacity Building Programme Office, ISRO Headquarters. The document comprises of the research problems along with brief summary. This will help the academia and R&D laboratories other than Space Technology Cells (STCs) and Regional Academic Centre for Space (RAC-S) to select and submit the research proposals.

I wish all the best for this endeavor and look for a wider participation of academia and R&D laboratories across the country to contribute towards the Indian Space Programme.

30/12/2020

Dated: December 30th, 2020

(कै. शिवन / K. Sivan)

इसरो मुख्यालय
अन्तरिक्ष विभाग
भारत सरकार
अन्तरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूरु - 560 094, भारत
दूरभाष : +91 80 2341 0079 / 2217 2118
फैक्स : +91 80 2341 6316
E-mail : pvv_krishnan@isro.gov.in

ISRO HEADQUARTERS
Department of Space
Government of India
Antariksh Bhavan
New BEL Road, Bengaluru - 560 094, INDIA
Tel (Off) : +91 80 2341 0079 / 2217 2118
Fax : +91 80 2341 6316
E-mail : pvv_krishnan@isro.gov.in

Dr. P.V. Venkitakrishnan
Director, CBPO

PREFACE

RESPOND, the Sponsored Research Programme of ISRO aims to establish strong links with the academic institutions in the country to carry out research and development projects which are of relevance to ISRO and derive useful outputs of such R&D efforts to support ISRO programmes.

ISRO is looking for a more intense contribution from academia to meet the urgent R&D requirements which has increased manifold with the upcoming challenging missions like interplanetary missions, advanced throughput satellites, Human Space Flight programme to name a few.

To meet the same, "RESPOND Basket", second in the series is being brought out by RESPOND, CBPO, ISRO HQ. The document comprises of around 180 most urgent and important research problems identified by ISRO/DOS Centre / Units on the basis of their ongoing and upcoming programmatic R&D requirements. Each research problem comprises of a brief write-up about the topic, expected deliverables etc., for the faculty of the academic Institutions/R&D laboratories, which are not covered under Space Technology Cells (STCs) and Regional Academic Centre for Space (RAC-S) to submit proposals.

I warmly invite academia to come forward and submit the proposals under RESPOND Basket and contribute in the ongoing research and development activities of Indian Space Programme.

P V Venkitakrishnan

GENERAL INSTRUCTIONS

1. RESPOND BASKET comprises of the most urgent and important research problems identified by ISRO/DOS Centre / Units on the basis of ISRO's upcoming programmatic R&D requirements. Each research problem comprises of a brief write-up about the topic for the faculty of the academic Institutions / R&D laboratories other than the Space Technology Cells (STCs) and Regional Academic Centre for Space (RAC-S) to select and prepare the proposals.

2. An individual or group(s) of scientists / faculty members affiliated to any academic institution/ autonomous R&D institutions are eligible for submitting the proposals. The Principal Investigator(s) should be a full-time employee(s) of the concerned institution.

3. Principal Investigator shall be a domain expert in the area to which the proposal belongs to and must be a full time employee / faculty of the institution forwarding the application. There may also be co-investigator(s) from the same / different institution(s) working on the project. But satisfactory completion of a project will be the responsibility of the Principal Investigator and the institution involved.

4. The age limit for the Principal Investigator is below 65 years (sixty-five) including the project period. The Head of the academic institution must forward proposals with application for research grants. Proposals from individuals not affiliated to any recognized institution / R & D institutions will not be considered.

5. "Application for Grant of Funds including the project proposal" and "Form-C" shall be submitted in the prescribed formats only. Formats are given in the Annexure-1 & 2.

6. One hard copy and one soft copy of the proposal shall be submitted to the respective ISRO/ DOS centre with a copy to Respond Office, ISRO HQs. The addresses and e-mail ids of Respond Coordinators of respective ISRO/DOS centre and Respond Office, ISRO HQs are given in Annexure -3.

7. For other information regarding terms and conditions of ISRO Grants, details on research fellowships and Guidelines governing the allocation of funds etc., please visit ISRO website (https://www.isro.gov.in/capacity-building/sponsored-research).

8. The last date for submitting the proposals under "RESPOND Basket' is **March 15, 2021.**

9. The submitted proposal will be subjected to critical evaluation by the ISRO/DOS Centre experts. The proposal will be evaluated on the basis of novelty, methodology, approach, experience of the PI in the subject area, duration of the project, budget etc.

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VIKRAM SARABHAI SPACE CENTRE
THIRUVANANTHAPURAM

VSSC - 001

1. Name of ISRO Centre/Unit
Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal
Jet noise field for a supersonic underexpanded jet

3. Name of Co PI from ISRO Centre/Unit
Shri B Venkata Subrahmanyam

4. Contact Address of Co PI & e-mail id
ACD/ADSG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: b_subrahmanyam@vssc.gov.in

5. Area of Research
Aerodynamic Characterisation

6. Summary of the proposed research and expected deliverables
Jet noise is one of the primary factors that induces dynamic load on vehicle structures during lift-off of launch vehicle. The high level of vibration produced during lift-off can lead to malfunction of electric/electronic packages, control system components and fatigue failure of light weight structures. Further, the noise specifications in the crew module are also governed by the jet noise. Hence, the transmission of the jet noise is an essential technology to be developed for efficient design of the crew module and associated systems. The jet noise distribution (PSD and spatial correlation) is used as a forcing function to compute the transmitted noise along a structure.

Scope of the work:

Large Eddy Simulations using either a new developed code or open-source code for an ideally expanded supersonic jet to be carried out and the jet noise results are to be validated. LES simulations for a free jet (Me=2.8, Pe/Pinf=2.4) have to be carried out and the jet noise field (temporal PSD and spatial correlation) has to be characterized in both near and farfield. Development of a simplified model for computing the noise characteristics for this jets at different regions is also encouraged.

Deliverables:

LES code along with the details of the implementation and jet noise field for the free jet.

VSSC - 002

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Influence of back pressure perturbations on the unsteady shock wave-boundary layer interaction

3. Name of Co PI from ISRO Centre/Unit

Dr. Desikan. SLN

4. Contact Address of Co PI & e-mail id

HWTD/ AERONAUTICS Entity
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: sln_desikan@vssc.gov.in

5. Area of Research

Wind Tunnel Studies

6. Summary of the proposed research and expected deliverables

The scramjet engine is prone to an undesirable situation so called unstart due to many factors. Such a scenario occurs due to the combustion instability waves produced in the combustion chamber situated downstream of the isolator exit propagate upstream as strong pressure waves or as a normal shock. If the isolator fails to prevent the normal shock wave reaching the intake duct, the intake is prone to unstart. Hence, to understand the dynamics of the normal shock due to the downstream pressure perturbations and its interaction with the boundary layer certainly help for understanding the start/unstart characteristics of an intake. Thus, the study will aid in selection of suitable control devices to prevent unstart event.

Scope of the work:

As a part of this project, the response of an unsteady shock wave to the various back pressure perturbation frequencies and the nature of unsteady pressure field on its subsequent interaction with the turbulent boundary layer to be briefly studied at various supersonic Mach numbers. The flow physics needs to be captured using unsteady pressure measurements and the time resolved schlieren images. Also, suitable control mechanisms to be proposed in case of unstart events.

Deliverables:

A complete report with the detailed analysis of the shock wave dynamics and its interaction with the boundary layer in the presence of back pressure fluctuations and suitable control mechanisms shall be submitted.

VSSC - 003

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Data assimilation for fluid dynamics using experimental and computational data

3. Name of Co PI from ISRO Centre/Unit

Shri Padmanabha Prasanna Simha

4. Contact Address of Co PI & e-mail id

WTDD/WTG, AERONAUTICS Entity, VRC
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: padmanabha_prasanna@vssc.gov.in

5. Area of Research

Experimental Fluid Mechanics

6. Summary of the proposed research and expected deliverables

Data assimilation is a popular technique used in geophysics, meteorology and oceanography. In several cases highly complex, multi-scale turbulent flow dynamics exist and must be captured. Experimental methods frequently give data in limited numbers due to facility, model and instrumentation limitations. Computational methods are only as good as the dynamical system model and the fidelity of the simulations performed. In such situations, data assimilation can be a valuable tool to mutually integrate experimental data and CFD simulations in order to compensate for the deficiencies in both techniques.

The assimilated flow should be able to recover quantities in the experiment which would otherwise be inaccessible or difficult to measure such as pressure, vorticity and Reynolds stresses, by reducing noise and improving resolution. It is also possible to extrapolate the flow beyond the experimental view by solving the equations on a larger domain. CFD results of multiple fidelity levels can also be used as inputs to data assimilation where a DNS/LES performed on a small domain can be assimilated with data.

Data assimilation methods available in literature can be reproduced initially. The method formulated must be able to incorporate an arbitrary number of point flow measurements (velocity/pressure) along with the experimental or computational flowfield data. These will be applied to real world problems and attempts to improve the methods of data assimilation must be explored.

Scope of the work:

1. Formulation of a data assimilation method after interactions with VSSC using limited experimental velocity field data and computational data.

2. Identification of suitable test cases including cold jets and flows past cone cylinder configurations (After an interaction with VSSC).
3. CFD simulations of appropriate fidelity on the test cases.
4. Experimental measurements (PIV/schlieren/point probe measurements) on all the identified test cases. If feasible, some experimental measurements will be performed in VSSC.
5. Implementation and testing of the formulated method.
6. Exploration of improving data assimilation techniques for aerodynamics.

Deliverables:

1. A software tool that performs data assimilation using experimental flowfield data and CFD data.

Supplementary information:

Several techniques for data assimilation are available in literature. Methods such as Ensemble Kalman Filter, optimal control based variational approaches that treat data assimilation as a problem of optimal state estimation are available.

This technique also lends itself to situations where flow control mechanisms that are difficult to model such as oscillating ribbons, suction, and jets are used.

Improved estimates of mean flow obtained from data assimilation can be used in subsequent analysis techniques for flow instability, transition and turbulence.

VSSC - 004

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Effect of blockage and wall correction methodology on scaled models at subsonic Mach numbers.

3. Name of Co PI from ISRO Centre/Unit

Shri M Prasath
Shri Padmanabha Prasanna Simha

4. Contact Address of Co PI & e-mail id

WTDD/WTG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: m_prasath@vssc.gov.in

5. Area of Research

Wind Tunnel Studies

6. Summary of the proposed research and expected deliverables

Scaled wind tunnel models are used for wind tunnel testing due to tunnel size. Higher size models are always preferable due to model fidelity and obtaining higher Reynolds number. Due to larger model size, wind tunnel models offer blockage to the flow and hence, data obtained is corrupted. This proposal seeks to formulate a computer program to correct the wind tunnel data on general models (slender, wing body & bluff bodies etc.,) by measuring wall pressures and carrying out appropriate corrections on the aerodynamic coefficients.

Scope of the work:

Carryout force measurements on various blockages (minimum 3) on 3 kind of models (HRLV / SSLV, RLV and CM) and simultaneously measure the wall pressure / other suitable measurements. Device a suitable numerical method to correct for the solid blockage and wake blockage such that all the data from different blockage model collapses and also the minimum blockage for which aero data is not affected.

Deliverables:

1. Computer program for wall correction in subsonic regime, velocity upto 80 m/s.
2. Experimental Results obtained on scaled models.

VSSC - 005

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of high temperature Fiber-Bragg Grating (FBG) strain sensors for static strain measurement up to 800^{o}C

3. Name of Co PI from ISRO Centre/Unit

Shri Murakonda Sai Krishna

4. Contact Address of Co PI & e-mail id

ASTD/AHTG, AERONAUTICS Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: ms_krishna@vssc.gov.in

5. Area of Research

Aero-Thermal Simulation & Testing

6. Summary of the proposed research and expected deliverables

Fiber Bragg Grating (FBG) strain sensors offers several advantages over conventional resistance strain gauges in terms of their size and serial multiplexing capability. High temperature FBG sensors are state of the art technology essential for thermo-structural qualification and health monitoring of hot structures in future Reusable Launch Vehicles (RLV). They offer the inherent advantage of distributed strain measurement with minimum mass penalty. Annealed single mode optical fibers with gold coating as cladding are used for making the high temperature FBGs capable of strain measurement up to 800°C.

Scope of the work:

As part of this project, method to develop Fiber-Bragg Grating sensors from SMF28 compatible optic fibers has to be developed. Scope of work includes the following,

1. Grating to be generated on the optical fiber to reflect center wavelength: 1550nm±0.5nm.
2. Gold coating procedure to be evolved. Tensile breaking load/ bending radius without permanent damage need to be evaluated post gold coating.
3. Annealing procedure to be evolved for stable operation from RT to 800°C. Excellent repeatability and linearity of temperature to reflected wavelength need to be ensured post annealing. Peak power level of Bragg wavelength and spectra width to be provided post annealing procedure. Senor optic coefficient matrix has to be assessed.
4. Characterization of free- standing FBG sensor apparent strain output up to 800°C.
5. Validation of FBG strain measurement with resistance strain gauges/exact solution at RT in a tensile/bending test.

Deliverables:

1. Methodology for generating gratings on SMF28 compatible optical fibers. (Equipment details, complete operating instructions, procedure for generating gratings in optical fiber, demonstration and training)
2. Methodology for gold coating (Equipment details, complete operating instructions, procedure for gold coating in optical fiber, procedure for removal of gold coating, gold coating post annealing, demonstration and training.)
3. Methodology for Annealing (Equipment details, complete operating instructions, procedure for annealing, re-annealing, procedure for measurement of reflected wavelength vs temperature post annealing)
4. Apparent strain data of free-standing sensor and validation strain data at room temperature.
5. Supply of 25 Nos. of high temperature Fiber-Bragg Grating (FBG) strain sensors for static strain measurement up to 800°C.

VSSC - 006

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of integrated tool for interplanetary trajectory design

3. Name of Co PI from ISRO Centre/Unit

Ms. Pooja Dutt

4. Contact Address of Co PI & e-mail id

APMD/AFDG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: pooja_dutt@vssc.gov.in

5. Area of Research

Inter-Planetary Trajectory Studies

6. Summary of the proposed research and expected deliverables

Interplanetary trajectory design for high ΔV targets are possible with the help of Multiple Gravity Assist (MGA). The search for optimal MGA involving gravity-assist to planets/moons/asteroids/comets etc with or without deep-space maneuvers/low thrust/aero-gravity assists/resonance orbits, under launch window constraints is a complex problem. It is observed that well known optimization methods fail to search for an optimal trajectory. Hence it is envisaged to have an integrated simulation tool with all the above capabilities.

Scope of the work:

As part of this project, an integrated tool is to be developed to design interplanetary trajectory utilizing one or more of the following techniques:

- multiple gravity assists
- deep space manoeuvres
- low-thrust
- aero-gravity assists
- resonance orbits
- launch windows

The integrated tool must be developed in distributable programming language and not with commercial platforms and should have the following features:

- Multiple gravity assist trajectory design with gravity assist to any of planets/moons/asteroids/Comets etc.

- Search algorithm for 1/2/3 impulsive transfer (with/without plane change, node change, pericenter change, hyperbolic entry/exit) at any planet.
- The low-thrust trajectory design with deep-space maneuver (B-plane parameters, start-time, end-time, gravity loss etc.).
- Design with finite burn maneuver capabilities.
- Capable to ingest user-defined ephemeris (for comets and asteroids etc.).
- Launcher database for performance comparison.
- The generated trajectory files in standard format.
- Targeters (eg. Differential Corrector) for achieving the desired arrival conditions.
- Capability to generate the entire numerically propagated trajectory with full-force propagation model considering ground-station coverage/visibility, eclipse times etc. and user defined parameter evaluation, from the resultant optimized trajectory.
- Development of integrated optimization tools.
- Identification and generation of optimal trajectories.
- 2D and 3D orbit visualization features.

The tool must be tested and validated extensively with past missions and other results available in literature. The performance of integrated optimization algorithms must be well documented.

Deliverables:

1. Details of the algorithm developed along with the implementation details and test cases.
2. Integrated Simulation Tool with visualization (in any distributable programming language)

VSSC - 007

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Methods to specify the size and shape of Boundary Layer trips on wind tunnel models at low and high AOA in subsonic regime.

3. Name of Co PI from ISRO Centre/Unit

Shri Balasubramanian P
Shri Saravanan R

4. Contact Address of Co PI & e-mail id

WTDD/WTG, AERONAUTICS Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: p_balasubramanian@vssc.gov.in

5. Area of Research

Wind Tunnel Studies

6. Summary of the proposed research and expected deliverables

During lift off of launch vehicles, the vehicle AOA continuously decreases from 90° to 0°. Typically scaled wind tunnel models are used in WT for obtaining loads at various AOA. At higher AOA, in order to get the loads accurately, the flow field on both the WT model and in flight should be same. Hence, various kinds of BL trips are used on WT models to simulate the flight Reynolds number. This proposal seeks an appropriate procedure for arriving at the size and shape of boundary trips on a variety of wind tunnel models in the angle of attack range of 0° to 90°.

Scope of the work:

Experimental investigation to derive the procedure/methodology/pattern to distribute the boundary layer trips on typical scaled down models of slender body (SSLV/ Gaganyaan/ TVP etc), blunt body (Crew Module) and lifting body (RLV, GEV) at subsonic speeds and demonstrate aero coeffcient independence with speed by proper BL tripping in speeds upto 80 m/s at various angles of attack and wind plane angles. Alternatively tunnel flow turbulence can be increased by use of appropriate grids and TBL on model can be demonstrated.

Deliverables:

1. Methodology to finalise boundary layer trip scheme to simulate the turbulent boundary layer on the slender body, wing body and blunt body configurations.
2. Experimental results obtained on scaled models using wire trips / carborundum particles / screens etc.
3. Change in force and moment coefficient for various boundary layer trips.

VSSC - 008

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Quantification of epistemic Uncertainty in CFD simulations due to turbulence model formulation

3. Name of Co PI from ISRO Centre/Unit

Shri Harichand MV
Shri Fatehdeep Singh Walla

4. Contact Address of Co PI & e-mail id

CFDD/ADSG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: harichand_mv@vssc.gov.in

5. Area of Research

Computational Fluid Dynamics

6. Summary of the proposed research and expected deliverables

CFD is predominantly used in the initial design of the aerospace vehicles. Quantifying uncertainty is very crucial task in CFD simulation results and plays a significant role in design and analysis. The uncertainty in design can come from 1) tolerances in geometry 2) variation in free-stream input parameters as well as various input parameters used in solver 3) Turbulence modeling approaches used in CFD. The first two uncertainties fall under aleatoric category and last one falls under epistemic uncertainty.

Current research focuses on the aspect of developing the techniques to assess epistemic uncertainty in CFD solvers.

Scope of the work:

VSSC has in-house unstructured mesh Finite Volume CFD solver. At present SST and SA turbulence models are implemented in the solver. The scope of present proposal is to develop an algorithm to quantify the variation in results due to turbulence model epistemic uncertainty, applicable for both SST and SA models.

Deliverables:

1. Developed algorithm and C++ code to quantify the turbulence model epistemic uncertainty.

VSSC - 009

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Quantification of aleatoric Uncertainty in CFD simulations due to input parameter variation

3. Name of Co PI from ISRO Centre/Unit

Shri Jiju R Justus
Shri Vinod Kumar

4. Contact Address of Co PI & e-mail id

CFDD/ADSG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jiju_rj@vssc.gov.in, vinodkumar_g@vssc.gov.in

5. Area of Research

Computational Fluid Dynamics

6. Summary of the proposed research and expected deliverables

CFD is predominantly used in the initial design of the aerospace vehicles. Quantifying uncertainty is very crucial task in CFD simulation results and plays a significant role in design and analysis. The uncertainty in design can come from 1) tolerances in geometry 2) variation in freestream input parameters as well as various input parameters used in solver 3) Turbulence modeling approaches used in CFD. The first two uncertainties falls under aleatoric category and last one fall under epistemic uncertainty.

To quantify the variation in CFD results due to input parameter variation (aleatoric), a large number of CFD simulations are required. In a production environment it is impossible to carry out such large number of simulations.

Scope of the work:

VSSC has in-house unstructured mesh Finite Volume CFD solver. At present SST and SA turbulence models are implemented in the solver. The scope of present proposal is to develop an algorithm & technique to quantify the variation in results due to aleatoric uncertainties.

Deliverables:

Developed algorithm, technique and a C++ code to quantify the aleatoric uncertainties in CFD process.

VSSC - 010

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of Multigrid algorithm for unstructured grid finite volume CFD solver

3. Name of Co PI from ISRO Centre/Unit

Shri Aaditya Chaphalkar
Shri Harichand MV

4. Contact Address of Co PI & e-mail id

CFDD/ADSG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: aaditya_chaphalkar@vssc.gov.in & vinodkumar_g@vssc.gov.in

5. Area of Research

Computational Fluid Dynamics

6. Summary of the proposed research and expected deliverables

In order to capture the flow field variation/gradients large unstructured meshs are used in CFD simulations. One of the drawback of refined meshes is the slow or poor solution convergence. To improve the convergence and computational efficiency is a very important aspect in CFD. Multigrid methods are very useful in this context. Various multigrid techniques are 1) Geometric MG (Agglomeration), 2) Algebraic MG (AMG) 3) Mode Multigrid (MMG).

There are many other difficulties for the geometric multigrid such as the proper data transfer between successive meshes, the treatment for the highly stretched anisotropic hybrid grids and the paralleling computing. Algebraic MG extends the main idea of geometric multigrid wherein the coarse grids are generated using agglomeration of fine grids. This is done in a purely algebraic setting, yielding robustness and algorithmic simplicity.

Mode Multigrid is an emerging technique developed and is being further improved by various researches, wherein mesh need not be changed and modal decomposition is used.

Scope of the work:

VSSC has in-house unstructured mesh Finite Volume CFD solver. The scope of present proposal is to develop an algorithm to implement Mode Multigrid in unstructured CFD solver.

Deliverables:

Developed algorithm and a C++ code for implementation in unstructured grid FV-CFD solver.

VSSC - 011

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Turbulence model tuning to capture wide range of flow features

3. Name of Co PI from ISRO Centre/Unit

Shri Mayank Kumar
Shri Jiju R Justus

4. Contact Address of Co PI & e-mail id

CFDD/ADSG, AERONAUTICS Entity, VRC,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: mayank_kumar@vssc.gov.in

5. Area of Research

Computational Fluid Dynamics

6. Summary of the proposed research and expected deliverables

Turbulence is an ever-occurring physical phenomenon in high speed flows over aerospace vehicles. This presents a challenge in computational characterization of external as well as internal aerodynamics in correctly depicting the physical flow field. For the various ongoing and upcoming projects in ISRO, RANS based CFD tools are increasingly used for design prediction of aerothermodynamic coefficients of the launch vehicles and other configurations. Fidelity and solution quality of the CFD studies is improved via establishing validation with respect to a flight and/or experimental database. This inherently involves choosing a suitable turbulence model to match CFD results to the required database. Owing to the availability of SST & SA turbulence model in in-house unstructured grid Finite Volume CFD code, it is then envisaged to arrive at a suitable set of coefficients for these turbulence models.

Scope of the work:

The proposal should analyse the sensitivity of various coefficients of a turbulence model towards flow parameters & Aero coefficients for standard test case e.g Shock-Boundary layer interaction, Shock-shock interaction, Shock induced Separation, boat-tail separation etc. When this part of the study is completed, based on the sensitivity and validation analyses, the proposal should be able to devise a algorithm for selecting these coefficients, to achieve the spatially varying desired flow features. The test cases could be formulated based on a discussion with VSSC team.

Deliverables:

Sensitivity report, algorithm to implement the choice of turbulence model coefficient for spatially varying flow features of a CFD run.

VSSC - 012

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Noble Metal Coating over Carbon-Carbon Composites

3. Name of Co PI from ISRO Centre/Unit

Shri Jhon Paul

4. Contact Address of Co PI & e-mail id

CCDD, Composites Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jhon_paul@vssc.gov.in

5. Area of Research

Carbon-Carbon Composites

6. Summary of the proposed research and expected deliverables

Carbon-Carbon Composite materials are coated with SiC to protect from oxidation when the applications temperature is higher than 400ºC. However due to numerous applications of the material above 1700ºC, development program to coat Carbon-Carbon Composite with Noble Metals is initiated. Also during thermo-structural applications which demands leak tightness of C-C products like C-C combustion chamber, coating of Iridium on C-C composite is considered to be an ideal solution. Iridium (Ir) is considered as promising candidate for oxidation resistant materials at elevated temperature due to its high melting point (2430ºC), good chemical stability, low oxygen permeability, impermeability to gases, good chemical compatibility and low carbon solubility below the eutectic temperature of 2100–2300ºC. Considering the various merits offered by Electro-Deposition (ED) method for coating, it is proposed to develop the coating of Iridium (Ir) on Carbon-Carbon (C-C) Composite through ED. Also to overcome the problem of CTE mismatch between C-C and Ir, interlayer coating of Rhenium shall be provided through the same methodology.

Scope of Work:

- Development of Coating Methdology of Iridium on Carbon-Carbon Composite Samples through electrodeposition.
- Development of Interlayer Coating of Rhenium through electrodeposition.
- Microstructural & Compositional Characterisation of Coating.
- Demonstration of the process on various geometries (Conical & rectangular).

VSSC - 013

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of C-C derived CMC through Reactive Melt Infiltration

3. Name of Co PI from ISRO Centre/Unit

Shri Jhon Paul

4. Contact Address of Co PI & e-mail id

CCDD, Composites Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jhon_paul@vssc.gov.in

5. Area of Research

Carbon-Carbon Composites

6. Summary of the proposed research and expected deliverables

CMC's derived from C-C composites are considered as ideal materials for thermo-structural products and dimensional stable structures for space applications. Incorporation of ultra-refractory materials into C/C composites is an effective route to enhance structural capability, ablation resistance and to maintain dimensional stability. For realisation of UHTC's using C-C as base material, reactive melt infiltration (RMI) is considered one of the potential processes.

The utilization of polymeric/hydrocarbon precursors densifies porous carbon preform and leads to formation of specific characteristic in micro-structure of porous carbon/carbon composites after pyrolysis/infiltration, showing discrete translaminar capillary channels. In these channels, capillary force driven fluid transport allows good penetration of the preform by liquid silicon/ zirconia. This enables high infiltration velocities and mounting heights densifying the porous C-C to desired density levels. Exothermic reactions between a porous carbon matrix with an infiltrating melt provide an economic solution for grain-boundary diffusion to synthesize Ceramic Matrix Composites (CMC's). The fast conversion kinetics that are generally observed enables to manufacture reaction-bonded silicon /zirconia carbides through capillary infiltration of molten silicon or zirconia. However to ensure the optimal structural behaviour of the final CMC, the content of the refractory matrix in the CMC's shall be properly controlled.

The scope of work towards Development of C-C derived CMC through Reactive Melt Infiltration (RMI) involves the following:

1. Demonstration of densification of porous C-C having density with SiC/ZrC and SiC-ZrC matrix.
2. Optimisation of process conditions based with respect to different carbon matrix of C-C composite.
3. Investigation of Morphology & microstructural features of matrices in the Composite.
4. Thermostructural behaviour of CMC's realised through RMI.

VSSC - 014

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Process Optimization of Isothermal CVI process

3. Name of Co PI from ISRO Centre/Unit

Shri Jhon Paul

4. Contact Address of Co PI & e-mail id

CCDD, Composites Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jhon_paul@vssc.gov.in

5. Area of Research

Carbon-Carbon Composites

6. Summary of the proposed research and expected deliverables

One of the most promising and common methods of fabrication of thinner Carbon-Carbon & Carbon-Silicon Carbide Composites is through vapor phase densification of porous structure of carbon fibers acting as reinforcement. During CVI process, the hydrocarbon gases or vapors of silanes decompose to produce the desired carbon /Silicon carbide matrix within the pores of the preform and thereby increase the density. The density aimed after the final densification is based on the targeted mechanical and thermal properties required for the specific use of application of the product. Practically, the major hindrance of realisation of C-C/ C-SiC products through CVI process is the long processing duration required to achieve the desired density. Furthermore the process must be intermediately interrupted to permit surface machining or heat treatment at high temperature in order to open the pores for further densification.

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

VSSC - 015

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Inelastic Finite Element Model of Multidirectional Carbon-Carbon Composites to predict the material characteristics and behaviours

3. Name of Co PI from ISRO Centre/Unit

Shri Jhon Paul

4. Contact Address of Co PI & e-mail id

CCDD, Composites Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jhon_paul@vssc.gov.in

5. Area of Research

Carbon-Carbon Composites

6. Summary of the proposed research and expected deliverables

Multidirectional C-C composites (3D, 4D) are composite materials wherein the reinforcing fibres act as reinforcement at various directions. 4D C-C composites has found successful applications in solid rocket nozzles especially as ITE's. The material behaviour of nD C-C composites is highly anisotropic and shows nonlinear elastic behaviour. Most of the work

carried to assess the behaviour of multidirectional C-C composites is evaluated through destructive testing, hence limited data is generated for the mechanical properties. In this, limited work has been carried to theoretically predict the mechanical behaviour of the material and corresponding material properties associated with this class of material. Since at VSSC, nD C-C composites are envisaged to have application as SRM throat inserts and also as TPS material for certain applications, it is planned to initiate the micromechanical model studies to theoretically predict the material behaviour vis-a-vis the mechanical properties.

Scope of work includes development of an elastoplastic finite element model, including homogenised mono-axial stiffness that can predict the material properties as has been referred in literature and available tested material properties.

VSSC - 016

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of C-SiC Composite through CVI using Mono-Methyl-Silane

3. Name of Co PI from ISRO Centre/Unit

Shri Jhon Paul

4. Contact Address of Co PI & e-mail id

CCDD, Composites Entity,
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: jhon_paul@vssc.gov.in

5. Area of Research

Carbon-Carbon Composites

6. Summary of the proposed research and expected deliverables

Carbon-Silicon Carbide is considered as an ideal material for future Thermo-Structural applications, considering the various advantages offered by the material. SiC matrix is derived presently using Methyl-Trichlo-Silane, having drawbacks in due to high corrosive nature of the chemical and by-products of chlorides which are formed during the process. To meet the future requirements of C-SiC composites and also to provide SiC coating over Carbon-Carbon Composite products for various space applications, it is envisaged to use Mono Methyl Silane (MMS) as precursor for Chemical Vapour Infiltration/Deposition method. MMS is considered to be advantageous compared to other MTCS and Silane precursors, considering the chemical nature (Low Molecular Weight), processing under low temperature (~800 ºC) and being less hazardous, non corrosive and non toxic.

The scope of work in this program includes the following:

- Development of process Technology to provide SiC coating on C-C product through CVD using MMS as a process precursor.
- Development of process technology to densify Carbon preform with SiC matrix through CVD using MMS as a process precursor.
- Evolve details of storage, handling and usage of MMS for CVI and CVD processes.

VSSC - 017

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of Porous Media Based Condensing Heat Exchanger for Space Systems

3. Name of Co PI from ISRO Centre/Unit

Shri Bhatt Tushar Shriram

4. Contact Address of Co PI & e-mail id

PED / PSCG / PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: bhatt_tushar@vssc.gov.in

5. Area of Research

Material Science and Chemical / Mechanical Engineering

6. Summary of the proposed research and expected deliverables

Condensing Heat Exchangers (CHX) are essential for thermal and humidity control in manned space flight system. The control of temperature and humidity within a spacecraft requires removal of both sensible heat generated by power consuming equipment and crew (humans), and water vapor primarily generated by evaporation from humans. A CHX is designed to accomplish both of these functions. The conventional system for control and humidity removal in the crew module utilizes a two- stage process. First, moisture is condensed onto the fins of a plate-fin heat exchanger which is then forced through the “slurper bars” by the air flow. The slurper bars take in a two-phase mixture of air and water that is then separated by a rotary separator.

A more efficient design of a CHX would condense and remove the water directly from the air stream without the need for an additional water separator downstream.

This proposal envisages to develop a novel CHX based on a porous substrate with high thermal conductivity as the cold surface over which condensation occurs. The condensed water can then be removed by an embedded porous media connected to a suction device. The thermal properties, the porosity and the wetting characteristics of the porous materials

required to be chosen judiciously so that efficient condensation is promoted and at the same time air penetration into the suction lines is avoided.

It is anticipated that the porous media based condensing heat exchanger can provide a robust, lightweight passive condenser and liquid separator and it will be operationally simple.

The unique geometrical configuration of the heat exchanger and the need for it to operate in varying gravity field including microgravity are the major challenges in development of the proposed CHX based on porous media.

Following deliverables are expected from the project:

- Material selection/realization which will not be susceptible to fouling and bacterial contamination of the porous substrate
- Design (size and geometric shape) and fabrication of a porous substrate with desired porosity
- Realization and demonstration of proof-of-concept of the porous media CHX prototype

VSSC - 018

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of structure property correlations of energetic materials for use in Propellants / Explosives

3. Name of Co PI from ISRO Centre/Unit

Dr. S. Reshmi

4. Contact Address of Co PI & e-mail id

PED / PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: s_reshmi@vssc.gov.in

5. Area of Research

Energetic Materials

6. Summary of the proposed research and expected deliverables

Understanding the structure property correlation of materials is one of the important aspect in the field of energetic materials is vital for assessing the hazard as well as performance characteristics for propellant as well as explosive in aerospace applications. Addressing the solid state properties of energetic materials using computational approach to understand the structural, mechanical, bonding, vibrational and electronic structure of energetic solids is essential prior to undertaking laboratory level processing.

The following deliverables are expected:

1. Comparing the structural energy difference between various polymorphs using the crystallographic data of energetic materials developed at VSSC.
2. Understanding the lattice dynamics, vibrational properties and thermal expansion of energetic materials addressing the structural stability in high pressure conditions considering operation of propellants/energetic materials.
3. Electronic, lattice thermal conductivity as well as mechanical properties through elastic constants of energetic solids to assess the influence of specific morphology on processing aspects.
4. Equation of state and thermodynamic properties for computation of performance (detonation velocity, specific impulse etc.) at varying pressures.

VSSC - 019

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of high voltage (> 3.0 V) gel electrolytes for Flexible SuperCapacitors (FSSCs)

3. Name of Co PI from ISRO Centre/Unit

Dr. Sujatha S

4. Contact Address of Co PI & e-mail id

APSD / PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: s_sujatha@vssc.gov.in

5. Area of Research

Energy Systems for Satellite & Launch Vehicles

6. Summary of the proposed research and expected deliverables

With rapid development of portable and wearable electronics in recent years, there has been increasing demand for the development of flexible energy storage devices, which will be an integral part of future electronic systems. The key challenge in developing flexible high voltage supercapacitor (> 3.0 V) depends on the realization of flexible electrode materials and suitable electrolytes which offers high operating voltage, high conductivity, high energy & power characteristics and long-cycle stability. Development of hybrid ionic liquids / organic electrolytes-based gel / quasi-solid electrolytes are highly essential to achieve the flexibility, improved safety and to reduce the cause packaging, portability, and leakage risks associated with the conventional liquid electrolytes. In view of the above, it is imperative to develop hybrid Ionogel based electrolyte systems with operating voltage: > 3.0 V, Ionic conductivity: >10 mS/cm, Temperature window: -20 to 70°C, Vickers's Hardness: 0.10-0.15 MPa and elastic modulus: 1 ± 0.2 MPa. The expected deliverables from the project are,

- Ionogel based electrolytes with the above-mentioned properties and method of synthesizing / formulating the same
- Design and realization of Flexible Supercapacitors with the synthesized electrolytes and performance evaluation
- Demonstration of the super capacitor behaviour under various mechanical deformations such as twisting, stretching, bending, and folding etc

VSSC - 020

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of high capacity cathode materials

3. Name of Co PI from ISRO Centre/Unit

Smt. Mercy TD

4. Contact Address of Co PI & e-mail id

ESD/PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: td_mercy@vssc.gov.in

5. Area of Research

Materials for Lithium-ion batteries

6. Summary of the proposed research and expected deliverables

Lithium ion cells are used in many applications ranging from portable electronics to space. The specific energy of lithium ion cells depends on the capacity and voltage of the cathode materials used. The specific capacity of present cathode materials is limited to ~200 mAh/g. In order to further improve the energy density of lithium ion cells, high capacity cathode materials with specific capacity >250 mAh/g. Most of the present day high capacity cathode materials use cobalt which is toxic and costly. So, It is required to avoid cobalt in these cathode materials to make the material cheap and environment friendly. So high capacity Co free Lithium Nickel Manganese Oxide based materials with specific capacity >250 mAh/g are required. Also, in order to improve the specific capacity and cycle life, suitable ceramic coating may also to be given.

The following are the deliverable expected from this project:

1. High capacity cathode materials with specific capacity>250 mAh/g.
2. Improvement in cycle life of these high capacity cathode by suitable ceramic coating.
3. Process scaling up of the material for large scale application.

VSSC - 021

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of high voltage cathode materials for Lithium ion cells

3. Name of Co PI from ISRO Centre/Unit

Smt. Mercy TD

4. Contact Address of Co PI & e-mail id

ESD/PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: td_mercy@vssc.gov.in

5. Area of Research

Materials for Lithium-ion batteries

6. Summary of the proposed research and expected deliverables

The specific energy of lithium ion cells depends on the capacity and voltage of the cathode materials used. The average voltage of present cathode materials is limited to 3.6-3.8 V. Lithium ion cells with high voltage are required to meet the high voltage demand for certain applications. So, cathode materials with high voltage (>4V) are required for developing high voltage lithium ion cells for such applications.

The following are the deliverable expected from this project:

1. High voltage cathode materials with average voltage > 4 V.
2. Process scaling up of the material for large scale application.

VSSC - 022

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Simulation study of electronic/photonic band gap materials for microwave applications

3. Name of Co PI from ISRO Centre/Unit

Dr. K. Ashok

4. Contact Address of Co PI & e-mail id

Electronic Ceramic Section, GEM/MMG/MME
Vikram Sarabhai Space Centre
Thiruvananthapuram.
e-mail: ashok@vssc.gov.in

5. Area of Research

Electro Magneto Ceramics

6. Summary of the proposed research and expected deliverables

Artificially engineered materials with exotic properties emerged as a new frontier of material science and engineering. Simulation study on 2D/3D electronic band gap materials targeting UHF-Ku band application will be the research topic. Numerous intriguing phenomena and applications associated with metamaterials can be studied through simulation/modeling. The effect of permittivity or permeability on band gap materials through simulation study shall be envisaged.

The deliverables would be the simulation study results and relevant documentation. Material with permittivity 10 -12; loss $<10^{-3}$ and temp.co-efficient of dielectric constant <25 can be used as input parameters to simulate using HFSS/CST or other software. Dielectric properties can be specific to control EM bandpass/band stop modeling in microwave region.

VSSC - 023

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Multi-scale simulation of weld solidification cracking in Ni-based superalloys used in aerospace applications

3. Name of Co PI from ISRO Centre/Unit

Shri Agilan M

4. Contact Address of Co PI & e-mail id

Engr In-Charge,
Welding development section (WDS), HWMD/MMG/MME,
Vikram Sarabhai Space Centre
Thiruvananthapuram.
e-mail: m_agilan@vssc.gov.in

5. Area of Research

Welding and Joining

6. Summary of the proposed research and expected deliverables

Nickel based superalloys such as Inconel 718 and XH67MBTЮ (67Ni-18.5Cr-4.5Mo-4.5W-2.5Ti-1.3Al-1.7Fe) Russian grade alloys are used in ISRO's launch vehicle applications. Based on processing conditions (restraint, stress, heat input, chemical composition etc.), these materials are prone for weld solidification cracking or hot cracking. It is necessary to understand the role of processing parameters/conditions which causes cracking. Experimental methods for this study are time-consuming and expensive. Multi-scale simulation (macro scale for three-dimensional heat and mass transfer & micro scale for microstructural evolution) approach can figure out the critical processing conditions for cracking.

Deliverables:

The project deliverables shall be multi-scale simulation of weld solidification cracking in Ni-based superalloys and validation with experimental data. A comprehensive database on the role of processing parameters on solidification cracking and weld microstructure evolution to be brought out.

VSSC - 024

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Modelling of process parameters for 3D printing

3. Name of Co PI from ISRO Centre/Unit

Dr. Anilkumar V,
Dr. Govind

4. Contact Address of Co PI & e-mail id

GH, CSFG/MMG, MME,
Vikram Sarabhai Space Centre
Thiruvananthapuram.
e-mail: govind@vssc.gov.in

5. Area of Research

Physical/mechanical Metallurgy

6. Summary of the proposed research and expected deliverables

Optimization of process parameters for 3D printing of any new material is exhaustive task. It needs number of coupons to be printed and characterized. This project envisages development of simulation tool for optimized process parameters though thermo-physical properties of the materials. Tools like machine learning and AI shall be used. This tool should be able to suggest DOE plan also for any new system. This tool should be validated with the extensive experiments.

The project deliverables shall be

1. Simulation tool based on the existing data base of standard alloys.
2. Simulation tool shall be able to predict the optimal value of parameters like Laser Power, Scan Speed and Hatch distance for achieving >99% density. These prediction shall be based on thermophysical properties and the data base of existing alloys for given materials.
3. It should also be able to predict the DOE for a given composition.

VSSC - 025

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Development of durable and smart catalyst layer structures for low temperature PEM fuel cells

3. Name of Co PI from ISRO Centre/Unit

Dr. M Shaneeth

4. Contact Address of CoPI & e-mail id

ESD / PCM
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: m_shaneeth@vssc.gov.in

5. Area of Research

Fuel Cells

6. Summary of the proposed research and expected deliverables

The main objective of the proposal is to develop novel catalysts for the cathode of a Proton Exchange membrane fuel cell (PEMFC) with the objective of replacing platinum catalyst. The work would be to evaluate the performance of these cathode catalysts in PEM fuel cell as compared to a Platinum catalyst, study the performance degradation of these catalysts in an operating PEM fuel cell and understand the life term performance of these novel catalyst.

The project deliverables would be novel cathode catalysts synthesized for testing in a PEM fuel cells (along with the synthesized catalysts, the synthesis procedures and electrochemical characterization studies), for further full-level charecterisation and field trials at VSSC.

VSSC - 026

1. Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

2. Title of the research proposal

Copper Coating on Epoxy-Carbon Composite for Radio Frequency Reflector Antennas

3. Name of Co PI from ISRO Centre/Unit

Shri Vinu Viswanath

4. Contact Address of CoPI & e-mail id

CSSD/CMSE
Vikram Sarabhai Space Centre, Thiruvananthapuram.
e-mail: vinu_viswanath@vssc.gov.in

5. Area of Research

Composite antenna reflectors

6. Summary of the proposed research and expected deliverables

Satellite antenna reflectors use CFRP sandwich sheets as reflecting surface. The RF reflectivity of CFRP degrades at high frequency. This shortfall shall be overcome by metallising the reflector surface. This process has to be simple and should give uniform wrinkle-free deposition, defect free/joint-free and better thermal/structural behavior of sandwich.

As a part of project deliverable, we should get:

Copper coated epoxy-carbon composite sheets for material characterisation, testing and evaluation.

Copper coating on epoxy-carbon composite prototype sub-size antennas on the given sample panels provided by VSSC for testing.

Process for selective coating of copper by electroless / electrolytic technique.

SPACE APPLICATIONS CENTRE
AHMEDABAD

SAC - 001

1. Name of ISRO Centre/Unit
Space Applications Centre, Ahmedabad

2. Title of the research proposal
GPR Return Signal Simulator

3. Name of Co PI from ISRO Centre/Unit
Smt. Swati Shukla
Shri Gaurav Seth

4. Contact Address of Co PI & e-mail id
MRSA-MSIG-MSSD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: swatiduggal@sac.isro.gov.in, gauravseth@sac.isro.gov.in

5. Area of Research
System simulator for Ground Penetrating Radar (GPR)

6. Summary of the proposed research and expected deliverables
The proposed project is aimed towards development of an end-to-end GPR system simulator software.

The classical operation of GPR relies upon measurements carried out at network of positions and subsequent analysis of the echoes by inversion algorithms to retrieve the three-dimensional (3-D) structure below the ground.

The GPR return signal simulator software should be able to build a numerical code that can simulate the operation of the GPR with enough accuracy in an actual environment. It should have the flexibility of changing Soil properties (including soil mixtures as well as layering).

In order to evaluate the real performance of an instrument, the software should be able to take into account the entire system, starting with the actual signals fed to the electric antenna at emission, simulating the antenna operation, the wave propagation and backscattering in the subsurface and ending by computing the electromagnetic field of waves exiting from the surface and the corresponding current generated in the antennas and sent to the receiver input.

It should have customizable transmit signal properties (Pulsed/ SFCW/FMCW) as well as plugins to include inputted antenna pattern, transmitter and receiver responses. It should also be able to simulate the return echoes as per a defined trajectory (where the waypoints are customizable) of the platform.

The software should be able to introduce clutter to the transmit/receive signal similar to what would be generated in the actual operation due to surface returns from antenna side lobes.

During GPR operations, coherent integrations can be performed in order to improve the signal/ noise ratio. The deliverable software should also have this capability.

Deliverables

The deliverable would be a software package, which can simulate the radar echo and process it to generate a radargram.

SAC - 002

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

High Level Synthesis methodolgy based Robust Synthetic Aperture Radar (SAR) processing algorithm development amenable for FPGA implementation

3. Name of Co PI from ISRO Centre/Unit

Shri B. Saravana Kumar

4. Contact Address of Co PI & e-mail id

MRSA-MSDG-MSDPD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: saravana@sac.isro.gov.in

5. Area of Research

Radar Signal Processing

6. Summary of the proposed research and expected deliverables

The proposed research project aims to apply the High Level Synthesis (HLS) methodologies for development of real time SAR processor. This includes design of robust processing algorithms (with low precision arithmetic) for image generation in the absence (or low update rates) of accurate spacecraft attitude/pointing/velocity estimates. The low-latency SAR algorithm thus developed must be implemented on a Field Programmable Gate Array (FPGA) platform using High Level Synthesis tools/methodologies and benchmarked for performance.

The objectives of the proposed research are following:

- Development of robust algorithm capable of focused SAR image generation in the absence of accurate attitude/pointing/velocity information.
- RTL generation of proposed algorithm using HLS methodology.
- Implementation, benchmarking and performance assessment of the proposed algorithm on a FPGA based kit.

Expected Deliverables:

1. Robust SAR processing algorithms.
2. One proof of concept hardware along with RTL code (Synthesized using HLS) and MATLAB/C/High Level code.

SAC - 003

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design of Rad Hard By Design (RHBD) Non-Volatile memory IP for 180nm CMOS process

3. Name of Co PI from ISRO Centre/Unit

Shri Himanshu N. Patel

4. Contact Address of Co PI & e-mail id

MRSA-MSDG-MSCED
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: hnpatel@sac.isro.gov.in

5. Area of Research

VLSI, Semiconductor Memories

6. Summary of the proposed research and expected deliverables

This Proposal is design & development of Radiation Hard By Design (RHBD) Non Volatile memories for 180nm CMOS process. RHBD memories are used in space borne ASICs for various on board applications like payload control, data acquisition, digital communication etc. RHBD ASIC contains various modules like microprocessor core, coprocessors, peripheral modules, SRAM, analog modules and various types of I/Os. RHBD standard cell libraries and IP for on chip volatile memories (SPRAM/DPRAM) have been developed indigenously, but RHBD Non-volatile memory IP is still not available indigenously. Non-volatile memory in terms of One Time Programmable (OTP) or Multiple Time Programmable (MTP) with size of 64K Bytes or larger may be developed. As part of this project, RHBD NV memory with optimized area and timing performance should be designed, simulated and GDS-II layout should be generated for 180nm CMOS process. RHBD techniques can be used at various

design stages like circuit level, layout level and system level. Radiation performance can be validated through various fault injection simulations. Test chip fabrication and radiation testing can be done jointly by ISRO & academic institute.

Deliverables:

- Design documents
- Schematic & layout files
- Simulation & test results
- GDS-II for test chip

SAC - 004

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design, Development of sub millimeter-wave Superconductor-Insulator-Superconductor(SIS) mixers

3. Name of Co PI from ISRO Centre/Unit

Ms. Harshita Tolani
Shri Prantik Chakraborty

4. Contact Address of Co PI & e-mail id

Space Applications Centre
Jodhpur Tekra, Ahmedabad.
e-mail: harshita@sac.isro.gov.in, prantik@sac.isro.gov.in

5. Area of Research

High Sensitivity Sub Millimeter-wave Receivers for Astronomical Applications

6. Summary of the proposed research and expected deliverables

The research proposal is for design and realization of SIS based fundamental mixers, operating at 438-493GHz frequency band. SIS mixer technology has provided mm-wave and sub mm-wave astronomers with remarkable sensitivity across a wide observational spectrum extending to sub mm-wave frequencies.

The SIS junction is an electronic device consisting of two superconductors separated by a very thin layer of insulating material. SIS mixer based receiver front-ends, operating at ~ 4K temperature, can achieve state-of-the-art noise performance of the order of 2-5 times the quantum limit at mm & sub-mm frequencies.

Scope of the research work: Design and development of cryogenically cooled (~ 4K) SIS based fundamental mixersat at 438-493GHz frequency band.

Deliverables:

1. Design Report comprising the simulation results.
2. Design files along with the 3D Model .dxf /.gbr/ .sat/.stp files.
3. SIS mixer modules operating at 438-493GHz frequency band.

SAC - 005

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Development of measurement systems and sensors for gas concentration

3. Name of Co PI from ISRO Centre/Unit

Smt. Payal Sharma
Ms. Shikha Tomar

4. Contact Address of Co PI & e-mail id

HSTD/HSTG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: payal@sac.isro.gov.in

5. Area of Research

High Sensitivity Sub Millimeter-wave Receivers for Astronomical Applications

6. Summary of the proposed research and expected deliverables

Human Spaceflight requires continuous measurement of concentration of major air constituents (O2, CO2, CH4, NH3 & CO) and more than 200 trace gases including trace volatile organic compounds (VOC) at ppm to ppb levels, which are relevant to astronaut's health. These are by-products of metabolism/combustion/chemical reactions in the cabin.

Measurement of these gases can be achieved by discrete sensors for each gas or by holistic techniques like spectrometry. Both approaches have their own advantages. Handheld measurement systems can use discrete sensors to build compact, light-weight and battery powered systems. Other techniques can be used to measure array of gases from the same sample. Indigenous development of compact and lightweight sensors and other systems using laser, chromatography, Fourier transform techniques etc. have good potential for present and future applications in HSP.

Expected Deliverables:

1. Study report
2. Simulation results
3. Test results
4. Gas Sensors/measurement system

SAC - 006

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Compact fire suppression systems for crewed missions for micro gravity applications

3. Name of Co PI from ISRO Centre/Unit

Smt. Payal Sharma
Shri Arvind Singh

4. Contact Address of Co PI & e-mail id

HSTD/HSTG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: payal@sac.isro.gov.in

5. Area of Research

Human Spaceflight

6. Summary of the proposed research and expected deliverables

On board fire in HSP is one of the most serious on-board hazards. Every HSP mission carries fire suppression system. FSS should be safe for humans, should be quick and efficient in dousing fire, should be clean and its application should be safe for on-board electronics. Fine water mist based FSS is in use on-board ISS now.

Indigenous development of compact, portable, easy to use and safe FSS is needed for current and future HSP missions.

Expected Deliverables:

1. Study report
2. Design document
3. Simulation and test results
4. Fire Suppression System

SAC - 007

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Next generation fire detection systems

3. Name of Co PI from ISRO Centre/Unit

Smt. Payal Sharma
Shri Akash Gupta

4. Contact Address of Co PI & e-mail id

HSTD/HSTG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: payal@sac.isro.gov.in

5. Area of Research

Human Spaceflight

6. Summary of the proposed research and expected deliverables

Fire is one of the most critical on-board hazard for any HSP mission. Detection fire is of paramount importance. Sensors must have very high sensitivity to variety of fire, flame and electric spark. At the same time, it should offer high immunity to false detection.

Most mission experiences have reported early detection by humans through smell, rather than on-board sensors. Development of “Electronic Nose” which can detect very low concentrations of combustion products can help in early detection of fire.

Fire is detected by measurement of concentration of specific gases, heat, temperature, flame etc. Novel approaches in detection, new parameters that can aid to detection of fire also is needed to enhance the fire detection scenario.

Expected Deliverables:

1. System design report
2. Simulation and test results
3. Electronic Nose (Fire Detection System)

SAC - 008

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Personalized instrumentation for astronauts

3. Name of Co PI from ISRO Centre/Unit

Smt. Payal Sharma
Shri Jayesh Jayarajan

4. Contact Address of Co PI & e-mail id

HSTD/HSTG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: payal@sac.isro.gov.in

5. Area of Research

Human Spaceflight

6. Summary of the proposed research and expected deliverables

Personalized instruments like wearable health monitors etc. are essential for all human spaceflight missions. Variety of sensors are flown with astronauts for monitoring of crew health parameters like Blood Pressure, Oxygen Saturation, Pulse Rate, Exhaled Breath Analysis etc. Wearable medical devices need to be developed for continuous monitoring and transmission of these parameters to ground. This is essential for both long term and short term missions. Apart from its on-board application, they are equally useful during training and simulation studies.

These instruments would have immense applications in all kinds of human spaceflight missions for safe, reliable and continuous health monitoring of all crew.

Expected Deliverables:

1. System concept design document
2. Package design modelling report
3. Simulation and test results
4. Wearable Health Monitors

SAC - 009

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Multi-channel stackable input perfect reconstruction transmultiplexer for satellite communication

3. Name of Co PI from ISRO Centre/Unit

Dr. Deepak Mishra
Shri Himanshu N. Patel

4. Contact Address of Co PI & e-mail id

SNPA-ODCG-DCD
Space Applications Centre
Jodhpur Tekra, Ahmedabad – 380015.
e-mail: deepakmishra@sac.isro.gov.in, hnpatel@sac.isro.gov.in

5. Area of Research

Transmultiplexer

6. Summary of the proposed research and expected deliverables

The proposed research project aims to apply the design methodologies of uniform and non-uniform filter banks and wavelet transform techniques for design and implementation of transmultiplexers with variable number of input channels with the emphasis on improved performance in terms of reconstruction and ease of implementation on Field Programmable Gate Array (FPGA) or on Application Specific Integrated Circuit (ASIC). The work includes Perfect reconstruction based filter bank design, Novel wavelet based perfect reconstruction based filter bank. It includes less overhead compare to known existing approaches, the process and deliverables of the proposed work are clear and achievable.

The objectives of the proposed research are following:

- Development of a unified algorithm for uniform and non-uniform filter banks.
- FPGA realization of the pro posed transmultiplexer of the unified algorithm on commercially available development kit and ADC board.
- FPGA realization and testing on custom made hardware.

Deliverables:

1. Wavelet base perfect reconstruction based filter bank based algorithm.
2. One proof of concept hardware along with RTL code and Matlab code.

SAC - 010

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

To study potential protocols for satellite-based secure quantum communication under ambient atmospheric conditions

3. Name of Co PI from ISRO Centre/Unit

Shri Adarsh Jain
Shri Koushik Basak
Shri Jaydeep Kaintura

4. Contact Address of Co PI & e-mail id

SNPA-ODCG-DCD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: adarshjain@sac.isro.gov.in, koushik@sac.isro.gov.in,
jaydeep@sac.isro.gov.in

5. Area of Research

Space Based Quantum Communication

6. Summary of the proposed research and expected deliverables

To bring out modelling and simulation methodology for evaluation of quantum channel (single & entangled photon) with atmospheric effects on entangled or single photon and its characterization for free space application. It is expected to analyzes various QKD protocols such as BB84, decoy state, E91, SARG04 etc. required for establishing secure communication. The systematic polarization analysis for satellite based QKD protocols and change in polarization states due to satellite motion, payload optics, other atmospheric parameters to be studied. The algorithm for error correction (EC) techniques preferably LDPC (Low Density Parity Check) and Privacy Amplification (PA) methods is to be implemented on FPGA. Modeling of noisy quantum channel for free space applications. Systematic polarization analysis for satellite based QKD protocols, effects due to satellite motion, payload optics and other atmospheric parameters. The simulation and analysis is to be carried out for QKD scenarios in LEO & GEO orbits, link budget analysis in terms of power and quantum key rate is to be performed. The PI is expected to carryout simulation and analysis for MIMO system modelling for Quantum communication system.

Deliverables:

1. Modelling methodology and simulation results for evaluation of quantum channel (single & entangled photon) with atmospheric effects for free space application.
2. Simulation and analysis results for various QKD protocols such as BB84, decoy state, E91, SARG04 etc. clearly indicating merits/demerits of them.
3. Systematic polarization analysis results for satellite based QKD protocols, effects due to satellite motion, payload optics, other atmospheric parameters.
4. Source characterization methodology including polarization dependent observations and corresponding results.
5. FPGA code, implementation results for Error Correction (EC) algorithm, preferably LDPC and Privacy Amplification (PA) algorithm along with results.
6. FPGA code, implementation results for random number generation.
7. Simulation and analysis results for QKD in LEO & GEO orbits, link budget analysis in terms of power and quantum key rate.
8. Simulation and analysis results for MIMO system modelling for Quantum Communication system.

SAC - 011

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design and analysis of Error Correcting codes for satellite Communication and Navigation

3. Name of Co PI from ISRO Centre/Unit

Dr. Deepak Mishra
Smt. Anita Panday

4. Contact Address of Co PI & e-mail id

SNPA-ODCG-DCD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: deepakmishra@sac.isro.gov.in, anitapanday@sac.isro.gov.in

5. Area of Research

SATCOM SATNAV Technology

6. Summary of the proposed research and expected deliverables

- To develop indigenous Novel parity check matrix of LDPC codec for Navigation payload without depending upon patented technologies.
- To develop Cost effective efficient design approach for encoder and decoder of LDPC codec: - Reduce implementation cost low complexity encoding and decoding algorithms improve hardware efficiency and power efficiency, which in turn reduces system implementation cost.
- To develop New channel codec design for optical payload as the optical links are prone to errors and signal corruption, thus the proposed work is expected to aim for high data rate in optical links which can be achieved through efficient FEC codes that should be tailor-made for the satellite optical communication channels.
- Design methodology of channel codec for optical payload to enable high-speed and high data rate links although optical links consume low power than traditional microwave links, they provide higher bandwidth, narrower beam width and very high data rates.

Scope of the research includes

- Design efficient FEC codes for the data packets in NavIC system.
- Develop encoding and decoding algorithms with low computational complexity.
- Provide design methodologies for efficient hardware architectures for implementing FEC codec algorithms.
- Simulate and evaluate the performance of the developed FEC codes in satellite channels.

- Design efficient error correcting codes for communications in satellite optical channel.
- Design efficient rate-adaptive encoding techniques to improve optical link throughput.
- Provide design methodologies for constructing optical channel-specific code structures that provide high rate and very low error rates.
- Explore polar codes as a potential solution to the FEC coding problem in optical satellite links.
- Analyze and evaluate the performance of fountain codes for satellite links with feedback communication.
- For the designed codes, develop encoding and decoding algorithms with low computational complexity and efficient architectures for implementing the same in field programmable gate arrays (FPGA).
- Simulate, evaluate and benchmark the performances of the various codes developed for optical links under various channel scenarios.

Deliverables:

Efficient FEC codes for quicker and cheaper enrollment of the NavIC system without relying on patented foreign technologies

1. MATLAB based encoder and decoder design algorithm.
2. Parity matrix or generator polynomial for Navigation signals.
3. Design approach for channel codec for optical communication payload

SAC - 012

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Survey and analysis of different types of SOTM system and simulation of their tracking and control algorithms and implementation

3. Name of Co PI from ISRO Centre/Unit

Shri Sudhir Agarwal,
Shri Pinakin Thaker,
Ms. Ushma Dad

4. Contact Address of Co PI & e-mail id

SSAA-CTAG-CAD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: sudhir@sac.isro.gov.in, ushma@sac.isro.gov.in

5. Area of Research

Satellite communication, antenna and control system for antenna tracking

6. Summary of the proposed research and expected deliverables

Satellite communications On The Move (SOTM) is a communications capability used for high speed satellite connectivity in moving vehicle. SOTM terminal with vehicle mounted automatic tracking antenna will provide two-way, high-speed communications on the move under various operational conditions using HTS (High Throughput Satellite). The major challenges in Ku band SOTM are Adjacent Satellite Interference, Antenna de-pointing, Antenna Tracking, Dynamic link, Doppler effect, beam switching, Rain fade etc.

The proposed research includes survey of different types of SOTM systems and comparison of them. Automatic pointing and tracking algorithms for different antennas to be studied and MATLAB and C simulations to be carried out. Different algorithms for mechanical scanning, electronic beam steering and hybrid scanning techniques to be studied and simulations to be carried out.

Deliverables:

1. Study report containing survey results, algorithm details for all tracking techniques and other technical details
2. MATLAB and C Simulations for tracking algorithms.

SAC - 013

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Development of 1.2-meter aperture CFRP Mirror for visible/optical wavelength application

3. Name of Co PI from ISRO Centre/Unit

Shri Jaimin Desai

4. Contact Address of Co PI & e-mail id

ESSA-EnTSG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: jaimin_desai@sac.isro.gov.in

5. Area of Research

Composite Components Development and Fabrication

6. Summary of the proposed research and expected deliverables

Space based camera uses Telescope that consists of Reflective mirrors. It is the prime goal for any space based camera/telescope to be of light weight coupled with ease of Assembly,

Integration & testing. SAC, Ahmedabad is mainly responsible for the development of space based earth observation cameras with varied applications for missions like Chandrayaan, Mars orbiter mission, INSAT VHRRs, Cartosat series, Resourcesat series, OCM series etc. The space based telescope needs the mirrors with high dimensional stability (insensitive to temperature excursions- almost zero CTE- co-efficient of thermal expansion-materials). We have been using Zerodur as glass mirrors materials of construction. This material is low CTE material but has disadvantage of very poor strength with high brittleness, which adds to the long realization time.

With the increased high resolution requirements of the order of 1 meter & better, the main aperture size of the telescope increases, which adds to the weight & fragile materials (Zerodur Glass) handling complexity.

CFRP- Carbon Fiber Reinforced Plastic- is a special type of material with Carbon fibers being used as a structural – load carrying member. The Carbon fiber at an individual level is having low & negative CTE of the order of @ (-2 to 0) X 10^{-6} / cent. By properly mixing matrix & carbon fibers, we can achieve near zero CTE. CFRP is a light weight, high stiffness, high strength material apart from low CTE material. Thus, CFRP is a prime candidate & is a material of construction for optical mirrors being used in present days.

Surface figure/profile accuracy requirement for 1.2meter primary aperture is Lambda/20 rms & @ Lambda/6 p-v at 633 nm. The surface roughness requirement is up to 2 nm maximum. The values are kept coarse at the initial stage, however, after gaining confidence from process & other parameters point of view, the final value shall be communicated which shall be more stringent.

SAC - 014

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Development of Cryocooler for 100-30K and 30-4.5 K temperature

3. Name of Co PI from ISRO Centre/Unit

Mr Harish Balaji
Mr Vivek Kumar Singh
Mr. A.P.Vora

4. Contact Address of Co PI & e-mail id

STG/MESA
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: singhvivek@sac.isro.gov.in

5. Area of Research

Thermal Engineering, Cryogenics, Heat Transfer, sub Kelvin Cooling

6. Summary of the proposed research and expected deliverables

For development of a sub-Kelvin cooler system, intermediate temperature stages are required to reduce parasitic heat load into the system. Cryocoolers are preferred over stored cyrogens in space missions to achieve the intermediate temperatures of 30K and 4.5K, due to their compact volume and for prolonged mission life. This research will target the overall cryocooler system design and its optimization. It is expected that a design methodology including code to simulate the cryocooler performance is developed and validated with existing literature. A working prototype is to be developed with the validated design code and a cooling power of atlest 200mW and 20mW at 30K and 4.5K respectively is to be demonstrated. In addition to being used for sub-Kelvin cooler system, the cryocooler design methodology can be adopted for indigenous IDDCA development for Optical payloads. Preffered technology will be Pulse Tube Cryocooler, however other options also can be proposed.

Deliverables:

- Design and analysis code of Cryocooler system.
- Working prototype of light weight (<20 Kg) and vibration free Cryocooler of 100-30K (Q≃10 W) and 30-4.5 K temperature (Q≃1 W).
- Continuous operation of unit (approximately 1 year at least) need to be demonstrated.

SAC - 015

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design and development of optical cooler for 80-100K temperature range

3. Name of Co PI from ISRO Centre/Unit

Mr. Vivek Kumar Singh
Mrs. Moumita Dutta
Mr. A.P.Vora

4. Contact Address of Co PI & e-mail id

STG/MESA
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: singhvivek@sac.isro.gov.in

5. Area of Research

Thermal Engineering, Cryogenics, Heat Transfer, Optical Cooling

6. Summary of the proposed research and expected deliverables

Solid-state optical refrigeration uses anti-Stokes fluorescence to cool macroscopic objects to cryogenic temperatures without vibrations. A passive optical cooler need to be developed

for 80 K temperature range at 100mW dissipation approximately. Designed and developed system should be light weight and power requirement to excite the laser should be as much as less possible. Total system mass should be less than 25 Kg. Design and analysis code need to be developed comprising physics of anti-Stokes fluorescence, thermal aspect, etc. Materials and coating methodology required for the work also need to be developed and characterized. Adhesion free bonding technique (without optical adhesive) to join doped and undoped crystal also need to be developed.

A prototype of optical cooler will be developed and tested jointly with SAC.

Deliverables:

- Design and analysis code of optical cooling system.
- Development of working prototype of light weight (<25 Kg) optical cooler for 80-100K temperature range (Q≃100 mW).

SAC - 016

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Additive manufacturing (3D printing) using Carbon Allotropes

3. Name of Co PI from ISRO Centre/Unit

Shri Ravi Kumar Varma
Shri Dhaval A Vartak

4. Contact Address of Co PI & e-mail id

SRA-MQAG-PMQD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: rkv@sac.isro.gov.in, dhaval@sac.isro.gov.in

5. Area of Research

System Reliability

6. Summary of the proposed research and expected deliverables

Traditionally mechanical parts for space are produced through conventional process using conventional bulk material, which is called subtractive manufacturing. Conventional material has low specific strength as compared to materials like carbon fibre and graphene, which are allotropes.

With the advancement in manufacturing technology and material, production time and cost can be reduced manifold by introduction of 3D printing technology. Currently worldwide aerospace

industry is producing parts through 3D printing for commercial flights, with same reliability as conventional method.

Carbon Allotropes such as Carbon NanoTubes (CNT), graphene and metal particles, allows one to build objects with multifunctional properties having good electrical conductivity, thermal conductivity, mechanical strength, and stiffness at a relatively low cost.

Deliverables:

- Development of standard prototype part and performance demonstration under defined environmental conditions.

SAC - 017

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

An empirical analysis on deriving test cases from natural language text using Model Based Testing (MBT) approach

3. Name of Co PI from ISRO Centre/Unit

Shri Sanjay M Trivedi
Shri Akhilesh Sharma

4. Contact Address of Co PI & e-mail id

SRA-SQAG
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: sanjay@sac.isro.gov.in, akhilesh@sac.isro.gov.in

5. Area of Research

System Reliability

6. Summary of the proposed research and expected deliverables

Implementation of Machine Learning techniques like natural language processing for review of Software Requirements Specification (SRS) Quality and improving it.

Study and implementation of different MBT techniques for automated test case generation based on design models from SRS to enable effective software testing.

Different MBT techniques needs to be studied, established and applied in different project contexts.

Study and implementing the above mentioned research point will help in analysing and evaluating the applicability of MBT approaches and will streamline the process of deriving

test cases from the Software Requirements Specification (SRS) using Natural Language (NL) requirements.

Anticipated Benefits:

- New Testing approach will help in automating the test case generation from specifications and improve the overall testing process.

SAC - 018

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Fabrication and performance optimization of Thin Film Bulk Acoustic Wave (BAW) resonators and filters

3. Name of Co PI from ISRO Centre/Unit

Shri Santanu Sinha

4. Contact Address of Co PI & e-mail id

LMDD/MEG/ESSA
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: shantanu_sinha@sac.isro.gov.in

5. Area of Research

Microelectronics

6. Summary of the proposed research and expected deliverables

Thin film Bulk Acoustic Wave (BAW) filters offer compact high performance filtering, typically beyond 1 GHz. Latest research work has shown their promise well beyond X-band of frequencies. Aluminium Nitride (AlN) piezoelectric thin film based resonators form the building blocks of these filters. Film Bulk Acoustic Resonator (FBAR) and Solidly Mounted Resonator (SMR) are the two approaches employed for the realization of these resonators.

The scope of the proposed research work shall be to carry out the fabrication of FBAR/SMR based BAW filters, based on the target filter specifications provided by SAC. The researchers shall be responsible for carrying out resonator stack design and optimization, resonator RF performance prediction, optimization of fabrication processes and finally fabrication of resonators/filters. The performance of the fabricated resonators/filters shall be verified against target specifications.

Deliverables

- Process recipes for fabrication of thin film BAW filters

SAC - 019

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Development of LTCC tapes and compatible pastes for Space Applications

3. Name of Co PI from ISRO Centre/Unit

Shri Santanu Sinha

4. Contact Address of Co PI & e-mail id

LMDD/MEG/ESSA
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: shantanu_sinha@sac.isro.gov.in

5. Area of Research

Microelectronics

6. Summary of the proposed research and expected deliverables

Low Temperature Co-fired Ceramic (LTCC) based System-in-Package technology is the technology of choice for the realization of compact multi-layer Radio Frequency/Microwave sub-systems. Realizing the potential of this technology, SAC, Ahmedabad has set-up a LTCC foundry, through the in-house development of all key unit processes.

However, when it comes to LTCC material, SAC/ISRO is fully reliant on import. In-order to bridge this gap in indigenous material availability, proposals are invited for the development of LTCC materials, viz. high frequency LTCC ceramic tapes and compatible pastes, for space use. The tapes to be developed shall have consistent properties at least up to Ku-band of frequencies. The compatible conductor and via-fill pastes should have good conductivity and should be fit for use in space environment.

Deliverables:

1) Process recipes for development of LTCC tapes and compatible pastes.
2) Recommended processing conditions for the fabrication of LTCC Multi-chip-modules.
3) Tape and paste samples for evaluation at SAC LTCC foundry.

SAC - 020

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design and Development of Fabry Perot Cavity based Feed Cluster

3. Name of Co PI from ISRO Centre/Unit

Shri Shashank Saxena
Shri Kaushik Kannan

4. Contact Address of Co PI & e-mail id

ASG/SCAD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: shashank@sac.isro.gov.in, kaushik153@sac.isro.gov.in

5. Area of Research

Antenna Systems

6. Summary of the proposed research and expected deliverables

The proposal is sought for design and development of fabryparot cavity based feed cluster. Currently multiple beam antennas for HTS satellites require 4 apertures to generate contiguous beams over the given service area. It is required to find out a technical solution to reduce number of reflectors required to generate the multiple beams. One of approach is use of fabryperot cavity based feed cluster to illuminate the reflector and generate multiple spot beams. However, there are limitations of this technology namely narrow operating bandwidth and high coupling between adjacent elements and power handling capability. The proposal is invited from researchers to suggest suitable design which overcomes the current limitations. Objectives of the proposal and specifications are given below.

Scope of the Work:

1. RF design and realization of a Fabry Perot Cavity (FPC) based High Gain 7-feed cluster (septet) is required with individual feed performance as specified in below mentioned Table-1.
2. Detailed analysis of impedance matching of individual feed input port in FPC configuration.
3. Development of conceptual understanding of mismatch phenomenon occurring on FPC.
4. Sensitivity analyses of the entire FPC based feed assembly including feed horns, Partially Reflecting Screens and support structure.

With following specification of Individual feed in the cluster

S.No	Parameter	Specification
1	Frequency	2.5-2.7GHz
2	No. of feeds in cluster	7 (Septet); Triangular lattice with 120mm feed center-to-center spacing
3	Feed Radiation Pattern	Edge-Taper of -15dB to -17dB @ ±33°
4	Return Loss	<-17dB
5	Phase Center variation	< λ/5 over the freq band at specified Edge-Taper
6	Polarization	RHCP

7	Feed Insertion-loss	<0.4dB
8	Axial Ratio	<2dB within ±33°
9	Feed Port-to-Port Isolation	>35dB
10	Power handling	250W CW
11	Preferred Feed Configuration	Waveguide Horn fed FPC with Partially reflecting Screen(s) (PRS)

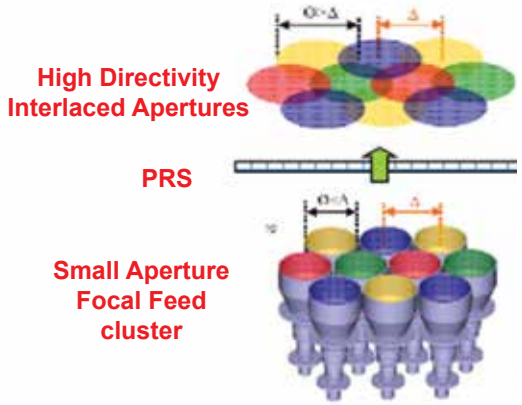


Figure-1: Schematic of an FPC

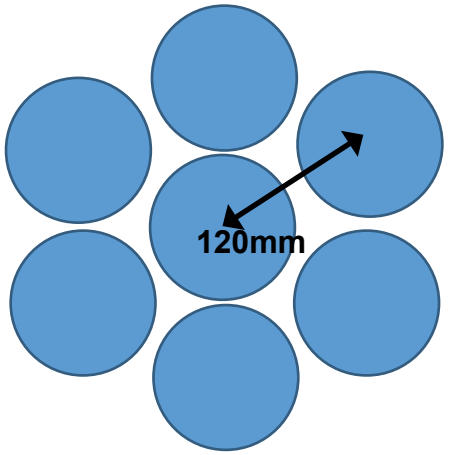


Figure-2: Seven-Feed cluster Configuration

Deliverables:

1. Antenna design files and its simulated results.
2. Realized hardware for both band with verification reports with Realized hardware for both band with verification reports with measured parameters and Simulated results.

SAC - 021

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Appraisal of lake water dynamics and security through high resolution satellite imageries

3. Name of Co PI from ISRO Centre/Unit

Dr. Shard Chander

4. Contact Address of Co PI & e-mail id

EPSA-GHCAG-LHD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: schander@sac.isro.gov.in

5. Area of Research

Hydrology

6. Summary of the proposed research and expected deliverables

The proposed research directly deals with the crises of water quality/quantity in terms of anthropogenic and natural stress impacts. Earth observation multi temporal datasets of ISRO missions (Resourcesat-2/2A) along with other freely available multispectral dataset (Landsat-8, Sentinel-2A/2B) will be used to comment the present status of water bodies in comparison to previous dates. The study results would indicate the inland water ecosystem health. This is important as majority of the population heavily depends upon them.

The scope of the proposed research are following.

- Quantitative estimation of Suspended Particulate Matter (SPM), Chlorophyll-a and CH_4 emission using earth observation datasets.
- To estimate the volume and water loss from lake using geo-statistical approach using earth observation datasets.
- To classify lake's ecological status using earth observation datasets.

Expected Deliverables:

1. Water quality (Chlorophyll, sediments, eutrophic status) for the study lakes
2. Volume/bathymetry information over the lakes

SAC - 022

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Assimilation of Remote Sensing and Hydrogeological Data for Aquifer Zonation vis-à-vis Determining Structural and Lithological Control over Groundwater Quality and Quantity in Central – Southern Kachchh Mainland, Western India

3. Name of Co PI from ISRO Centre/Unit

Dr. R P Singh

4. Contact Address of Co PI & e-mail id

EPSA-GHCAG-LHD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: rpsingh@sac.isro.gov.in

5. Area of Research

RS Applications

6. Summary of the proposed research and expected deliverables

The present project is aimed at zoning the aquifer of central-southern Kachchh Mainland by analyzing multisensor satellite data using digital interpretation techniques in conjunction with GIS. The present study will focus on utilizing digital image processing and enhancements

techniques on multisensor satellite data followed by field investigations to study geological structures and how groundwater flow behaves towards different geological structures. It shall lead to understand role of geological structures and lithology on groundwater quality and quantity as well ground water targeting.

The scope of the proposed research:

- To identify the potential ground water domains based on geological structures using Remote Sensing and Hydro-geological Data.
- To delineate the impact of geological structures and lithology on groundwater flow and quality using geochemistry and isotope technique.
- To decipher Groundwater Occurrence, Flow Direction and Recharge Zone.

Deliverables:

1. Geospatial database of thematic maps
2. Well inventory data and its geospatial analysis
3. Ground water quality data and its geospatial analysis
4. Geospatial model for aquifer zonation
5. Aquifer zonation maps mentioning quality and quantity of ground water
6. Improved understanding of control of structures and lithology on quality and quantity of ground water in form of scientific publications
7. Ground water targeting and recharge sites

SAC - 023

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Impact of climate change on offshore wind and wave power potential in the India EEZ region

3. Name of Co PI from ISRO Centre/Unit

Dr. Rashmi Sharma,
Dr. Surisetty,
Shri V V Arun Kumar

4. Contact Address of Co PI & e-mail id

EPSA-AOSG-OSD(E)
Space Applications Centre
Jodhpur Tekra, Ahmedabad – 380015.
e-mail: rashmi@sac.isro.gov.in; arunkumar@sac.isro.gov.in

5. Area of Research

RS Applications

6. Summary of the proposed research and expected deliverables

The proposed research proposal is intended to simulate the climate change scenario on wind-wave energy production capacity of India using modelled data. This is first of its kind research work attempt in India. The research work will primarily focus on the impact of climate change on offshore wind and wave power potential in Indian Exclusive Economic Zone (EEZ). Coordinated Regional Climate Downscaling Experiment (CORDEX) RCMs are forced with CMIP5 GCMs and run at a resolution of 50 km (0.44° × 0.44°) over CORDEX South Asia Domain. With the aim of recognizing the most suitable GCM or RCM dataset for the estimation of future resources and the impact of climate change, the historical wind datasets will be validated with reference to the ECMWF reanalysis/satellite data. The wave climate over Indian ocean region would be simulated using a third generation wave model (WAVEWATCH III) forced with wind inputs obtained from CMIP5 and CORDEX. The simulated wave characteristics will compare with ERA Interim reanalysis or satellite altimeter wave data or in-situ observations for the same period. Further, the aim is to develop a relation between climate models (GCMs/RCMs) data with reanalysis/satellite data. The spatial distribution maps of wind and wave properties for present and future Representative Concentration Pathways (RCP) emission scenarios will be developed. Also, the wind turbine and wave energy converter characteristics, technical offshore wind and wave power potential in study area will be estimated. Finally, multi-criteria analysis will be used to identify the most suitable location by considering the technical, economical, environmental and socio-political factors for present and future emission scenarios.

Deliverables:

1. High-resolution spatial distribution maps of offshore wind resource for past, present and future climate scenarios (wind power density, inter annual variability, capacity factor and annual energy production).

2. High-resolution spatial distribution maps of wave resource for past, present and future climate scenarios (wave power potential, inter annual variability, capacity factor, annual energy production).

3. Techno-economic analysis of offshore wind and wave energy potential by considering state of art offshore wind turbines and wave energy converters for past, present and future climate scenarios.

4. Identification of favorable locations by applying multi-criteria decision making model for individual offshore wind and wave energy exploitation under climate change.

SAC - 024

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

The design and analysis of a Silicon Particle Detector Array using High Voltage CMOS process for Space Applications

3. Name of Co PI from ISRO Centre/Unit

Shri Sanjeev Mehta,
Shri Mohammad Waris

4. Contact Address of Co PI & e-mail id

SEDA-SEG-SFED
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: smehta@sac.isro.gov.in, waris.mohammad@sac.isro.gov.in

5. Area of Research

Detector Technology

6. Summary of the proposed research and expected deliverables

The aim of the project is to design and characterize a front end analog circuitry of the silicon particle detector with 3x3 pixel array with the back-end electronics. The proposed device include particle detection upto 50MeV with <5mW power consumption. The detector would be packaged in CoB type package for radiation measurements and in a plastic package for lab measurements. Once developed this is expected to be the first of its kind particle detector being developed in India, while competing with designs being developed outside India. Radiation particle detectors available in the international market are already planned to be used in few ISRO missions.

The scope of the proposed research:

- Detail understanding and design of a particle detector of 3×3 pixels array using CMOS devices.
- Cross-corner PVT, statistical mismatch and post layout simulations.
- Tapeout.
- Characterization of the designed particle detector.
- Mathematical analyses of noise and crosstalk for the proposed detector.

Deliverables:

1. Fabricated detectors
2. Design documents, schematic and layout files.
3. Datasheets
4. Evaluation board

SAC - 025

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Design and development of Focal Plane Processing (FPP) ASIC

3. Name of Co PI from ISRO Centre/Unit

Shri Rajiv Kumaran,
Shri Anuj Srivastava

4. Contact Address of Co PI & e-mail id

SEDA-SEG-SFED
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: rk_0474@sac.isro.gov.in, anuj918@sac.isro.gov.in

5. Area of Research

VLSI

6. Summary of the proposed research and expected deliverables

Next generation astronomical instruments require building of large mosaics from individual detector arrays, which essentially complicates focal plane array (FPA). To simplify and minimize the focal plane system, we must have a Focal Plane Processing (FPA) Application Specific Integrated Circuit (ASIC). This ASIC will manage and control all aspects of multiple sensor arrays. The proposed ASIC will not only minimize the real estate required on the focal plane array but also reduce lot of system complexities in realizing a miniaturized system.

The scope of the proposed research:

- Detailed understanding of the sensor arrays and finalizing proposed architecture for the proposed ASIC.
- Selection of suitable technology considering space usage & identification of design blocks.
- Design, Cross-corner PVT, statistical mismatch and post layout simulations
- Tapeout.
- Characterization of the proposed ASIC.

Deliverables:

1. Functional chip
2. Design documents, schematic and layout files.
3. Datasheets

SAC - 026

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Multi-wavelength LIDAR for Terrain Mapping and Atmospheric Measurement

3. Name of Co PI from ISRO Centre/Unit

Shri. Nitesh Thapa

4. Contact Address of Co PI & e-mail id

SEDA-EOSDIG-SSD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: niteshthapa@sac.isro.gov.in

5. Area of Research

Electro-optical sensors

6. Summary of the proposed research and expected deliverables

Light Detection and Ranging (LIDAR) is an active remote sensing technique, that can be suitably used to obtain Surface Topography data and measure Atmospherics. By examining and analyzing the echo signal of the laser from satellite or airborne platform, one can measure the distance, direction and characteristics of the target.

In last two decades, significant progress has been made in utilizing LIDAR data and has generated interest and scope for many more applications. Apart from generating high resolution Digital Elevation Model, the technique has been contributing to study of Polar Ice, aerosol/ cloud characterization, measurement of tropospheric winds and estimation of greenhouse/ trace gases. Day and night operation capability along with simultaneous measurements of related parameters through other instruments have become essential requirements.

The scope of the proposed research:

The responsibilities will include:

- Generation of requirements of a LIDAR System specific to application (including platform).
- Identification of components and end to end realization of system.
- Demonstration of performance.

SAC - 027

1. Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

2. Title of the research proposal

Noise Reduction and Compression of Hyperspectral Images

3. Name of Co PI from ISRO Centre/Unit

Shri. Ankur Garg

4. Contact Address of Co PI & e-mail id

SIPG-ODPD
Space Applications Centre, Jodhpur Tekra, Ahmedabad.
e-mail: agarg@sac.isro.gov.in

5. Area of Research

Electro-optical sensors

6. Summary of the proposed research and expected deliverables

Recent developments in hyperspectral sensing during the past two decades has made it possible to acquire several hundred spectral bands of observational scene in a single acquisition. The increased spectral resolution of these hyperspectral images allows for detailed examination of land surfaces and different materials present in the observational scene, which was previously not possible with low spectral resolution of multispectral imaging scanners. However, hundreds of bands and large scene size poses problem of handling noise and storing of such huge data. The objective of this project is to reduce the noise or unwanted information in these images and compress it without losing any spectral and spatial information, so that it would be easy for end user to manage compressed images for interpretation and post-processing. There are many modern techniques and algorithms published and being experimented in this direction, for example, Quantized Auto encoders blended with different variations can perform the purpose of noise reduction and compression of hyperspectral images effectively. Program Linkages: ISRO's future EO and Planetary Missions will have Hyperspectral Payloads, the proposed deliverables will be useful in pre-processing as well as post-processing software packages.

Deliverables: A complete software suit for compression and noise reduction of hyperspectral images. Also, it can visualise the impact of noise reduction and compression of image data on further processing of hyperspectral images.

U R RAO SATELLITE CENTRE
BENGALURU

URSC - 001

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

2. Title of the research proposal
High Stiffness Hinge for boom deployments of Unfurlable Antenna

3. Name of Co PI from ISRO Centre/Unit
Shri N S Murali

4. Contact Address of Co PI & e-mail id
Spacecraft Mechanisms Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: nsmurali@ursc.gov.in

5. Area of Research
Spacecraft Mechanisms

6. Summary of the proposed research and expected deliverables
Very large deployable antenna need to be positioned away from spacecraft to meet the optical geometry of antenna and feed system. Long carbon composite booms are used in positioning unfurlable antennas away from satellites. Due to launch envelope constraints, these long booms are split into two or more units and held along one face of satellite during launch by hold downs. Upon reaching orbit, the booms are deployed using a motor in the hinge and the hinge is finally latched, thereby creating a single boom of longer length (~6m). Two of the important parameters which govern the design of hinge mechanism are the latching accuracy and deployed natural frequency. These requirements demand developing a suitable compact hinge meeting the deployed natural frequency for different configuration of the booms which latches with required accuracy. Generally a motor with cam based locking mechanism are used for hinge mechanism. A large cam radius would provide sufficient locking accuracy however this design result in a large hinge mechanism. A compact multiple link mechanism driven by a motor has also been used which provides compact design meeting the deployed stiffness and locking accuracy.

The objectives of the proposed research:

- Developing a suitable hinge which satisfies the above requirements.
- Developing a mathematical model of the hinge and boom in a FE software and carrying out frequency analysis.

- Developing a prototype of the hinge and boom and show by tests that the development meets the requirements specified.
- Develop subroutine for configuring the hinge for different size of boom and different angles between the boom.

URSC - 002

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Development of Robotic Arm for Autonomous Berthing of two Spacecrafts

3. Name of Co PI from ISRO Centre/Unit

Shri Abhinandan Kapoor

4. Contact Address of Co PI & e-mail id

Spacecraft Mechanisms Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: akapoor@ursc.gov.in

5. Area of Research

Spacecraft Mechanisms

6. Summary of the proposed research and expected deliverables

Docking of spacecrafts refers to joining of two space vehicles for replenishment of fuel, propellant, power, food, man transfer or maintenance for space systems. Docking can be temporary or partially permanent. Presently, two types of docking concepts are in practice. In the first type, the relative velocities between the chaser and target spacecraft are used to activate the docking mechanism and it is known as “Impact Docking”. The second type of docking is the low impact docking concept. Berthing of spacecrafts falls in the category of low impact docking. The ‘Berthing’ scheme refers to the use of an intermediate system, typically a robotic arm to capture the target vehicle. Further, the robotic arm performs the manoeuvres required to position the vehicles for the desired interface and subsequently docks the target Spacecraft to chaser Spacecraft by means of motor driven latches provided on the chaser spacecraft. This activity has a potential application in India’s future space station development.

The objective of the proposed research:

- Development of a 6DOF Robotic arm with a finger type gripper capable of performing berthing of two small spacecrafts.
- Demonstration of berthing capability of robotic arm using a Helium balloon based or any novel zero-g system to simulate nearly 6 DOF on ground.
- Closed loop simulation of robotic arm using encoders & feedback from sensors (Vision sensors, tactile sensors e. g. force & torque sensors, vision cameras), Programming, path sensing, simulation studies of robotic arm.

URSC - 003

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Numerical Simulation and Test Correlation of Low Velocity Impact of Flexible Body on Granular Soil

3. Name of Co PI from ISRO Centre/Unit

Shri Gaurav Sharma

4. Contact Address of Co PI & e-mail id

Spacecraft Mechanisms Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: gsrs@ursc.gov.in

5. Area of Research

Spacecraft Mechanisms

6. Summary of the proposed research and expected deliverables

Soft landing of spacecraft on planetary body is a complex task. Generally the landers need to be designed to survive residual horizontal and vertical velocities along with angular orientations after the completion of retro rocket firing. The low velocity impact touch down induce acceleration on the lander structure which needs to be reduced to acceptable levels for payloads. Hence landers are configured with flexible legs and honeycomb absorbers in order to limit the overall acceleration during landing. The pre-crushed honeycombs absorb a part of landing energy by plastic deformation. The honeycomb dampers need to be modelled, analysed and tested for prediction of overall accelerations using flexible-rigid body model of the lander. The granular regolith also absorbers some portion of the energy due to landing. The horizontal velocity component induces bulldozing motion on the soil which results in potential stability problems for the lander. Mathematical models of the honeycomb dampers along with a good test correlated model of the granular soil provide valuable input at the early stages of design and also reduce the system level test efforts.

The objective of the proposed research:

- Numerical modeling and test correlation of honeycomb damper energy absorption with respect to geometry, impact velocity and momentum.
- FEM/DEM Impact modeling of the soil and test correlation.
- Numerical modeling and test correlation of flexible-rigid body dynamics.

URSC - 004

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengluru

2. Title of the research proposal

Mathematical Modeling and Test Correlation of Deployment Dynamics of Large Deformation Deployable Space Mechanisms

3. Name of Co PI from ISRO Centre/Unit

Shri Sidharth Tiwary

4. Contact Address of Co PI & e-mail id

Spacecraft Mechanisms Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: sidharth@ursc.gov.in

5. Area of Research

Spacecraft Mechanisms

6. Summary of the proposed research and expected deliverables

Large space structures are stored compactly and deployed on orbit due to launcher envelope constraints. Traditionally rigid body links and joints are used to stow the structure. However due to the advancement of functional composites, the option of stowing the structure by large deformation and obtaining the required deployed shape is available with the designer. High stored strain energy due to large deformation results in uncontrolled deployment which needs to be evaluated. And also the structure would be tested for deployment several times before being launched and hence need to be designed for fatigue life as well. The stowed structure needs to survive the launch loads before reaching the orbit. The above requirement needs to be met with suitable analysis using Finite Element Methods. The numerical simulation becomes challenging due to large stain energy release which needs to be correlated with testing.

The objective of the proposed research:

- Design and development of mathematical models for Large deformation of composite deployable structures.
- Development of Test methodology for deployment dynamics correlation.
- Test correlation of the dynamic behavior.

URSC - 005

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Development of Flexible heat pipe for space application

3. Name of Co PI from ISRO Centre/Unit

Shri A.R. Anand

4. Contact Address of Co PI & e-mail id

Thermal Systems Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: aranand@ursc.gov.in

5. Area of Research

Spacecraft Thermal Systems

6. Summary of the proposed research and expected deliverables

Similar to heat pipe / loop heat pipes, capillary pressure of the working fluid developed in the wick of flexible heat pipes drives the flow. However, the difference lies in the use of flexible bellow type tubes for vapor / liquid transport. The advantages of flexible heat pipes are flexibility in assembly and alignment unlike conventional heat pipes and loop heat pipes that are limited by the number of bends and better vibration isolation between heat source and heat sink.

Development Requirements:

- Design and development of flexible heat pipe for space application.
- Fabrication of proto-model, testing for space qualification and performance demonstration.

URSC - 006

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

High conductive heat spreader plate

3. Name of Co PI from ISRO Centre/Unit

Dr. Arpana Prasad

4. Contact Address of Co PI & e-mail id

Thermal Systems Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: arpanapd@ursc.gov.in

5. Area of Research

Spacecraft Thermal Systems

6. Summary of the proposed research and expected deliverables

High conductive heat spreaders are very essential in spacecraft thermal management. Computationally identify and experimentally realize isotopically pure Boron Nitride as an ultrahigh thermal conductivity material, with applications to heat spreaders etc.

Development Requirements:

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

URSC - 007

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Development of super thermal insulating material (AEROGEL) based flexible blanket system for the inter-planetary missions with gaseous convective environments

3. Name of Co PI from ISRO Centre/Unit

Shri N. Sridhara

4. Contact Address of Co PI & e-mail id

Thermal Systems Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: sridhara@ursc.gov.in

5. Area of Research

Spacecraft Thermal Systems

6. Summary of the proposed research and expected deliverables

Aerogels are a diverse class of porous, solid materials that exhibit an uncanny array of extreme materials properties. Most notably Aerogels are known for their extreme low density and very low thermal conductivity. These kind of synthetic porous and ultralight Aerogels are derived from a gel, in which the liquid component of the gel has been replaced with a gas. The result is a solid with extremely low density (< 0.1 g/cm3); and thermal conductivity (0.01W/mk) with High Solar Transmission: > 95% and High compressive strength.

The envisaged uses of Aerogel are:

- As a highly efficient thermal barrier (insulator).
- To be used as insulating blanket material (in gaseous environment of Planets Mars, Venus, Jupiter etc. by incorporating / embedding Aerogel material in a flexible fibrous material.
- As a porous micro-structure for stopping/capturing like High Velocity Particles (HVPC).

Development Requirements:

- Technology for impregnation / embedding Aerogel material in a flexible fibrous material (Flexible fibres to withstand higher temp. > 400°C.)

- The flexible composite layer should be optically opaque (200-2500 nm WL) with adequate mechanical integrity.
- Human rated materials may also be explored to be used in human based space program.

URSC - 008

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Electrochromic Device/ materials

3. Name of Co PI from ISRO Centre/Unit

Ms. Anju M. Pillai

4. Contact Address of Co PI & e-mail id

Thermal Systems Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: anjum@ursc.gov.in

5. Area of Research

Spacecraft Thermal Systems

6. Summary of the proposed research and expected deliverables

Electro-chromic device is typically a multi-layered system incorporating two electrochromic (EC) layers separated by an electrolytic layer sandwiched between two conducting electrodes. One of this EC layer function as an ion storage layer in the device. These devices can be fabricated on rigid as well as flexible substrates.

When a small voltage is applied, ions move from the ion storage layer through the electrolyte in to the electro-chromic layer, or vice versa, resulting in a redox reaction. This ion intercalation and ion extraction from the active layers changes the optical properties.

Typical thin film electrochromic Layers used in such devices include:

WO_3 MoO_3, Nb_2O_5, TiO_2 etc. (Cathodic) and NiO, IrO_2, CoO_2, MnO_2etc (Anodic)

- These devices offer the functionality of mechanical louvers but with decreased mass, cost and mechanical complexity.
- Using these coatings, it is possible to actively control emissivity values (0.2 to 0.9) by applying a very low voltage DC power. It is lightweight (1.6 kg/sq.m compared to mechanical louver system (4 to 10 kg/sq.m).
- It is reversible and repeatable.
- This work involves fabrication of device using thin film and wet chemistry processes, characterization and testing.

Development Requirements:

- Technology of such multi-layered materials coatings.
- Technology to develop it as a device for application.
- To develop and establish the required test and characterization facilities.

URSC - 009

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengluru

2. Title of the research proposal

Thermo-Chromic Variable Emittance Coating

3. Name of Co PI from ISRO Centre/Unit

Shri Arjun Dey

4. Contact Address of Co PI & e-mail id

Thermal Systems Group,
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: arjundey@ursc.gov.in

5. Area of Research

Spacecraft Thermal Systems

6. Summary of the proposed research and expected deliverables

Small spacecraft have low thermal capacitance subject them to large temperature swings when either the heat generation rate or the thermal sink temperature changes. This needs modulating the heat rejection rate. Variable emittance thermal control coatings change the effective infra-red emissivity of a thermal control surface to allow the radiative heat transfer rate to be modulated (adaptive or “smart’ thermal control of spacecraft). These are useful thermal control coatings, whenever fluctuating heat loads are experienced. Thermo-chromic materials and Pervoskite materials changes its properties by sensing the heat/temp.

Development Requirements

- Technology to develop the thermo-chromic (vanadium oxide or Pervoskite/ LSM based) coatings on flexible (Polyimide) /rigid (Aluminized quartz and Polished Al alloy) substrates with a targeted smart and reversible transition temperature in between 20 to 40°C.
- Coating must be stable, reversible and repeatable for several cycles.
- Scale up possibilities must be addressed.
- To develop suitable characterisation tools.

URSC - 010

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Development of customized alumina & ferrite based substrates for space electronics applications

3. Name of Co PI from ISRO Centre/Unit

Shri BHM Darukesha
Shri Shaji V. Sebastian

4. Contact Address of CoPI and e-mail id

Head, Thin Films Division, HIG/CMMA
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: daru@ursc.gov.in, sebas@isac.gov.in

5. Area of Research

Development of Microwave modules for Space applications, as import substitutions.

Microwave engineering relies on the properties of dielectric substrate used as transmission medium. The selection of substrates has been based on parameters such as loss tangent, dielectric constant, isotropy, thermal conductivity and ease of handling. While alumina has been the industry standard substrate, advances in materials science and engineering have brought many alternate substrates including zirconia, AlN, etc. There is a huge scope to exploit such developments to improvise the performance of microwave modules.

6. Summary of the proposed research and expected deliverables

- It is proposed to develop dielectric substrates with a desired dielectric constant, permeability, size and thickness suitable for the fabrication of microwave modules including microwave integrated circuits (MICs), microwave windows and non-reciprocal devices.
- Ferrite materials have applications in integrated inductors, transformers, filters and non-reciprocal devices at RF and microwave frequencies. These magnetic materials will be formed into sheets by tape casting process and sintered at asuitable temperature.
- The most common used ferrite material for electronics application is zinc ferrite. The titanium doped manganese zinc ferrite is a promising composition for isolators. The present work is focused on fabrication of $Ti_xMn_yZn_{(1-y)}Fe_{2-x}O_4$ composition suitable for isolators.
- Alumina (99.6%) substrates will be developed in different sizes (1" x1" & 2" x2") and thickness (10, 15 & 50 mil). These substrates will be polished for MIC application.
- The process parameters will be tailored to achieve space grade alumina substrates based on the test results.

Objectives of the project:

- To develop ceramic substrates with desired dielectric constant, permeability, size and thickness suitable for microwave modules including windows and non-reciprocal devices.
- To choose the best compositions of ferrites based on the published literature and prepare the materials in-house.
- To fine-tune and optimize these materials and tape-casting and sintering processes with high quality and quick turn-around time.

URSC - 011

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Understanding Photoexcitonic Mechanism of Hybrid Ferroelectric Discotic Liquid Crystal (HFLC) Solar Cell

3. Name of Co PI from ISRO Centre/Unit

Ms. Krishnapriya
Ms. USHA G
Dr. Dineshkumar

4. Contact Address of CoPI and e-mail id

SPD
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: daru@ursc.gov.in, sebas@isac.gov.in

5. Area of Research

Hybrid solar cells

6. Summary of the proposed research and expected deliverables

The recent invention by Prof Ananda Rama Krishna Selvaraj is a Hybrid ferroelectric discotic liquid crystal solar cell. In his invention he has introduced a DLC- discotic liquid crystal - materials that have the properties of both crystals and liquids (tri phenylene core with two additives) in place of Iodine REDOX electrolyte in DSSC solar cell.

The self-organization of disc-like or plate-like molecules leads to the formation of DLCs. A majority of DLCs are composed of polycyclic aromatic cores, such as triphenylene (TP), anthraquinone, phthalocyanine (Pc). In this columnar arrangement of aromatic cores, each column acts as a molecular wire where the electrons or holes migrate efficiently along the columns in quasi one dimension. Owing to this unidirectional arrangement, the electrical conductivity along the columns have been observed to be many orders of magnitude greater than that in perpendicular direction. Long exciton diffusion length and high charge-carrier mobility are the key factors to realize efficient solar cells. This liquid crystal shows Ferro electric behavior and contributes to the increase in efficiency of HFLC solar cell.

For a 0.2 cm^2 solar cell, PCE is 24.4%, J_{sc} 21.5 mA/cm^2 and Voc is 2.14 V. The spectral response is observed from 300 nm to 1100 nm.

URSC - 012

1. Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

2. Title of the research proposal

Use of Artificial Intelligence (AI)/Expert Systems (ES)/Machine Learning (ML) in Mission Operations

3. Name of Co PI from ISRO Centre/Unit

Mrs. Nandhini Harinath

4. Contact Address of CoPI and e-mail id

MDG
U R Rao Satellite Centre, Vimanapura Post, Bengaluru.
e-mail: nandini@ursc.gov.in

5. Area of Research

Machine Learning, Expert Systems, Artificial Intelligence, Neural Networks, Fuzzy Logics, Natural Language Processing, Genetic Algorithms, Robotics.

6. Summary of the proposed research and expected deliverables

1. **Introduction:**
   With increase in launch frequency, a large number of spacecraft with varying configurations, orbital slots, payloads, applications have to be maintained in peak operating conditions with very low or nil downtime for the duration of their useful mission lifetimes (ranging from months to decades). This trend demands a high degree of automation of on-board and ground operations, and this is where use of techniques from artificial intelligence for spacecraft health monitoring and anomaly handling is really beneficial. The applications of AI include expert systems, Neural Networks (NN), Fuzzy Logics (FL), Natural Language Processing (NLP), Genetic Algorithms, robotics and machine learning. Spacecraft operations broadly classify into two categories namely Health Monitoring & Anomaly Management and Planning and Execution of routine planned activities.

2. **Mission Operations automation at MDG/URSC**
   Virtual Satellite operation is planned to optimize the utilization of the ground segment resources, viz. infrastructure and human. Towards this, an expert system based Health Monitoring and Anomaly Management is being developed. The automation of Planning and Execution of routine operations is also in progress.

URSC - 013

1. Name of ISRO Centre/Unit

U R RAO Satellite Centre, Bengaluru

2. Title of the research proposal

Simulation for performance of Nanomaterials for EUV/X-ray polarimetry

3. Name of Co PI from ISRO Centre/Unit

Shri K. Sankarasubramanian
Shri Ankur Kushwaha
Shri Anand Jain

4. Contact Address of CoPI and Phone Number

Space Astronomy Group,
U R Rao Satellite Centre
Vimanapura Post, Bengaluru.
e-mail: sankark@ursc.gov.in

5. Area of Research

Space sciences

6. Summary of the proposed research and expected deliverables

Polarization measurements of astronomical sources (even for the Sun which is the closest object) in Extreme Ultra-violet and X-rays are not yet carried out systematically. One of the major reasons is due to the non-availability of suitable polarization components in EUV and X-rays. EUV uses thin film coated mirrors for narrow band polarimetry. In X-rays special detection techniques are developed for measuring the polarization (e.g., Gas-Electron Magnification based detector or high-Z scatterer based polarimeter). Both these techniques are currently being developed and space missions are being planned for the same.

Carbon Nano Tubes (CNTs) are nanotubes with high electrical conductivity. It has been theoretically shown that aligning these nanotubes in specific directions and spacing can make them an efficient polarizer like wire grid polarizers used in Infra-red polarimetry. A detailed study of the characteristics of these aligned nanotubes through simulation is required to understand its polarizability for different energy bands (wavelengths) along with its efficiency. The simulation will also provide an opportunity to optimize the distance between the CNTs for maximum efficiency in any particular band of wavelength (or energy). The studies to be carried out to optimize the required aligned of CNTs for laboratory as well as space usage including the response to the temperature and radiation environment.

URSC - 014

1. Name of ISRO Centre/Unit

U R RAO Satellite Centre, Bengaluru

2. Title of the research proposal

Multi-wavelength investigation of WIMP Dark Matter in dSph galaxies

3. Name of Co PI from ISRO Centre/Unit

Dr. M.C. Ramadevi

4. Contact Address of CoPI and Phone Number

Space Astronomy Group,
U R Rao Satellite Centre
Vimanapura Post, Bengaluru.
e-mail: ramadevi@ursc.gov.in

5. Area of Research

Space sciences

6. Summary of the proposed research and expected deliverables

Dark matter is a form of matter predicted theoretically and required to explain many of the phenomena seen in the universe. Current understanding is that about 85% of the universe consists of dark matter. They are named as Weakly Interacting Massive Particle (WIMP) and study of this is one of the high end research area in cosmology. The Dwarf Spheroidal Galaxies (dSph) are low luminosity and low surface brightness systems along with low metallicity. They constitute old stellar population with negligible gas/dust. However, their kinematic studies from observations implicitly reveal the presence of dark matter.

In dark matter models developed so far, these WIMP annihilate to standard model particles during which radiation is emitted in multi-wavelength (through inverse Compton, Bremsstrahlung, Synchrotron). By observing these galaxies in multi-wavelength, the models of dark matter can be constrained. Data from both ground and space based observatories will be utilized along with new observations from GMRT and AstroSat.

The aims of this proposal are: (I) Constraining WIMP dark matter particle parameters from combined radio, X-ray and γ-ray data (II) understanding the properties of the ionized gas of the dwarf spheroidal galaxies.

Study of dark matter and cosmology is a new domain for SAG/URSC. Deliverables are expertise in dark matter research, experience in collaborative work with radio data analysis, research publications on this work, possible instrument proposals for future science missions for dark matter research etc. Also, demonstration of this study with AstroSat will increase its utilization for cosmology studies.

NATIONAL REMOTE SENSING CENTRE
HYDERABAD

NRSC - 001

1. Name of ISRO Centre/Unit
National Remote Sensing Centre, Hyderabad

2. Title of the research proposal
Design, Modeling & analysis of tilt mechanism for 7.5M Diameter antenna

3. Name of Co PI from ISRO Centre/Unit
Shri K Koteswararao

4. Contact Address of Co PI & e-mail id
GH (S&ASG), SDR&ISA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: koteswararao_k@nrsc.gov.in

5. Area of Research
Tilt Mechanism, Satellite tracking, Design modelling

6. Summary of the proposed research and expected deliverables
NRSC is a key player to establish Remote sensing Satellite ground stations for Earth Observation Program and Disaster Management Support Program. Ground Antenna system is capable to receive data from S, X band frequencies. A suitable tilt mechanism shall be designed and analyzed for the existing 7.5 m Antenna system in all aspects for operational requirements. Critical parameters like Force estimates, civil structure analysis, height of the antenna pedestal from the ground level, servo design need to be considered while designing the tilt mechanism. Interfacing tilt axis with gear box, encoder and limit switch assembly including stowing of the antenna shall be addressed.

Deliverables:

- Technical Evaluation Procedure, Results and Inferences of Antenna System
- Design and Analysis details of Train Axis System
- Solid Model drawings of the Antenna Structure
- Tilt axis fabrication drawings

NRSC-002

1. Name of ISRO Centre/Unit

National Remote Sensing Centre,Hyderabad

2. Title of the research proposal

Development of deep learning framework for inventory of horticultural plantations using High Resolution Satellite Images

3. Name of Co PI from ISRO Centre/Unit

Shri Hebbar Ramachandra R

4. Contact Address of Co PI & e-mail id

RRSC-South, Bengaluru,
National Remote Sensing Centre
e-mail: hebbar_kr@nrsc.gov.in

5. Area of Research

Satellite Image Processing, Pattern Recognition, Machine Learning, Deep Learning

6. Summary of the proposed research and expected deliverables

The horticultural crops are diverse, small holding, scattered and large variations are observed in terms of plant spacing and management practices and hence, the spectral signature of these crops are complex with varying tone and texture. The traditional per pixel classifier may not be applicable to address the large variability. The object-based classification using machine learning technology showed promising results but, the post classification updation using visual interpretation is very time consuming. Several studies have shown the potential use of artificial Intelligence like deep learning for pattern recognition and object detection using remote sensing images with improved accuracy.

It is essentially required to design and develop high performance computing model that uses deep learning techniques for inventory of horticulture plantations using high resolution satellite images using parallel computing architecture and data analytics framework with major focus on horticulture plantation crops like mango, coconut, areca and cashew.

Deliverables:

- State of art computing architecture/Optimal computing system for processing of large volume RS datasets for inventory of horticulture crops.
- Generation of crop map for the selected horticulture crops in the study areas and area estimation.
- Pre-trained Deep Learning Model for classification of highresolution data for operational use.
- Customised User Interface Module: module for training, classification, validation, display and visualization.

NRSC - 003

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Advanced image processing techniques

3. Name of Co PI from ISRO Centre/Unit

Shri RVG Anjaneyulu

4. Contact Address of Co PI & e-mail id

Head, SPD, Data Processing Area
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: anjaneyulu_rvg@nrsc.gov.in

5. Area of Research

Image Processing, AI &Machine Learning Algorithms

6. Summary of the proposed research and expected deliverables

Development of the cutting-edge multi-resolution, multi-temporal / multispectral and hyperspectral data harmonization techniques, advanced image processing algorithms for restoration and de-noising.

Development of algorithms for DSM/DEM/DTM extraction from high resolution satellite stereo imagery and their validation. Development of new open-source based advanced solutions for multi high resolution imagery automated geometric processing using bundle adjustment.

Advanced research themes include Deep Neural Networks for Remote Sensing Applications, image synthesis and time series modeling.

Deliverables:

- Design document
- Evaluation details
- Algorithms and software tools

NRSC - 004

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Local Scale impact evaluation of development initiatives using high resolution data in rural ecological context employing machine learning approaches

3. Name of Co PI from ISRO Centre/Unit

Dr. Girish S Pujar

4. Contact Address of Co PI & e-mail id

Rural Development and Watershed Monitoring Division, Land Resources Group,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: pujar@nrsc.gov.in

5. Area of Research

Remote Sensing Application for rural development

6. Summary of the proposed research and expected deliverables

Wide array of ridge to valley treatments are being taken up under different rural development initiatives such as IWMP, MGNREGA, RKVY and PDMC to conserve water, bring in more greening in terms of additional crop or afforestation or horticultural plantation cropping. Remote Sensing datasets when used for multi-temporal sequence involving high resolution multispectral images /moderately high resolution images has high potential to detect the impacts generated. Impacts such as increase water surface, establishment of plantations, occurrence of additional agriculture at fine scale needs study. Satellite images acquired as suitable time sequences can discern such impacts especially as a phenological sequence. Machine learning approaches as well as object based approaches can be experimented with, to bring out the fine scale impact at site level. Exploiting the strong field inventory of locations available under these projects, it would be plausible to explore the impact assessment standardization through a algorithmic approaches focusing of multi-scale observations. Compliance of such interventions in contribution to SDG's can also be combined to add value to the monitoring approach available so that remote sensing oriented comprehensive evaluation can be designed and applied for improved monitoring.

NRSC-005

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Automated Change Detection in treated micro-watersheds

3. Name of Co PI from ISRO Centre/Unit

Dr. T Ravisankar,
Dr. Girish Pujar

4. Contact Address of Co PI & e-mail id

Group Director
Land Resources, Land Use Mapping and Monitoring Group (LRUMG), RSAA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: pujar@nrsc.gov.in

5. Area of Research

Land Use/ Land Cover data, Micro-Watershed, Change detection

6. Summary of the proposed research and expected deliverables

Remote sensing data is continuously being used to monitor across India. The change in the land use pattern adversely affects the hydrological processes in Catchment area. Automatic change detection tools for studying the dynamics of land use/land cover in the watershed are prime focus for this research.

Algorithm for Automatic change detection of LULC classes in the watersheds to assess the impact of the interventions is envisaged in this research topic.

Deliverables:

- Design document
- Evaluation criteria and results
- Transfer of algorithm / Software developed for change detection.

NRSC-006

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Web GIS and Data Dissemination for geoportal applications and services

3. Name of Co PI from ISRO Centre/Unit

Shri AVV Prasad,
Shri Arul Raj

4. Contact Address of Co PI & e-mail id

Bhuvan Geoportal & Data Dissemination Area,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: prasad_avv@nrsc.gov.in, arul_m@nrsc.gov.in

5. Area of Research

Geospatial Web Applications and analytics

6. Summary of the proposed research and expected deliverables

GIS today encompasses many critical aspects of geospatial data dissemination, including metadata information, geospatial web services, information retrieval, automated discovery, geotagging, geospatial data sharing and interoperability.

Data dissemination was always a significant activity in all types of ISRO Operational Programmes and its legislative framework has to be continuously updated with new regulations and decisions.

The objectives of the research shall focus on the development of Web-GIS tools to support decision making and also provide various data and information to the scientific community interested in natural resource applications.

Some of the applications to be addressed are Augmented Reality, Real-time geospatial intelligence, Indoor Mapping with Wifi/Bluetooth, Passive GIS sync with Social media. Sensor Web with Uniform Resource identifier, Opensource data centre computing. Geointelligence of crowd sourced information, Trend Analysis on Time series thematic data.

NRSC - 007

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Cloud Computing in satellite data processing environment

3. Name of Co PI from ISRO Centre/Unit

Ms. Manju Sharma

4. Contact Address of Co PI & e-mail id

Data Processing Area,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: manjusarma_s@nrsc.gov.in

5. Area of Research

Satellite Image Processing and Cloud computing

6. Summary of the proposed research and expected deliverables

NRSC is having huge data archive amounting to petabytes acquired over the years right from 1988. Moreover, with upcoming satellite like GISAT that will be downlinking data 24*7 of the tune of 5-6 TB per day, data and metadata storage, cataloguing and search becomes a daunting challenge. As the volume of satellite EO data continues to grow, new analytical possibilities arise requiring new approaches for data management and processing. The traditional approach to acquire and process satellite EO datasets shall be updated to address these new challenges of data analysis.

Processing Online on Cloud computing infrastructure for quick archival and retrieval of remote sensing data utilizing lossless data compression techniques, Further, generation of super resolution images with multi temporal low resolution and high resolution images shall be focused.

Advanced research applications include Block chain based Cloud Computing Cloud and Computing aware ML algorithms.

NRSC - 008

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Automatic extraction of river networks from satellite images

3. Name of Co PI from ISRO Centre/Unit

Shri E. Siva Shankar

4. Contact Address of Co PI & e-mail id

Head, WRAD
Water Resources Group, RSAA,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: sivasankar_e@nrsc.gov.in

5. Area of Research

River Networks, Automatic extraction Image Processing

6. Summary of the proposed research and expected deliverables

Various approaches have been developed to extract river networks from multispectral images.

The existing methods include water indexing, thresholding techniques, perceptron and multilayer perceptron model. The problems with the above approaches are misclassification of mountain shadows, urban areas or other background noise as water bodies. These water pixels are very sensitive to threshold changes and cannot be separated from land easily.

To overcome these difficulties, a new research study is required with the following objectives:

- Development of a technique with automatic feature extraction for mapping of rivers / drainage network from high resolution multispectral satellite image.
- Evaluation of different classification techniques by a comparative study with the performance measures.
- Development of suitable tools to estimate the width of the river at regular intervals along the longitudinal traverse.
- Developing a suitable software application integrating all process for mapping river network in various types of satellite images.

NRSC - 009

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Large Scale Urban GIS Maps updation using High Resolution Satellite Data with Deep Learning Techniques

3. Name of Co PI from ISRO Centre/Unit

Dr. K. Venu Gopala Rao

4. Contact Address of Co PI & e-mail id

Scientist 'G', Group Director, Urban Studies &Geoinformatics,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: venu_koppaka@nrsc.gov.in

5. Area of Research

Urban Studies &Geoinformatics

6. Summary of the proposed research and expected deliverables

The proper management of urban areas calls for accurate and vital information to be available on a regular basis. With the advances in remote sensing and geographic information system, the plan making process can be expedited with integration of both spatial and attribute data, which enables detailed assessment of spatial growth of towns/cities, landuse status, physical infrastructure facilities, etc. in anticipation of the projected population growth.

Very large scale GIS maps or Geodatabase from Very High Resolution (VHR) satellite data are important for urban applications such as city Master Plan Formulation, infrastructure planning and monitoring. Under the national projects like Atal Mission for Rejuvenation and Urban Transformation (AMRUT), very large scale map (1:4000 scale) have been generated from VHR satellite data for GIS based Master Plan Formulation. Generation of large scale maps for very high resolution satellite data / Aerial/ Drone images is very cumbersome and it is generated by skilled Remote sensing GIS expert or a draftsman. It is estimated about 16 hour's time for one Sq km area for generation of such maps. Urban areas are very dynamic and such maps/ database need to be updated periodically for effective use in planning/governance in urban areas.

The traditional manual intensive procedures need an automated approach for generating an accurate and updated Base Map of the planning area, showing roads and building layouts, spatial extent of development and information on the use of each parcel of land etc.

Deliverables:

- Methodology Framework
- Software program

- Project execution document and documents such as design and user docs, papers implemented.

NRSC - 010

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Assessment of fluoride contamination in ground water using satellite and Geospatial data using machine learning techniques

3. Name of Co PI from ISRO Centre/Unit

Dr. V.M Chowdary

4. Contact Address of Co PI & e-mail id

Dy. General Manager
RRSC (North), New Dellhi.
e-mail: chowdary_vm@nrsc.gov.in

5. Area of Research

Satellite data, Ground water, Fluoride contamination

6. Summary of the proposed research and expected deliverables

High concentrations of naturally occurring fluoride have been detected in groundwater in different parts of India for the past eight decades. The chronic consumption of fluoride in high concentrations is recognized to cause dental and skeletal fluorosis. This research shall focus on the spatially continuous predictor variables of predominantly geology, climate and soil parameters using satellite data and geospatial data. The broad objectives of the research are:

- Determining the fluoride concentration in ground water used for drinking and irrigation purposes.
- Study the spatial and temporal distribution of fluoride in ground water using satellite data, Geospatial inputs and machine learning techniques.
- Analysis of the relationship between fluorosis prevalence in water used for drinking and irrigation purposes and spatio-temporal distribution of fluoride in groundwater.
- Mitigation measures to address the fluoride concentration and possible solutions to the societal needs.

Deliverables:

- Methodology Framework
- Evaluation and analysis reports

- Spatial distribution of fluoride in the study area
- Software program
- Project execution document and documents such as design and user docs, papers implemented.

NRSC - 011

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Assessment of Blue, Green and Grey Water Footprint at River Basin Level Using Remote Sensing datasets

3. Name of Co PI from ISRO Centre/Unit

Dr. V M Chowdary

4. Contact Address of Co PI & e-mail id

Dy. General Manager
RRSC (North), New Dellhi.
e-mail: chowdary_vm@nrsc.gov.in

5. Area of Research

Water Resources Management Using Space Technology

6. Summary of the proposed research and expected deliverables

This research study shall address Water footprint assessment using geospatial technologies: Quantification of green, blue and grey water footprints and evaluation of efficiency, equitability and sustainability of water use for agricultural application.

Development of methodologies for assessment of crop water requirements using remote sensing techniques.

Optimization of strategic actions to be prioritized in order to make a footprint sustainable.

Outcome: Green, blue and grey water footprint within the river basin needs to be assessed and compared to national water footprint as well as to those river basin in world whose water footprint have been evaluated. Assessed water footprint of the basin needs to help for policy making in integrated water resource planning and management in the country.

NRSC-012

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Drought Monitoring and Forecasting at fine spatio-temporal resolution using multi-sensor, multi-temporal Earth Observation time series

3. Name of Co PI from ISRO Centre/Unit

Dr. V.M. Chowdary

4. Contact Address of Co PI & e-mail id

Dy. General Manager
RRSC (North), New Dellhi.
e-mail: chowdary_vm@nrsc.gov.in

5. Area of Research

Spatial downscaling of rainfall and soil moisture, Artificial Intelligence and machine learning, time series analysis, Copula based hydrological modelling.

6. Summary of the proposed research and expected deliverables

Monitoring and providing timely seasonal forecasts at fine spatio-temporal scale are essential for integrated drought risk reduction. The utility of space-borne Earth Observation time series data has been proved to be quite successful in drought assessment. One big challenge in using satellite-based products for drought studies is coarse resolution of rainfall and soil moisture dataset required for meteorological and agricultural drought assessment. The study will be expected to provide fine resolution rainfall and soil moisture by comparing deep learning and ensemble machine learning approaches. Another challenge in drought assessment is integration of meteorological, hydrological and agricultural drought and modeling the non-linear relationship that exists among the indicators. The study is also expected to provide multivariate index of drought by incorporating the non-linear relationship among different indicators and a framework for real-time forecasting at fine scale of the integrated multivariate drought indicator.

NRSC-013

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Study of coastal aquifer system and seawater intrusion dynamics using High Resolution satellite image and ground surveys

3. Name of Co PI from ISRO Centre/Unit

Dr. I C Das

4. Contact Address of Co PI & e-mail id

HGS, Geosciences Group
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: das_ic@nrsc.gov.in

5. Area of Research

Ground water and Sea Water Intrusion

6. Summary of the proposed research and expected deliverables

India has a very long coast line of 7516 km length. Around 10% of India's population lives in the area closer to the coast line. In this area, the freshwater aquifers are highly vulnerable to seawater intrusion and anthropogenic activities like aqua culture, salt pans etc. Fresh groundwater present in the shallow aquifers in these areas is the only source of drinking, domestic and irrigation uses. Effect of seawater intrusion in coastal aquifers is a major challenge for sustainability of these fresh water sources. Detailed characterization of the unconfined coastal aquifers is essential for prevention of sea water intrusion and remediation.

High resolution satellite images are useful to delineate the features of geomorphic importance in coastal areas. Ground Penetrating Radar (GPR) is the non-invasive geophysical technique that provides the high resolution profile of subsurface than any other geophysical techniques. GPR with different frequencies have the capability to detect water table as well as various layers present in the subsurface. Based on the penetration capacity it can also detect the saltwater/ freshwater interface zones. 3D model can be generated using GPR data to understand the manifestations of subsurface layers as well as the dynamics of seawater intrusion in the coastal areas.

NRSC has successfully carried out GPR based shallow aquifer mapping in coastal Andhra Pradesh as a part of National Rural Drinking Water Program (NRDWP) of Ministry of Drinking Water and Sanitation (MoDWS), Govt. of India. The research shall also address, development of explicit maps of sea water intrusion using information retrieval using multi-temporal high resolution remote sensing data along with ancillary data like geophysical, chemical, pumping tests with an objective to quantify seawater intruded and development of software tools for simulation of seawater under different climate scenarios.

NRSC - 014

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Development of an automatic technique for change detection using multi-temporal and multi-resolution satellite data in hilly terrain

3. Name of Co PI from ISRO Centre/Unit

Dr. P. Manjusree

4. Contact Address of Co PI & e-mail id

Head, Special user Flood and Landslide Monitoring Division (SFLMD)
DMSG, National Remote Sensing Centre (NRSC),
Balanagar, Hyderabad.
e-mail: manjusree_p@nrsc.gov.in

5. Area of Research

Disaster Management

6. Summary of the proposed research and expected deliverables

Timely and accurate change detection of Earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making. Most common techniques used are Image Differencing, Image Ratioing, Change Vector Analysis (CVA), principal component analysis, multi-level segmentation etc and in the recent years, spectral mixture analysis, artificial neural networks and other new techniques are developed.

This research should automatically detect the changes with respect to urban, biomass content, landform changes, water quality, regeneration/ deforestation, etc and cater to the complex environment like hilly terrain and cloudy/partial cloud free multi-resolution and multi-spectral satellite images.

NRSC - 015

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Development of techniques for correction of artefacts in Remote Sensing Images

3. Name of Co PI from ISRO Centre/Unit

Shri E Venkateswarlu

4. Contact Address of Co PI & e-mail id

MHRO-DPD / ODPG, Data Processing Area,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: venkateswarlu_e@nrsc.gov.in

5. Area of Research

Satellite data processing

6. Summary of the proposed research and expected deliverables

Remote sensing satellite images are interpreted at pixel level using various analysis methods. One key requirement for almost all the applications is the accuracy of the images. Any kind of noise and perturbation in pixel value or geometric position will cause misinterpretation of the data.

Each generation of IRS sensors shows improved data acquisition and image quality over previous generation. However, some anomalies are inherent to certain sensors and corrected in the data processing chain by applying mathematical formulas derived from distortions. These types of anomalies need special correction methods taking into consideration of scene level information.

The scope of the work is to identify and correct the artifacts / anomalies produced during imaging and processing stages in automatic mode in production chain. This utility with GUI can also be provided to users as part of open data policy. Data required for the above work can be ordered through NRSC.

NRSC - 016

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Storm surge inundation modeling in Coastal Region of India

3. Name of Co PI from ISRO Centre/Unit

Dr. K H V Durga Rao

4. Contact Address of Co PI & e-mail id

Group Head, Disaster Management Support Group (DMSG),
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: durgarao_khv@nrsc.gov.in

5. Area of Research

Disaster Management, Flood Inundation

6. Summary of the proposed research and expected deliverables

Coastal flooding or inundation due to storm surges is one of the potential hazardous elements that can have significant impact on any coastal zone. Therefore, there is a need to develop “integrated” flood management plans and strategies to minimise flood hazard and build flood resilience for coastal region. Keeping in view the above points, the study aims to develop and validate coastal storm surge inundation model to assess the risk associated with the tropical cyclones for vulnerable coast of India.

Objectives:

- Hydrodynamic modeling to understand the performance of inundation due to storm surge for the extreme events.
- Generation of flood inundation simulation for different scenarios.
- Storm surge flood risk assessment.

NRSC - 017

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Ecosystem Dynamics Studies to characterise long-term changes in key ecosystems using Earth Observation

3. Name of Co PI from ISRO Centre/Unit

Dr. Santonu Goswami

4. Contact Address of Co PI & e-mail id

BOD, ECSA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: goswami_s@nrsc.gov.in

5. Area of Research

Ecosystem Dynamics, Ecosystem Assessment, Sustainability, Remote Sensing

6. Summary of the proposed research and expected deliverables

Various ecosystems provide a range of Ecosystem Services (ES) for the benefits of society. Due to climate and anthropogenic changes, some of these ecosystems are experiencing drastic changes in Ecosystem Structures and Functions which in turn is impacting the ecosystem services. Earth observation data can take a key role to understand how an ecosystem has changed over time which can be driven by a range of climatic and anthropogenic forces. Studies need to be carried out to characterize changes in various key ecosystems in India in terms of land-use, vegetation, water quality etc using an integrated method of field studies, remote sensing and modelling to understand the state of key ecosystems in India. Key ecosystems such as coastal, riverine and Himalayan ecosystems are of special interest.

Deliverables:

1. Ecosystem assessment using field and remote sensing data
2. Long-term change detection maps
3. Biogeophysical parameters of key ecosystems
4. High resolution LULC

NRSC-018

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Permafrost degradation studies using earth observation data from ISRO missions

3. Name of Co PI from ISRO Centre/Unit

Dr. Santonu Goswami

4. Contact Address of Co PI & e-mail id

BOD, ECSA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: goswami_s@nrsc.gov.in

5. Area of Research

Permafrost Glacier Interactions, Algorithm Development

6. Summary of the proposed research and expected deliverables

Permafrost is a landform available in the high latitude regions as well as in the high altitude regions such as the Himalayas. These landforms were formed thousands and millions of years due to seasonal freezing and thawing mechanism and contain a huge amount of frozen organic carbon. Due to climate warming, these landforms are seeing active degradation and hence becoming sources of GHGs to the atmosphere and also posing a threat to the infrastructures due to their thermokarst activities. NRSC has been working on permafrost research in Arctic since 2018 and established a permafrost study site (the first permafrost study site by any Indian research in the Arctic). The NRSC team also plans to initiate permafrost research in the Himalayas in the near future. Proposals to understand the terrestrial impacts of permafrost degradation, glacier-permafrost interactions through fieldwork and ISRO earth observation data are sought.

Deliverables:

1. Field studies to understand permafrost degradation on terrestrial ecosystems.
2. Algorithm development to map permafrost degradation using earth observation data from ISRO missions.

NRSC - 019

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Carbon Cycle Modeling and Simulation (CCMS) for Indian Region using satellite based inputs

3. Name of Co PI from ISRO Centre/Unit

Shri R. K. Nayak

4. Contact Address of Co PI & e-mail id

POD/CSG/ECSA,
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: rabindrakumar_nayak@nrsc.gov.in

5. Area of Research

Physical Oceanography

6. Summary of the proposed research and expected deliverables

1. Development of methods for analysis of satellite and in situ data observations for carbon cycle model.
2. Optimization of the CASA terrestrial Ecosystem Model for Parameters through invers-modelling.
3. Implementation of GEOS-Chem Adjoint for assimilation of satellite, air-borne, and in situ observations of atmospheric CO_2.
4. Implementation of ROMS-Biogeochemical Cycle for the Indian EEZ & Tropical Indian Ocean.
5. Implementation of data assimilation in the ROMS for better prediction of circulation and biogeochemical elements.
6. Inverse modeling of air-sea fluxes for the regional oceans in the Indian Exclusive Economic Zone (EEZ) through ROMS- Ocean Biogeochemical Flux Module.

NRSC - 020

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Geospatial data security and Image streaming over web with dynamic data classification and efficient load balancing techniques

3. Name of Co PI from ISRO Centre/Unit

Shri Arul Raj,
Shri Subrat Kumar Acharya

4. Contact Address of Co PI & e-mail id

BG&WSG, BGDDA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: arulraj_m@nrsc.gov.in, subrat_acharya@nrsc.gov.in

5. Area of Research

Web Geospatial Application & Data Services Geospatial data security, Image streaming

6. Summary of the proposed research and expected deliverables

- To develop a model/system which can process the bulk satellite data over web domain for web streaming applications efficiently. Processing of large number of time series data from various data sources with dynamic data classification methods and machine learning based load balancing algorithms. This will enable a platform for data analytics over web services, which will in turn enhanced planning/decision making applications for users more efficiently.
- To develop a protocol to secure Spatial and Non Spatial data (vector, raster, attribute data) on its dissemination to users in the web environment.
- Expected deliverables includes the algorithm to store the data and disseminate over the network with proper encryption, in-built security protocol.

NRSC-021

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Nutrient modeling of soil for assessing the soil health and sustenance of soil fertility

3. Name of Co PI from ISRO Centre/Unit

Dr. S. Rama Subramoniam

4. Contact Address of Co PI & e-mail id

RRSC-S, NRSC,
ISITE Campus, Bengaluru, Karnataka
e-mail: ramasubramoniam_s@nrsc.gov.in

5. Area of Research

Agriculture and Soils

6. Summary of the proposed research and expected deliverables

Decline in soil fertility does not get the same public attention as that of floods, droughts, pest infestation *etc.*, since it is a gradual process and not associated with catastrophes and mass starvation and therefore largely invisible. This necessitates a regular monitoring of changes in soil fertility that occurs in the soil. For understanding the role of different process a budgetary approach offers good tool through analyzing the turnover of nutrients in the soil-plant system at different spatial scales. Nutrient balances can provide an early indication of potential problems arising from a nutrient surplus or a deficit, increasing the risk of toxicities or deficiencies, respectively, both of which reduce crop yields. This project is being proposed to give solutions

by identifying the root cause and assessing the nutrient inflows and outflows from the system i.e at field level, farm level and regional level. This will be done in a holistic manner by using nutrient budgeting model viz. NUTMON, etc in terms of nutrient stocks / flows as an crop / cropping system and farm as a whole and also as a district /regional level to know about the status of their soils and the strategies needed to sustain the fertility besides explore the possibilities for increasing the crop productivity in a environmentally sustainable way. High resolution data like CARTOSAT and LISS IV may be used in this study. Spatial variability of soils and nutrients availability is major components of this proposed study.

Deliverables:

A Model / Decision Support System will be developed for assessing the soil nutrient balance by considering all ways and means of inflow and outflow from the agro ecosystem; Nutrient balance assessment at plot, crop activity and regional level will be a useful tool at the hands of policy makers, researchers and soil testing personnel to evolve strategic decision on policy interventions DSS will assist the farming community to achieve economic and social prosperity through Best Farm Management Practices.

NRSC - 022

1. Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

2. Title of the research proposal

Crowd sourcing for landslide inventory using IoT

3. Name of Co PI from ISRO Centre/Unit

Dr. Tapas Ranjan Martha

4. Contact Address of Co PI & e-mail id

Head, GGD/GSG/RSAA
National Remote Sensing Centre (NRSC), Balanagar, Hyderabad.
e-mail: tapas_martha@nrsc.gov.in

5. Area of Research

Area - Earth and Ocean Applications
Sub-area - Geosciences

6. Summary of the proposed research and expected deliverables

India has a large area (0.42 lakh sq. km) prone to landslide disaster. Landslides occurring during rainy season are reported frequently by newspapers, online reports, citizens through smart phones (including videos). This is a potential source of rich information and has not been retrieved in India unlike done in few other countries.

The objective is to use IoT to geotag all news information. Then optimise the location within acceptable landslide location. This landslide location database will be used in conjunction with rainfall data and the threshold rainfall (daily or antecedent) will be estimated using deep learning algorithm. This will help rainfall-based landslide forecast for disaster management studies.

Deliverable will be a GIS database which will be continuously updated using new landslide events.

LIQUID PROPULSION SYSTEMS CENTRE
VALIAMALA

LPSC - 001

1. Name of ISRO Centre/Unit
Liquid Propulsion Systems Centre, Valiamala

2. Title of the research proposal
Analysis of throat film cooling for Semi cryogenic Thrust chamber

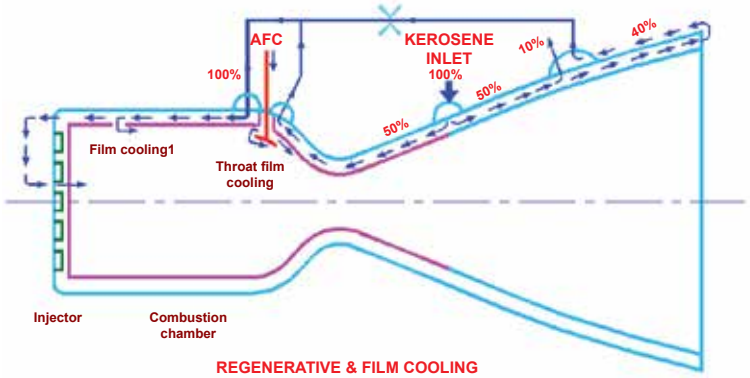
3. Name of Co PI from ISRO Centre/Unit
Shri. A P Baiju

4. Contact Address of Co PI & e-mail id
Division Head, Combustion Chamber Division-Cryo & Semicryo
Liquid Propulsion Systems Centre (LPSC),
Valiamala PO, Thiruvanthapuram.
e-mail: ap_baiju@lpsc.gov.in

5. Area of Research
Combustion modelling with liquid film cooling

6. Summary of the proposed research and expected deliverables
The 2000 kN Semi-cryogenic engine is a high thrust engine and generates high thermal load on the thrust chamber wall. Hence the thrust chamber is cooled by film cooling along with regenerative cooling. The throat region of thrust chamber is subjected to maximum heat flux. Hence positive film cooling is to be ensured in this portion to reduce the heat flux. The conventional film coolant injected near the injector end is not sufficient to keep the throat wall temperature below safe temperature limit. This calls for additional film cooling provision near the throat region. Isrosene (fuel used for semicryo engine: equivalent to RP1) is used for both film cooling as well as regenerative cooling in liquid state.

The film coolant, after injection in to the thrust chamber takes part in combustion, hence film coolant layer depletes gradually. For safe operation of engine, a positive film coolant is an essential requirement. This necessitates detail modelling (considering proper reaction steps, species and reaction rates) of phase change of film coolant and participation in combustion. Based on the CFD results an empirical correlation is also to be formulated for predicting the film coolant thickness in the thrust chamber for varying operating parameters.



REGENERATIVE & FILM COOLING
CONFIGURATION

Deliverables:

Throat film cooling code with reaction with validation results is to be provided to ISRO.

LPSC - 002

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

2. Title of the research proposal

Modelling of two phase flow heat transfer of liquid Methane in regenerative cooling channels of LOX/Methane rocket engines with Methane film cooling

3. Name of Co PI from ISRO Centre/Unit

Shri A P Baiju

4. Contact Address of Co PI & e-mail id

Division Head, Combustion Chamber Division-Cryo & Semicryo
Liquid Propulsion Systems Centre (LPSC),
Valiamala PO, Thiruvanthapuram.
e-mail: ap_baiju@lpsc.gov.in

5. Area of Research

Two phase flow modelling with conjugate heat transfer

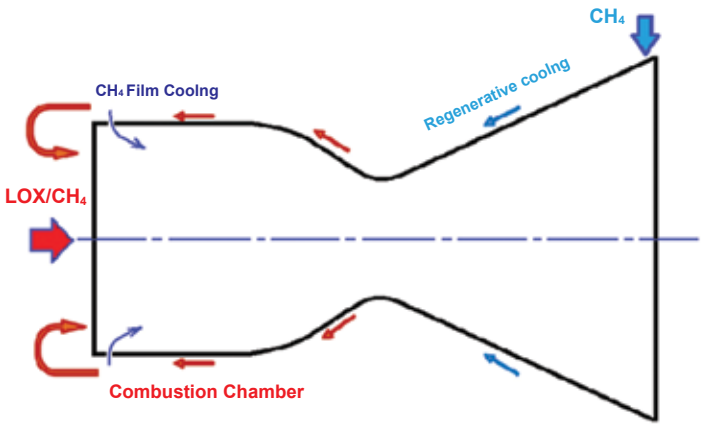
6. Summary of the proposed research and expected deliverables

LOX/Methane propellant combination is one of the most suitable solutions for future liquid rocket engines, due to good performances achievable in terms of specific impulse combined with operation advantages, such as storability, low toxicity, availability and production cost. Another reason to pursue the development of LOX/Methane propulsion systems is the potential for in-situ resource utilization during inter-planetary missions. Due to these advantages, ISRO is developing LOX/Methane engine for its future launch vehicles.

For cooling the thrust chamber, Methane is to be used for both regenerative and film coolant.

However Methane is an inferior coolant as compared to hydrogen and methane properties shows large variations in its operating regime due to two phase flow in the coolant channels.

This calls for detail modelling (considering proper reaction steps, species and reaction rates) of two phase flow of coolant in regenerative coolant channels, participation of film coolant combustion (effective film coolant layer thickness) and conjugate heat transfer from combustion products to chamber inner wall through film cooling layer.



Deliverables:

Validated flow & thermal code (including the source code) has to be submitted to ISRO.

LPSC - 003

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

2. Title of the research proposal

Machinability studies and development of a stable manufacturing technique for XH67MBTЮ nickel base superalloy for Semicryogenic engine applications

3. Name of Co PI from ISRO Centre/Unit

Shri George Oommen
Dr. Anoop CR

4. Contact Address of Co PI & e-mail id

Engr SG, CSPG-CSC & Engr , Engr SF, MDP-MME
Liquid Propulsion Systems Centre (LPSC),
Valiamala PO, Thiruvanthapuram.
e-mail: georgeoommen@lpsc.gov.in & cr_anoop@lpsc.gov.in

5. Area of Research

Machining and micro-machining

6. Summary of the proposed research and expected deliverables

Nickel base superalloy - XH67MBTЮ is most difficult-to-machine materials as they bear excellent heat resistant properties, high work hardening tendency and low thermal conductivity. (Mechanical properties: Yield strength:-530-550MPa, Ultimate strength:-920-940MPa, Hardness:- 260-300 BHN). The major problem faced while machining of the alloy by CNC turning is rapid tool wear and chipping of cutting edges which directly effects dimensional and geometrical accuracy of machined parts. Tool wear analysis and influence of cutting parameters on work hardening behavior of XH67MBTЮ nickel base superalloy need to be studied. Experimental investigation of cutting tool with appropriate tool geometry, coating and process parameters can be explored to improve the machinability of the surface. Since the machining residual stress is of tensile nature which aids cracking the need of minimum residual stress machining process is desirable. Influence of input material condition (solution treated condition and precipitation hardened condition) on machinability to be evaluated for obtaining minimum residual stress components.

Deliverables:

Stable machining technique which involves cutting tool geometry, tool coating, process parameters and lubrication strategies.

LPSC - 004

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

2. Title of the research proposal

Pressure evolution in a Cryogenic tanks during propellant sloshing and ullage venting

3. Name of Co PI from ISRO Centre/Unit

Shri Anant Singhal
Dr. Deepak Kumar Agarwal

4. Contact Address of Co PI & e-mail id

HTD/PRG/PRSE
Liquid Propulsion Systems Centre (LPSC)
Valiamala PO, Thiruvanthapuram.
e-mail: anantsinghal@lpsc.gov.in & d_agarwal@lpsc.gov.in

5. Area of Research

Heat transfer

6. Summary of the proposed research and expected deliverables

Cryogenic propellants undergo sloshing in tanks due to various forces on the stage during flight. Due to propellant sloshing, the tank ullage pressure can fall that can eventually lead to pump cavitation and non-ignition of engine in the worst case. Ullage venting also takes place

during the mission, based on the tank pressure algorithm. Thus, the evolution of tank pressure due to sloshing and ullage gas venting is necessary for finalizing pre-flight parameters. Hence, a 3D CFD model needs to be developed with the following objectives:

1. Modeling of thermal and fluid dynamic behavior during propellant sloshing and venting phase.
2. Effect of sloshing on thermodynamic parameters such as tank ullage pressure and temperature.
3. Interface heat and mass transfer modeling
4. Effect of ullage volume, ullage temperature and ullage species (condensable/ non-condensable) on thermo-fluidic behavior during sloshing.

The model has to be validated with the available literature data/ ISRO flight data for different cryogenic propellants (Liquid Nitrogen, Liquid Oxygen, and Liquid Hydrgen).

Deliverable:

A validated 3D CFD model capable of predicting tank pressure evolution during propellant sloshing and venting phase for ISRO's cryogenic propellant tanks.

LPSC - 005

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

2. Title of the research proposal

Thermal imaging of EB welds

3. Name of Co PI from ISRO Centre/Unit

Shri Ramprasad B

4. Contact Address of Co PI & e-mail id

Dy. Manager, QC-W&E
Liquid Propulsion Systems Centre
ISRO, Bengaluru.
e-mail: ramprasad@lpscb.gov.in

5. Area of Research

NDE (Thermal imaging)

6. Summary of the proposed research and expected deliverables

Spacecraft propellant tank is a Ti6Al4V alloy construction. The Electron beam welds of thickness 3-4 mm are to be evaluated for porosity, cracks and LOF.

The present NDE techniques cater to defect detection in the welds after welding, many a times there are possibility of reworks that take time and effort in choosing the location for rework as the hardware would have been un-mounted from the weld set-up.

A technique in-situ the weld chamber to evaluate the weld during welding in vacuum is proposed to be developed using thermal imaging in order to detect and characterise the defects.

The deliverables at the end of the research shall be the thermal camera along with the associated software for defect mapping and characterisation.

Further, a study is to monitor weld pool formation using non-invasive methods during welding and gain insights on the material behaviour, weld pool dynamics and thermal behaviour, thereby enabling better quality EB welds shall be a part of the above scheme.

LPSC - 006

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

2. Title of the research proposal

Image processing of X-ray radiography exposures

3. Name of Co PI from ISRO Centre/Unit

Shri Ramprasad B

4. Contact Address of Co PI & e-mail id

Dy. Manager, QC-W&E
Liquid Propulsion Systems Centre
ISRO, Bengaluru.
e-mail: ramprasad@lpscb.gov.in

5. Area of Research

NDE (X-ray-radiography) and image processing

6. Summary of the proposed research and expected deliverables

X-ray radiography is a major technique in evaluation of electron beam welds of Spacecraft and launch vehicle components. The weld geometries are well defined and the defect signatures are most of the times very clear and repetitive. In order to perform film interpretation and enhance POD and reduce human fatigue a proposal is put forth for coding of custom software that uses intuitive image processing and artificial intelligence algorithms in order to interpret and report the X-ray films obtained by conventional radiography techniques.

The deliverables at the end of the research shall be software with the code that would enable interpretation of the digitized films in an intuitive manner whose accuracy is continuously increased by data updation.

LPSC - 007

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

2. Title of the research proposal

Catalyst Development for Hydrogen Peroxide dissociation for monopropellant Thrusters

3. Name of Co PI from ISRO Centre/Unit

Shri Narender Kumar

4. Contact Address of Co PI & e-mail id

METG Group,
Liquid Propulsion Systems Centre
ISRO, Bengaluru.
e-mail: narender@lpscb.gov.in

5. Area of Research

Development of suitable catalyst for decomposition of Hydrogen Peroxide 90% & above concentration as monopropellant

6. Summary of the proposed research and expected deliverables

Hydrogen Peroxide based monopropellant system is to be developed for human space program. Development of H_2O_2 monopropellant thrusters is under progress and which required suitable catalyst for smooth & steady dissociation of H_2O_2. It is proposed to develop catalyst for decomposition of rocket grade Hydrogen Peroxide (with concentration of >90%).

The developing agency should develop, characterize & demonstrate the performance of catalyst in lab level tests. The catalyst shall be supplied to LPSC along with detailed report on physical & chemical properties, results of all the tests carried out. The catalyst would be subjected to hot firing test with Hydrogen Peroxide. The repeatability & life of catalyst would be evaluated based on results of hot firing test & feedback would be provided to developing agency.

Deliverables:

Catalyst and detailed report on process and technology for synthesis of catalyst along with results of development works done at academia.

LPSC - 008

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

2. Title of the research proposal

Development of Microstructure-Property-Processing correlations for nickel base super alloys

3. Name of Co PI from ISRO Centre/Unit

Shri Santhosh Kumar R

4. Contact Address of Co PI & e-mail id

MME
Liquid Propulsion Systems Centre (LPSC)
Valiamala PO, Thiruvanthapuram.
e-mail: r_santhoshkumar@lpsc.gov.in

5. Area of Research

Aerospace Materials, Composites & Mechanical Systems

6. Summary of the proposed research and expected deliverables

Nickel base superalloy are primarily strengthened by precipitates (γ'- Ni_3(Al, Ti) or γ" (Ni_3Nb)) and carbides depending to chemistry and heat treatment applied. The morphology of precipitates and carbides play important role in providing optimum property of alloy under different heat treatment conditions and subsequent manufacturing operations such as welding, forming etc. In launch vehicles, numerous grades of super alloys are used, for which microstructure-property –processing correlation are yet to be developed. Therefore, there exists a need for microstructural characterisation of precipitates, carbides etc. under different combinations of manufacturing process and heat treatment conditions (ST+forming+welding+Ageing) or (ST+Ageing).

Deliverables :

1. Optimized heat treatment cycle for various forms like shafts, rods, legs etc.
2. Structure-property correlation.(mechanical properties achievable for different hear treatment conditions)
3. Effect of manufacturing processes on mechanical properties.

LPSC - 009

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

2. Title of the research proposal

Development of packaging for Cryo temperature sensing

3. Name of Co PI from ISRO Centre/Unit

Ms. Subramaniam R Geetha

4. Contact Address of Co PI & e-mail id

DDH, FOS/SRDD
Liquid Propulsion Systems Centre
ISRO, Bengaluru.
e-mail:gsen@lpscb.gov.in

5. Area of Research

Sensors and Transducers

6. Summary of the proposed research and expected deliverables

It is proposed to developed Fiber Bragg Grating (FBG) based temperature sensors for replacing thermocouples in hazardous environments of LH2 and LOX.

FBG sensors have a Fiber Bragg Grating along the length of the optical fiber. This grating is a periodic variation in the refractive index of the core. When light is passed using a broad spectrum light source one wavelength called bragg wavelength is reflected from the grating. The reflected wavelength is given by Bragg's equation.

$$\lambda=2n\Lambda$$

n- Effective refractive index of the fiber

Λ- period of the grating

Remaining band of wavelength passes through the fiber. When the grating is strained by application of force along the length of the FBG, the grating periodicity is altered, this causes a shift in the wavelength of the reflected beam. This wavelength shift is a measure of the strain induced. FBG is sensitive to both strain and temperature. The challenge in packaging of the temperature sensor is to enhance the effect of strain due to temperature due to expansion of the coatings and variation in refractive index of the fiber due to temperature (Thermo optic effect).

Researchers have worked on various coatings on the FBG. The non metallic coating being Polyimide, Teflon, Poly Methyle Methacrylate (PMMA), Polybutylene Terephthalate (c-PBT). These Polymer coated temperature sensors have good performance in the low temperature regimen. Some can be used upto LN2 temperatures. Their performance in the high temperature is reported good till 300°C.

In addition to the coating the choice of Fiber and the type of grating decide the temperature of endurance and stability of the sensor. Chemical Composition Gratings (CCG) are preferred over UV based grating, it gives stability upto 1000°C. While UV grating get erased at these temperatures.

Reducing the strain sensitivity along with enhancing the temperature sensitivity is a challenge. This depends on the Poisson ratio and Young Modulus of the coating. The coating process plays a vital role in inducing residual stress.

The fixing of the coated sensor to the surface of the test article is yet another challenge, options of using thin foils on which FBG is fixed using ceramic based epoxy is widely considered. This is later spot welded to the surface for temperature measurement.

The various variables need to be carefully selected and the combined influence on the temperature measurement has to be carefully studied before finalizing the packaging methodology for our requirement.

Project relevance:

Low temperature measurement in Cryogenic stage and Semi cryo stage.

Problem definition

To study the various coating options available for packaging a FBG temperature sensor for measurement from -253°C to -196°C. Finalise the packaging method after trial and qualification.

Project purview

1. To study the feasibility of CCG grating on Silica based fiber.
2. To study the various coating options for temperature sensing (-253°C to -196°C.)
3. To study FBG encapsulation methods.
4. To design suitable methods of mounting the FBG sensor for sensing.
5. To experimentally prove the suitability of the packaging method.

Deliverables:

3 nos. Packaged cryo temperature sensors with suitable interrogator and GUI.

LPSC - 010

1. Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

2. Title of the research proposal

Design and Development of continuous level sensor using Fiber optic technology for LH2 and LOX.

3. Name of Co PI from ISRO Centre/Unit

Ms. Subramaniam R Geetha

4. Contact Address of Co PI & e-mail id

DDH, FOS/SRDD
Liquid Propulsion Systems Centre
ISRO, Bengaluru.
e-mail:gsen@lpscb.gov.in

5. Area of Research

Sensors and Transducers

6. Summary of the proposed research and expected deliverables

The advantages of Fiber optic technology for Cryogenic level sensing is in it light weight, low power consumption, remote sensing, dielectric material, immunity to corrosion environment.

LOX and LH2 continuous level sensor has been demonstrated in literature by Thermo-optic method. This is far less sensitive to surface contamination, can operate well in conditions of small refractive index contrast between fluid and gas above the fluid (a common problem in cryogenic applications) and 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 POF have been used for continuous level sensing in liquids with distinct difference in density of gas and thus refractive index of liquid state. This can also be studied for LOX level sensor realisation.

Project relevance:

Level sensing in Cryo stages and Semi cryo stage.

Problem definition

The design involves, demonstration of proof of concept with good resolution of signal since this is intensity based optical sensor. The selection of choice of suitable laser source, detection and interrogation technique is critical.

Project purview:

- Design and development of thermo optic continuous level sensor for LH2 and LOX environment. Other principles can be explored for LOX environment.
- Design and demonstration of signal conditioner.

Deliverables:

2 nos. of packaged level sensors of 700 mm measurement length with suitable signal conditioner and GUI.

ISRO PROPULSION COMPLEX
MAHENDRAGIRI

IPRC - 001

1. Name of ISRO Centre/Unit
ISRO Propulsion Complex, Mahendragiri

2. Title of the research proposal
Design and Development of Enhanced Secured Video Communication System for Video Sensor Network

3. Name of Co PI from ISRO Centre/Unit
Shri S.S.Murugan

4. Contact Address of Co PI and Phone Number
Manager, CIHSD
ISRO Propulsion Complex
Department of Space, Mahendragiri, Tirunelveli District, Tamil Nadu.
e-mail: ss.murugan@iprc.dos.gov.in

5. Area of Research
Network Security

6. Summary of the proposed research and expected deliverables
The potential of video sensor network is increasing in today's world due to their flexibility and the ease of use in uninhabitable environment. Secured transmission of video is to be ensured in faster and more reliable manner through Clustering technique with cryptographic and aggregation techniques.

Main objective is to develop an algorithm and to establish a reliable and uninterrupted communication and optimization algorithm by enhancing the security and speed of communication between the nodes in video sensor network.

Encrypted communication model by efficient algorithms and implement the system in real time environment. Wired mode of implementation is planned by means of connecting the elements through Unshielded twisted pair / Single mode fiber optic cable.

Deliverables:

- Detailed software modules with algorithm implementation
- Configuration of test system with implementation scheme
- Detailed design document
- Operation manual

IPRC - 002

1. Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

2. Title of the research proposal

Optimization of flux activated gas tungsten arc welding parameters for stainless steel AISI 304L to achieve maximum weld depth-to-width ratio and improved mechanical properties

3. Name of Co PI from ISRO Centre/Unit

Shri B. Kannan

4. Contact Address of Co PI and Phone Number

Manager, WF-MF/ESAIG
ISRO Propulsion Complex
Department of Space, Mahendragiri, Tirunelveli District, Tamil Nadu.
e-mail: kannan.b@iprc.dos.gov.in

5. Area of Research

Welding

6. Summary of the proposed research and expected deliverables

This project mainly focuses the optimization of process parameters involved in the activated gas tungsten arc welding of austenitic stainless steel AISI 304L material. Manual welding will be performed on the rolled plates of thicknesses 3mm, 4mm and 5mm using the flux coatings SiO_2, TiO_2 and SiO_2+ TiO_2 to fabricate the weld joints and achieve full penetration in single pass. The main outcome of this work is to achieve the full penetration with minimum width on the weld through the use of optimized welding heat input, proper selection of solvent flux combinations, and through the use of mixed shielding gas with appropriate ratio. The soundness of the weldment will be analyzed based on radiography DP test microstructure with special reference to the changes in fusion zone and heat affected zone. Further, the mechanical properties of the weldment will be investigated through the use of Vicker's micro hardness test; room temperature tensile test and the formability test i.e. three point bending on the weld specimens. The proposed study will deliver the activated gas tungsten arc welding procedure specification for the 3mm, 4mm and 5mm thick stainless steel AISI 304L plates. The optimum findings from this investigation will be implemented in the fabrication of AISI 304L weld joints used in the aerospace applications.

OBJECTIVES

- To improve penetration depth and bead surface morphology of austenitic stainless steel AISI304L weldment fabricated through activated gas tungsten arc welding process using micro and Nano fluxes (SiO_2, TiO_2, and combination of SiO_2 + TiO_2) mixed with different types of solvents.

- To understand and to identify the effect of Argon (98%) + Hydrogen (2%) mixture gas & trimixing shielding gas [Argon + Helium + Nitrogen] and flux coating width on AISI304L weldment fabricated through A-TIG welding.
- To achieve the optimized range of welding heat input during the activated GTAW process for the 3mm, 4mm, and 5mm thick rolled plates of austenitic stainless steel AISI304L in order to obtain the optimized weld width to depth ratio.
- To analyze the weld microstructure, bead surface morphology and the mechanical properties such as micro hardness, tensile properties and formability of the activated GTAW weldment.

Deliverables:

1. Combination of fluxes and their proportions, particles size of the flux.
2. Welding parameters such as current, welding speed, flow rate of gas.
3. Thickness and width of flux coat. How applied? Precaution taken to prevent peeling of flux during welding.
4. Properties obtained from specimen evaluation including micrographs and interpretation.

PHYSICAL RESEARCH LABORATORY
AHMEDABAD

PRL - 001

1. Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

2. Title of the research proposal
Quantum sensing based on photonic nanostructures

3. Name of Co PI from ISRO Centre/Unit
Dr. Goutam K. Samanta

4. Contact Address of Co PI & e-mail id
Photonic Sciences Lab.
Physical Research Laboratory
Thaltej Campus, Sindhubhavan Road, Ahmedabad, Gujarat.
e-mail: gsamanta@prl.res.in

5. Area of Research
Quantum optics, nonlinear optics, structured beams, coherent parametric sources

6. Summary of the proposed research and expected deliverables
Sensing technology, an evolving field in line with advancements in technology and needs, realizes the development of devices to measure physical parameters extremely accurately while consuming less power in an inexpensive and compact footprint. While photonic sensors based on classical light beams are already in the matured stage and serve their purpose in sensing applications, efforts are being made to use the quantum nature of light to develop photonic sensors with superior performance in accuracy, reproducibility, and sensitivity. In this regard, it is essential to generate single/entangled photons and find a suitable interface for efficient, coherent transfer of the photon for sensing. In principle, this can be facilitated using the quantum emitters based on different types of photonic nanostructures like high Q photonic crystal cavities and plasmonic nanostructures. While it is challenging to develop an efficient photon-emitter interface to enhance the coupling of one mode and suppress the other, in this regard, the photonic nanowires have emerged as a strong contender. Therefore, it is imperative to explore the possibility of developing such single-photon emitter/photonics nanostructures, couple them at room temperature and verify the sensing applications.

PRL - 002

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Laboratory Astrochemistry / Astrobiology

3. Name of Co PI from ISRO Centre/Unit

Shri Bhalamurugan Sivaraman

4. Contact Address of Co PI & e-mail id

AMOPH
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: bhala@prl.res.in

5. Area of Research

Astrochemistry/Astrobiology

6. Summary of the proposed research and expected deliverables

The cold dust in the InterStellar Medium (ISM) known as the cryogenic chemical reactors (10 K) are responsible for the molecular evolution. The icy mantles that form on such cold dust are processed by energetic particles. This leads to the breaking of existing and formation for new chemical bonds. Such processes can be simulated in the laboratory where the ISM conditions are recreated (10 K and ultrahigh vacuum conditions) and the physico-chemical nature of the dust and icy mantles can be studied.

There are regions in the ISM where the physico-chemical nature of the dust particles is altered by the shockwave. The ISM shock intensities are quite strong. However, there exists regions in the ISM where the shock intensities are moderate, 3 < M <10. Such moderate shocks are recreated in the laboratory conditions using a high intensity shock tube, M < 6.

Our laboratory is capable of simulating the coldest dust (10 K) and the dust that is processed by shocks, raising the temperatures to few 1000's of K. So we can understand the physico-chemical nature of the icy mantles and dust under such extreme conditions.

PRL - 003

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Investigation of Hydrometeorological processes in different hydroclimatic zones of India using stable isotopes of oxygen and hydrogen in conjunction with ground-based, satellite based and model derived meteorological parameters

3 Name of Co PI from ISRO Centre/Unit

Prof. R.D. Deshpande

4 Contact Address of Co PI & e-mail id

Geosciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: desh@prl.res.in

5 Area of Research

Isotope Hydrometeorology, Satellite Meteorology

6 Summary of the proposed research and expected deliverables

Hydrometeorological processes cause the transfer of water and energy between the land surface and the lower atmosphere. Hydrometeorological processes include the entire spectrum of events such as evaporation in the marine vapour source region, vapour transport, cloud formation, liquid condensation, vapour deposition, precipitation, rainfall, evaporation, sublimation, transpiration, convection and continental recycling.

Hydrometeorological processes govern the spatio-temporal distribution of water and therefore, extremely important for socio-economy of an agrarian country such as India. The contemporary hydrological cycle is slowly changing in response to rise in temperature due to climate change. The changes in the rainfall patterns in different parts of the country are being observed in terms of increase in the high intensity rainfall events, cloud bursts, change in arrival and departure of monsoon etc. While there are reports of these broad changes in the hydrological patterns, the detailed understanding of region specific hydrometeorological processes is not available. For example, contemporary hydrometeorological processes and imminent changes in different parts of the country e.g. Himalayas and other mountainous regions, glaciated regions, forested regions, wetlands, coastal regions and desert regions, are bound to be different. This is due to fact that intensity of convection, orographic lifting, surface water availability, potential evapotranspiration etc are different in different parts of the country.

The observed rainfall is a resultant of multitude of above factors which cannot be understood only by measuring rainfall amounts at different places. It is important that the incoming water flux (rain/snow), the outgoing water flux (evaporation or transpiration) and the residual water flux (surface water/ soil moisture) are tagged by independent tracers such as oxygen and hydrogen isotopic composition which can discern underlying processes. Interpretation of this isotopic data in conjunction with various other meteorological parameters such as temperature, vertical profile of cloud liquid content, specific humidity, cloud top temperatures, cloud thickness, vertical wind velocity, OLR, convective & stratiform rain fraction can provide useful insights about dynamics of hydrometeorological processes.

It is important that several studies are simultaneously initiated across the country following the uniform strategy of isotopic investigation and interpretation in light of meteorological parameters.

This theme of research is extremely important for understanding the subtle hydrometeorological processes going on in different parts of the country, and to discern region specific patterns and early warning of imminent changes and its consequences on water availability.

PRL - 004

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

I. Terrestrial Impact craters and its planetary significance
II. Terrestrial Analogue studies to Moon and Mars

3. Name of Co PI from ISRO Centre/Unit

Dr. Dwijesh Ray

4. Contact Address of Co PI & e-mail id

Planetary Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: dwijesh@prl.res.in

5. Area of Research

Planetary Geology, Meteoritics

6. Summary of the proposed research and expected deliverables

The Impact cratering is one of the fundamental geological processes in our Solar System that shapes the surfaces of the terrestrial planets and planetesimal bodies by hypervelocity impact of asteroid/comet. Due to the continued action of mountain building due to the modern plate tectonics, and weathering and erosion, the imprints of past records of impact on the Earth are poorly preserved. Thereof, identification of any new asteroid impact structure on Earth has been always a challenging discovery to planetologists. Till date, ~204 impact craters have been identified worldwide and many more still awaiting for discovery. Therefore, fresh scientific investigation is necessary to identify new impact structures especially the older impact structures on Earth. A near perfect terrestrial analogue locality to Moon and Mars that mimics the environment is still elusive on Earth. However, continued research on terrestrial analogue sites helps to better understand the geologic evolution, near-surface processes on Moon and Mars and Validate the ground truth information. Additionally, repeated scientific experiments on analogue sites also help to envisage the future landing sites.

PRL - 005

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Remote Sensing of rocky/icy Planetary bodies and Earth analogs

3. Name of Co PI from ISRO Centre/Unit

Dr. Vijayan S

4. Contact Address of Co PI & e-mail id

Planetary Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: vijayan@prl.res.in

5. Area of Research

Planetary Remote Sensing on Moon, Mars, icy bodies

6. Summary of the proposed research and expected deliverables

Remote sensing studies of planetary bodies is indeed important to understand the evolution of Earth. These planetary bodies are dominant with impact craters, fluvial, glacial, aeolian and volcanic activities. The study of such geological features on these planetary/icy bodies and correlating with the Earth analogs is indeed required to understand the evolution of planetary/ icy bodies in the Solar System.

PRL - 006

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Analogous Studies and Geo-physical Modeling of Moon/Mars

3. Name of Co PI from ISRO Centre/Unit

Dr. K. Durga Prasad

4. Contact Address of Co PI & e-mail id

Planetary Sciences Division,
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail:durgaprasad@prl.res.in

5. Area of Research

Planetary Surface Science

6. Summary of the proposed research and expected deliverables

Over the last few decades, Planetary Science and Exploration has advanced due to the availability of a number of remote and in situ observations. Although, mission instrumentation and theoretical understanding have continuously advanced, laboratory studies and modeling studies have been deferred due to various reasons, but are now the need of the time. Laboratory measurements of planetary analogous materials under simulated environments provide key support to the definition of science and measurement objectives of ground-based, orbital, and

lander observations; instrument design and calibration; mission planning; and analysis and interpretation of retrieved data. Such experiments aim at reproducing environmental conditions, at studying properties of species observed in different environments and at simulating their evolution according to mechanisms in active space. These experiments further supported by geophysical models viz. heat flow, seismic, magnetic-field, gravimetry, tectonic/volcanic, hydrological, provide a broader perspective and help in understanding the processes operating at and below the surfaces of the planets, both at present and in the past.

The main objective of the proposed research work would be to carryout experimental studies on planetary analogous samples under astrophysical and planetary environments and/or to develop comprehensive models to understand the various aspects related to the evolution of the Moon/Mars. Various areas that are particularly dependent upon laboratory studies includes atmospheric composition and chemistry, surface composition and chemistry, planetary geology and geophysics, planetary interiors, astrobiology, and astrophysics. Once in-situ geophysical data is available, these analogous studies and developed models can also aid in a better interpretation of data and in unlocking the past evolution and present-day structure of the planets.

PRL - 007

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Role of physical and chemical processes on the climate of Mars and Venus

3. Name of Co PI from ISRO Centre/Unit

Professor Varun Sheel

4. Contact Address of Co PI & e-mail id

Planetary Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: varun@prl.res.in

5. Area of Research

Planetary Atmospheres

6. Summary of the proposed research and expected deliverables

Scientists have gained important insights into the atmospheres of Mars and Venus through observations and modelling. However, several aspects of their climates are yet not well understood – for example, the complex couplings and super-rotation in Venus clouds, and the effect of boundary layer processes on dust distribution and photochemistry in the Martian atmosphere. Thus it is appropriate to develop complex models that would address current gaps in our understanding of the climate of Mars and Venus, and gainfully utilise the data from ISRO's future missions to Mars and Venus.

PRL - 008

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Estimation of water abundance on the Moon using Chandrayaan data-sets

3. Name of Co PI from ISRO Centre/Unit

Dr. Megha U. Bhatt

4. Contact Address of Co PI & e-mail id

Planetary Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: megha@prl.res.in

5. Area of Research

Infrared spectroscopic analysis/Remote Sensing

6. Summary of the proposed research and expected deliverables

'How wet or dry the Moon is' remains a major scientific question even after several decades of lunar science exploration. The concept of a wet Moon is reinforced with recent results from re-calibrated spacecraft based hyperspectral data, telescopic observations, lunar meteorites. In this context, Chandrayaan-2 is capable of answering this question, with its unique scientific payloads. A combined approach of study using remote sensing observations from Chandrayaan missions and modeling can be used to investigate variations and abundances of hydration on the lunar surface. Such an approach of looking to global scale variations using the spacecraft data will help to understand associated transport processes and its origin.

PRL - 009

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

(1) Instrumentation for future planetary missions/modelling of planetary lightning

(2) Instrumentation for future planetary missions/modelling of interplanetary/planetary dust at a planet

3. Name of Co PI from ISRO Centre/Unit

Dr. Jayesh P. Pabari

4. Contact Address of Co PI & e-mail id

Physical Research Laboratory
Navarangpura, Ahmedabad – 380 009. e-mail: jayesh@prl.res.in

5. Area of Research

(1) Planetary Lightning
(2) Interplanetary Dust Science

6. Summary of the proposed research and expected deliverables

Summary of Project 1: The electrical discharges are expected to occur in the Venusian and Martian atmosphere. Few past observations indicate possibility of lightning on Venus/mars and it may be similar to that on Earth. However, detailed study of the planetary lightning is needed through the instrument on future planetary missions/modelling to understand how lightning is initiated, how the waves are propagated in the medium, flash rate of lightning, the lightning spectrum etc.

Summary of Project 2: The Interplanetary Dust Particles (IDPs) are originated from asteroid belt and other sources. These IDPs sometimes are trapped between two planets and create a resonance dust ring. Also, planetary dust like dust storms/devils is of scientific interest. The properties of the dust at a planet may be understood using the instrument on future planetary missions/modelling. The project can cover such aspects related to the interplanetary/planetary dust science.

PRL - 010

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Space weather

3. Name of Co PI from ISRO Centre/Unit

Dr. Dibyendu Chakrabarty

4. Contact Address of Co PI & e-mail id

Space and Atmospheric Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: dipu@prl.res.in

5. Area of Research

1. Space-weather
2. Geomagnetic storms and magnetospheric substorms
3. Prompt penetration and overshielding electric fields
4. Ionospheric dynamics and plasma irregularities

5. Magnetosphere-Ionosphere (MI) coupling
6. Radiation belt physics
7. Solar wind and interplanetary processes
8. Solar Energetic Particles (SEP)

6. Summary of the proposed research and expected deliverables

Space weather refers to conditions on the Sun and in the solar wind, Earth's magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based logical systems and can endanger human life and health.

During space weather events, radiation, energetic particles and electric field perturbations affect the near-earth geo-space. In case of geomagnetic storm, under the influence of southward interplanetary magnetic field, the global magnetosphere and ionosphere undergo drastic changes. This alter the neutral and plasma dynamics, changes neutral composition and wind patterns and also generates plasma irregularities in the uppermost plasma layers of the earth. In addition, violent re-organization of the geomagnetic field during substorms also release enormous energy into the magnetosphere- ionosphere system. The impact of storm/substorm need critical attention as these have consequences in the context of navigational and other technological applications in space. With the upcoming Aditya-L1 mission, special attention will also be given to understand the properties of solar wind in the interplanetary medium based on measurements made at the first Lagrangian point of the Earth-Sun system by the Aditya Solar wind Particle EXperiment (ASPEX) of PRL. Expected deliverables include critical understanding of solar wind and the impact of solar disturbances on terrestrial and planetary ionosphere/magnetosphere/atmosphere.

PRL - 011

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Investigations of space environment, Space Weather, and Solar-terrestrial interactions

3. Name of Co PI from ISRO Centre/Unit

Prof. D. Pallamraju

4. Contact Address of Co PI & e-mail id

Space and Atmospheric Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: raju@prl.res.in

5. Area of Research

1. Ionosphere-Thermosphere-Mesosphere (ITM) interactions
2. Low- and equatorial-electrodynamics

3. Neutral wave dynamics
4. Vertical coupling of Atmospheres
5. Space weather and Solar terrestrial interactions
6. High- to low-latitude coupling during geomagnetic storms
7. High-latitude phenomena and Magnetosphere Ionosphere Thermosphere (MIT) coupling
8. Long term variations in ITM due to solar activity.
9. Day and night time optical aeronomy studies

6. Summary of the proposed research and expected deliverables

Magnetosphere, Ionosphere, Thermosphere, and Mesosphere (MITM) form the regions of space environment that contribute to the existence of life on the earth as they act as a shield by preventing the entry of harmful solar radiation. MITM hosts several neutral & plasma dynamical phenomena which are in constant turmoil due to the solar forcing from above (in terms of particles, magnetic flux and radiation) and lower atmosphere below (due to convective activities and waves). During solar events, such as the coronal mass ejections and solar flares several changes in terms of neutral temperatures, winds, plasma densities take place which need to be understood not only from the point of view of fundamental curiosity but also to significant application potential. This is the region which hosts almost all the applications satellites in LEO and GEO. The performance of these also get affected due to geomagnetic storms that are caused by variations of interplanetary magnetic fields of solar origin.

MITM can be investigated by optical airglow/dayglow measurements for neutral dynamics, radio measurements for ionospheric densities, electric fields, total electron content, and induced magnetic field measurements due to ionospheric/magnetospheric currents. These measurements can be ground-based, space-borne, or rocket borne.

It is important to understand the physics of the upper atmosphere (MITM) at different regions individually, either in horizontal scales (i.e., latitudes / longitudes), or vertical scales (i.e., altitudes), or both.

The deliverables of such investigations include understanding of these variations on shorter scales, which is “space weather” and on longer time scales, which is “space climate”.

PRL - 012

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Modeling of trace gases and aerosols over the Indian subcontinent

3. Name of Co PI from ISRO Centre/Unit

Dr. Narendra Ojha

4. Contact Address of Co PI & e-mail id

Physical Research Laboratory,
Navrangpura, Ahmedabad.
e-mail: ojha@prl.res.in

5. Area of Research

Atmospheric Science

6. Summary of the proposed research and expected deliverables

Atmospheric trace gases (e.g. ozone, carbon monoxide, hydrocarbons, etc.) and aerosols profoundly impact the air quality and climate. However, chemistry-climate models show strong biases in capturing their variations over the Indian subcontinent. Model biases have been attributed to diverse factors, such as the uncertainties in emissions and unresolved topography of this region. In this regard, up to date emissions and high-resolution topography are being implemented in the atmospheric models (e.g. WRF-Chem) employing the Vikram high performance computing cluster at PRL.

The research program aims to evaluate the suitability of different physical and chemical schemes in the models for the tropical Indian conditions. Model results will be evaluated against a suite of ground-based, balloon-borne, and space-based measurements. The model configuration, best reproducing the observations, will be used to investigate the impacts of anthropogenic, biomass-burning, and biogenic emissions on trace gases and aerosols over the Indian region. The impacts of trace species on the regional climate dynamics will also be investigated.

The deliverables include recommendations on the model configurations and detailed evaluation of model performance for the Indian region. The atmospheric budgets of tropospheric Ozone and related species over the Indian region will be estimated.

PRL - 013

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Mesosphere Lower Thermosphere (MLT) Research

3. Name of Co PI from ISRO Centre/Unit

Dr. Ravindra Pratap Singh

4. Contact Address of Co PI & e-mail id

Space and Atmospheric Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: ravindra@prl.res.in

5. Area of Research

MLT dynamics, Upper atmospheric Physics, Optical aeronomy, Optical (Visible and Infrared) instrumentation

6. Summary of the proposed research and expected deliverables

Forcing in the MLT region due to solar flux variations from above and wave activities from below give rise to dynamical variations across the latitude, longitude, and altitude. The effects of atmospheric waves (e.g. planetary waves, tides, and gravity waves) dominate the dynamics of the MLT region. Understanding and characterization of these waves using ground-based observations from individual sites or from a network of observatories is an important aspect of the MLT research.

Airglow emission intensities and temperatures have been used extensively to understand the dynamical processes in the MLT region. We will use in house built optical instruments to measure temperatures using OH(6-2) and OH(3-1) nightglow emission bands that have emissions in near infrared and shortwave infrared regions (SWIR). The research foci of high cadence SWIR observations are to understand high frequency waves in the MLT region.

Deliverables will include better understanding of MLT dynamics using mesospheric temperatures.

PRL - 014

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Study of the vertical distribution of Clouds, Atmospheric Water Vapor, Dynamics of Boundary Layer, Temperature, and Stratosphere-Troposphere exchange using Lidar

3. Name of Co PI from ISRO Centre/Unit

Dr. Som Kumar Sharma

4. Contact Address of Co PI & e-mail id

Space and Atmospheric Sciences Division
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: somkumar@prl.res.in

5. Area of Research

Atmospheric Sciences

6. Summary of the proposed research and expected deliverables

Atmospheric water vapor is a major greenhouse species, it plays a vital role in cloud formation, radiation balance, chemistry, dynamics, and consequently impacts the weather and climate system. Variability in water vapor predominantly modulates fluxes of longwave (infrared)

radiation and can influence the temperature in the Troposphere-Stratosphere system. Clouds are an essential component of the hydrological cycle and substantially impact the Earth's radiation budget. To explain the influence of water vapor on Stratosphere-Troposphere Exchange (STE) and cloud induced modulations in the radiation budget, in-depthinvestigations are needed covering different regions/habitats. Human-induced climateforcing is one of the significant causes of warming in the lower atmosphere, cooling of the stratosphere, rise of tropopause height, weakening of tropical circulation patterns and modulations in tropical precipitation.

Systematic investigations of the vertical distribution of watervapor, clouds, dynamics of the boundary layer and temperature are needed at different locations. Regular, systematic observation of these parameters over different locations will provide an essential set of inputs for the regional weather and climate models. A Lidar is a versatile instrument that provides the required information with high vertical and temporal resolutions. Various types of Lidars, such as Rayleigh, Mie, Raman, and Ceilometer, provide vertical distribution of atmospheric water vapor, Clouds, Boundary layer, and temperature, which are essential in the investigations of several atmospheric processes. A Lidar-based exploration over different Indian locations is proposed in this study. Simultaneous measurements of these parameters will provide a unique dataset to address the above-stated science objectives.

PRL - 015

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Investigation of solar eruptions using subphotosphericdynamics

3. Name of Co PI from ISRO Centre/Unit

Dr. Rohan Eugene Louis

4. Contact Address of Co PI & e-mail id

Udaipur Solar Observatory
Physical Research Laboratory, Navrangpura, Ahmedabad.
e-mail: rlouis@prl.res.in

5. Area of Research

Solar Physics

6. Summary of the proposed research and expected deliverables

Solar eruptions such as flares and Coronal Mass Ejections (CMEs) are major explosive events in our solar system that significantly influence the interplanetary medium including the Earth's geo-magnetic and upper atmospheric environment. It is crucial to understand the physical mechanism of such events from a solar physics as well as space weather perspective. The objective of this study is to determine the sub-photospheric dynamics associated with emerging

active regions and the conditions that render them active or quiescent. This could serve as a viable means of ascertaining the likelihood of ensuing eruptions from an active region that could be a valuable input for space weather models.

PRL - 016

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Solar Flares: Physics and Forecasting

3. Name of Co PI from ISRO Centre/Unit

Prof. Nandita Srivastava

4. Contact Address of Co PI & e-mail id

Udaipur Solar Observatory (Physical Research Laboratory)
Badi Road, Udaipur, Rajasthan.
e-mail: nandita@prl.res.in

5. Area of Research

Solar Physics

6. Summary of the proposed research and expected deliverables

Solar flares demonstrate the most energetic physical processes in the solar atmosphere with associated space weather phenomena. There has been a tremendous improvement in understanding the physics of their origin and thereby forecasting for space weather purposes. However, the complete solution remains elusive.

Efforts have been made on flare forecasting using photospheric magnetic field observations taken from Helioseismic and Magnetic Imager (HMI) onboard Solar Dynamics Observatory (SDO) of NASA. However, in such forecasting, the authors did not have access to the critical ingradient from chromospheric observations. Improving flare forecasting based on chromospheric observations is envisaged by including observations from ground-based existing and upcoming telescopes such as Multi-Application Solar Telescope of USO and Solar Ultraviolet Imaging Telescope (SUIT) onboard the Aditya-L1 mission of ISRO. Further, whenever possible co-spatial and co-temporal photospheric magnetic field data measurements will be used from the Multi-Application Solar Telescope (MAST) by utilising combined datasets from MAST, SUIT/Aditya-L1, and HMI/SDO, and implementing specific tools of “Deep Learning”, both supervised and unsupervised, it is proposed to study the physics of the origin of flares with the eventual goal of their real-time forecasting. Complimentary data of flare from the Soft X-ray Low Energy Spectrometer (SoLEXS) and the High Energy L1 Orbiting Spectrometer (HEL1OS), both onboard Aditya-L1 mission can also be utilised.

PRL - 017

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Exploring the role of waves and small-scale transients in the heating of solar corona and transition region

3. Name of Co PI from ISRO Centre/Unit

Dr. Girjesh R Gupta

4. Contact Address of Co PI & e-mail id

Udaipur Solar Observatory (Physical Research Laboratory),
Badi Road, Udaipur, Rajasthan.
e-mail: girjesh@prl.res.in

5. Area of Research

Propagation and dissipation of MHD waves in the solar atmosphere, Small-scale transients in the solar atmosphere, Solar UV and EUV spectroscopy

6. Summary of the proposed research and expected deliverables

The tenuous outer atmosphere of the Sun commonly known as 'corona', is orders of magnitude hotter (> 1 MK) than the solar surface (< 6000 K). It is now widely accepted that magnetic field plays an important role in the heating of solar corona. Magnetohydrodynamic waves such as Alfven waves, slow and fast MHD waves, and small-scale magnetic reconnection events (transients) such as microflares, spicules, jets etc are proposed to provide sufficient energy to maintain the hot corona and transition region. Although there exist ample observations of wave propagation and small-scale transients in the solar atmosphere, the exact physical processes/ mechanisms behind their dissipation and contribution to the heating of solar coronal plasmas are still unclear and not fully quantified. A thorough assessment of the role of each of these proposed mechanisms is required:

1) Quantification of energy contents of different type of MHD waves and small-scale transients in the solar atmosphere.
2) Correlation between wave power spectra observed in the photosphere and corona propagating through chromosphere and transition region.
3) To explore whether waves can induce small-scale magnetic transients and vice-versa.

For the purpose, simultaneous spectroscopic and imaging data obtained from space-based instruments such as AIA/SDO, IRIS, EIS/Hinode will be utilized. Proposed science goals will be heavily benefited from the data obtained from ISRO's upcoming space mission Aditya-L1. Data from Solar Ultraviolet Imaging Telescope (SUIT) and Visible Emission Line Coronagraph (VELC) both onboard Aditya-L1 will readily be utilized as soon as it becomes available.

PRL - 018

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Study of relation between temporal variations in near-surface zonal (rotation) / meridional flows and magnetic / thermal forces of active regions

3. Name of Co PI from ISRO Centre/Unit

Dr. Brajesh Kumar

4. Contact Address of Co PI & e-mail id

Udaipur Solar Observatory (Physical Research Laboratory)
Badi Road, Udaipur, Rajasthan.
e-mail: brajesh@prl.res.in

5. Area of Research

Helioseismology (Solar Physics)

6. Summary of the proposed research and expected deliverables

Local helioseismic ring-diagram analysis data products of GONG and SDO/HMI observations include synoptic maps of zonal and meridional flows in the near-surface layers (to depths of about 20 Mm). These instruments also provide photosphericmagnetograms, including the vector magnetic fields (HMI). Here, a systematic investigation involving calculations of Lorentz forces of active region magnetic fields (using magnetograms) and their correlations with aforementioned seismic maps of flows is proposed. Additionally, it is also proposed to derive flow maps from time-distance helioseismology for a robust estimation and comparison. Correlative studies of variations in Lorentz force maps and flows will help in understanding the origins of such variations in the large-scale flows and hence in providing inputs to data-driven models of solar dynamo and the solar cycle. These analyses will also provide a statistical data set of markers/predictors of enhanced activity (e.g. flares and CMEs) that are derivable from the flow maps and which aid in quantifying the basic processes that determine how the magnetic fields energise the solar atmosphere through sudden explosive phenomena.

PRL - 019

1. Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

2. Title of the research proposal

Astronomical UV Polarimetry

3. Name of Co PI from ISRO Centre/Unit

Dr. Shashikiran Ganesh

4. Contact Address of Co PI & e-mail id

Astronomy & Astrophysics Division
Physical Research Laboratory
Ahmedabad. e-mail: shashi@prl.res.in

5. Area of Research

Astronomy & Astrophysics

6. Summary of the proposed research and expected deliverables

UV polarimetry has been done on a very limited number of stars so far despite the immense potential of polarimetry to provide answers that cannot be found by any other means. Applications range from comets and asteroids to stars and active galactic nuclei. Interstellar extinction peaks strongly in the UV and has a very strong dependence on the direction of observation. A corresponding study of the directional dependence of UV polarisation is not available due to the lack of UV polarimeters in space. In the case of active galactic nuclei, the study of UV polarisation and its' variability in time will allow to constrain the uncertain information currently available about the energy generation mechanism of these compact but yet highly energetic objects.

Possible deliverables:

1. A full science case for a dedicated UV polarimeter in space covering different spatial and temporal scales over a wide range of object types from cool comets to ultra energetic active galaxies;

2. A catalog of objects for UV polarimetric observations with observations carried out in optical and near infrared using PRL's facilities.

3. A laboratory demonstration of a UV polarimeter. With suitable support this instrument could be flown on a balloon to target and study bright UV sources. This could be developed in future as a payload for a planetary mission (specifically for cometary targets) and also as a back-end instrument for a UV telescope for the study of interstellar polarization in the UV bands.

SATISH DHAWAN SPACE CENTRE - SHAR
SRIHARIKOTA

SDSC - 001

1. Name of ISRO Centre/Unit
Satish Dhawan Space Centre - SHAR, Sriharikota

2. Title of the research proposal
Developing a Jet Noise Source Localization Technique using a Microphone Array with Appropriate Beam Forming Algorithms

3. Name of Co PI from ISRO Centre/Unit
Shri G Venkatesh,
Shri V Venkata Ramakrishna

4. Contact Address of Co PI & e-mail id
E&HATF, SMP&ETF,
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: venkatesh.grandhi@shar.gov.in, vvrk@shar.gov.in

5. Area of Research
Supersonic jet acoustics

6. Summary of the proposed research and expected deliverables
Supersonic jet of a rocket exhaust has various noise producing components especially turbulent mixing noise, shock associated broadband noise and screech tones. Each noise component is dominant in distinct frequency bands. Spatial location of these noise sources highly influence the acoustic ambience of the launch vehicle during lift-off.

Locating these jet noise sources in the lift-off scenario of a launch vehicle will benefit immensely in developing the effective noise suppression techniques.

'Jet Noise Source Localization Technique using a Microphone Array' proposes to use an array of microphones and employ suitable algorithm and develop a code to locate the noise sources for free and impinging supersonic jet cases. Various algorithms available in the literature can be compared and an effective composite algorithm meeting the requirements of both free and impinging jets and also near & far field acoustics source localization can be studied.

SDSC - 002

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Fatigue life estimation of structural members under random vibrations through Strain Gauge Measurements

3. Name of Co PI from ISRO Centre/Unit

Dr. T.Srinivas Reddy,
Shri V Venkata Ramakrishna

4. Contact Address of Co PI & e-mail id

E&HATF, SMP&ETF,
Satish Dhawan Space Centre SHAR
Sriharikota – 524124, Andhra Pradesh
e-mail: srinivasreddy.t@shar.gov.in, vvrk@shar.gov.in

5. Area of Research

Structural dynamics

6. Summary of the proposed research and expected deliverables

During the lift-off of a launch vehicle, ground structures and also launch vehicle structures/ components experience intense vibration load due to lift-off acoustics. Also, during flight induced vibrations have a tremendous impact on the structural integrity of the flight sub-systems. Most of these vibration loads are random in nature. Various structural members subjected to these random vibration loads will be damaged due to fatigue. The problem of fatigue damage is more severe with respect to ground structures at launch pad. As these structures are critical with respect to safe launching of the rocket, proper estimation of fatigue damage of these structures is highly essential. As most of these structures are open to atmosphere, strain gauge based measurements are proposed for fatigue life estimation.

As the launch induced loads are random in nature, characterization of load and its spectral content is essential for understanding its impact on a given structure and estimation of fatigue life from strain gauge based measurements to be carried out.

SDSC - 003

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Modeling and evaluation of damping in threaded joints of load cells and its impact on measuring dynamic force components

3. Name of Co PI from ISRO Centre/Unit

Dr T.Srinivas Reddy,
Shri V Venkata Ramakrishna,
Shri C Rajakumaran

4. Contact Address of Co PI & e-mail id

E&HATF, SMP&ETF,
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: srinivasreddy.t@shar.gov.in, vvrk@shar.gov.in

5. Area of Research

Structural dynamics

6. Summary of the proposed research and expected deliverables

Large Solid Rocket Motors (SRM) need to undergo ground static tests for evaluating the thrust-time characteristics and structural integrity of the motor. During static firing tests, thrust produced by the motor is measured by connecting the SRM to a test stand and in turn to load cells. These load cells are generally have threaded interfaces at its end for connecting to the test stand. As large SRMs tends to produce pressure oscillations due to the vortex shedding phenomena (inside the combustion chamber) coupling with the chamber acoustic mode, the thrust produced can have a significant dynamic component associated with it. As the launch vehicle has different stages/sensitive components, accurate measurement of the dynamic thrust component is critical for its safe operation during flight. Among the several interfaces in the thrust transfer path from motor to load cell, the thread interface between load cell to test stand structure can play a significant role. The present proposal is for investigating/modeling the nature of damping in the threaded joint and its impact on the transfer of dynamic thrust component especially under different preloading conditions.

SDSC - 004

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre - SHAR, Sriharikota

2. Title of the research proposal

Simulation of Ammonium Perchlorate cleavage by inter-particle and surface impacts in Hammer Mill under different operating conditions

3. Name of Co PI from ISRO Centre/Unit

Shri D. Harish Reddy, Smt K. Ashwini

4. Contact Address of Co PI & e-mail id

Material Processing, SPP
Satish Dhawan Space Centre-SHAR
Sriharikota, Andhra Pradesh.
e-mail: harish@shar.gov.in, kasturi.ashwini@shar.gov.in

5. Area of Research

Size reduction in hammer mill

6. Summary of the proposed research and expected deliverables

Ammonium Perchlorate (AP) is used as oxidizer in Solid Propellant processing with wide particle size distribution. Coarse AP of ~300 microns average size is ground into fine of 50 micron average particle size. The microscopic properties of the material define fine tuning of end product properties.

Simulation of Particle breakdown during grinding in hammer mill due to impact with particle to particle, and housing surfaces under different operating conditions like rotor speed, air velocity, feed rate, number of particles is required.

This can be used to optimize the process conditions for wide particle size distribution, surface area control, packing density etc. and thus better tuning of final product towards the requirement.

SDSC - 005

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Method to get uniform Particle Size by innovative size reduction method for AP at lab scale

3. Name of Co PI from ISRO Centre/Unit

Shri Harekrushna Pathy,
Shri Hitesh babu

4. Contact Address of Co PI & e-mail id

Manager, Raw Material Processing
SPP & SPROB
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: srinivasbabu.n@shar.gov.in

5. Area of Research

Size Reduction

6. Summary of the proposed research and expected deliverables

Ammonium Perchlorate (AP) is a major ingredient in solid propellant which occupies around 68 weight percent in propellant formulation. Bimodal AP is prepared by AP coarse and AP fine for achieving desired burn rate. Ammonium Perchlorate is currently being ground by Hammer mill to produce AP fine, Hammer mill has impact mechanism to break the particles. This process gives a wide distribution of particle size, which is suspected to affect burn rate of propellant.

AP fine particle size distribution control is achieved with great difficulty due to various factors like residency of the grinder usage, selection of Mill RPMs and screens. It is difficult to get the desired PSD in the range of less than ±1 weight percentage, even with great care. With the requirement of control burn rate between paired motors, the variation in PSD upto the extent of ±1 weight percentage may not be meeting the requirement. Hence, it is proposed to explore for alternative methods to achieve the required specifications.

SDSC - 006

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Experimental studies on oxygen deficiency environments due to accidental spillage or release of gases

3. Name of Co PI from ISRO Centre/Unit

Shri B.Satish,
Shri M Sundar Rao,
Shri T Subbananthan

4. Contact Address of Co PI & e-mail id

SHAR Central Safety Division
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: subbananthan.t@shar.gov.in,
sundarrao.madiri@shar.gov.in, satish.b@shar.gov.in

5. Area of Research

Ground Safety

6. Summary of the proposed research and expected deliverables

The proposal is to study the oxygen exhaust environments which poses life threatening factor to the operational personnel in a closed room or confined Space operations. The Box model sub- scale gases dispersion studies can be used for understanding the behaviour of toxic gas dispersion. This can be used for estimating the concentration levels at various elevations and distances etc. Also, to optimize the location of the sensors and detection mechanisms for a faster detection.

The future programs like HSP crew module calls for detecting of any environmental parameter change which is life threatening to detect at the shortest possible time. Box Model Studies with provision for monitoring of gases at different elevations by releasing a known gas to establish the Oxygen deficiency zones is required.

SDSC - 007

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Smoke Extractor system for Solid motors exhaust gas during testing

3. Name of Co PI from ISRO Centre/Unit

Shri T Subbananthan,
Shri M Sundar Rao

4. Contact Address of Co PI & e-mail id

SHAR Central Safety Division
Satish Dhawan Space Centre -SHAR
Sriharikota, Andhra Pradesh.
e-mail: subbananthan.t@shar.gov.in, sundarrao.madiri@shar.gov.in

5. Area of Research

Ground Safety

6. Summary of the proposed research and expected deliverables

As a part of qualification trials for the solid motor testing of Agni motors have increased manifolds. Solid motors exhaust gases contain traces of toxic Products like HCl gas, Al2O3 and CO. In order to protect the environment and working personnel from these exposures, it is proposed for theoretical and experimental setup studies for a smoke extractor system towards safe collection of exhaust gases for disposal.

SDSC - 008

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Experimental studies on liquid propellant dispersion due to accidental release or spillages at SDSC SHAR

3. Name of Co PI from ISRO Centre/Unit

Shri M. Devendra Kumar

4. Contact Address of Co PI & e-mail id

Dy. Head, SHAR Central Safety Division
Satish Dhawan Space Centre -SHAR
Sriharikota, Andhra Pradesh.
e-mail: devendra.m@shar.gov.in

5. Area of Research

Safety / loss prevention

6. Summary of the proposed research and expected deliverables

Toxic and flammable liquid propellants are stored at site for launching satellite launch vehicles. This study is aimed to derive the dispersion of liquid propellants due to accidental release or spillages by considering various credible scenarios. This will ultimately estimate the toxic corridors with pollution levels from the source of leak by considering prevailing meteorological conditions. Also, to optimize the location of the sensors for a faster response and for initiating the safing actions.

SDSC - 009

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Design of Fire Alarm and Detection system for High Bays Based on Smoke Modeling

3. Name of Co PI from ISRO Centre/Unit

Shri T Subbananthan,
Shri SSVD Sairam,
Shri CH Sreenivasulu

4. Contact Address of Co PI & e-mail id

SHAR Central Safety Division
Satish Dhawan Space Centre -SHAR
Sriharikota, Andhra Pradesh.
e-mail: subbananthan.t@shar.gov.in,
sanka.sairam@shar.gov.in, sreenu@shar.gov.in

5. Area of Research

Ground Safety

6. Summary of the proposed research and expected deliverables

Most of the Integration facilities are accommodated with high rise and high bays where the flight related segments/stages activities with Solid/Liquid propellants will be carried out. These propellants are highly sensitive in nature. Any initiation of fire may cause catastrophe. Hence an optimal design with effective Fire Detection Alarm system for High rise and High bay is very much essential. Detection of fire at smoldering stage is crucial which can be acknowledged by smoke modeling/capturing techniques through high-tech visualization cameras. The above technique will analyze smoke evolvement with real time and alert it through Audio/Visual aids. The smoke modeling/visual base techniques are more reliable compared to conventional Fire detection alarm systems. The system has to be designed in wide range of scope to detect even in remote areas in a bay where conventional detectors are unable to route/implemented.

SDSC - 010

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

FPGA based IRIG-B Time Decoder and Time Insertion in 2K video

3. Name of Co PI from ISRO Centre/Unit

Shri A.Vaidhyanathan

4. Contact Address of Co PI & e-mail id

MOTR - RO
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail : vaidhyanathan.a@shar.gov.in

5. Area of Research

Image and video Processing in FPGA

6. Summary of the proposed research and expected deliverables

Time Synchronization (TS) represents an important necessity in the field of communication. Among different synchronization protocols, the Inter-Range Instrumentation Group (IRIG) - B time code has become one of the most employed protocol in real-time information transmission systems. Timing station in the range sends the Universal time and Count Down time in IRIG-B format. The Count Down Time (CDT) & Universal Time (UTC) time from Timing station are synchronous to IRNSS / GPS.

HD video (2K) of Real Time launch from various camera sources are available in Control room. These videos need to be precisely time tagged to IRIG-B decoded CDT in real time. This helps in capturing the various events in real time.

This RESOND proposal is to study the requirements and implement a FPGA based IRIG-B time Decoder and Time insertion in 2K video in real time.

Expected deliverables are detailed study, simulation of the required algorithms in Matlab. FPGA Hardware along with suitable IO & Media converter cards for IRIB-B time decoding, Image Processing of 2K.

SDSC - 011

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Real time JPDA & MHT based Data Association in dense multi target tracking environment

3. Name of Co PI from ISRO Centre/Unit

Shri A.Vaidhyanathan

4. Contact Address of Co PI & e-mail id

MOTR - RO
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: vaidhyanathan.a@shar.gov.in

5. Area of Research

Radar Data Processing

6. Summary of the proposed research and expected deliverables

Multi Object Tracking Radar (MOTR) is an L-Band Active Phased Array Radar designed to track multiple targets. It is a long range skin mode tracking radar capable of tracking 0.25m2 RCS target up to a range of 1000km. MOTR can track more than 10 simultaneous targets using single agile beam.

MOTR has implemented Linear Kalman filter (LKF) and Extended Kalman filter (EKF) for tracking multiple targets simultaneously and Simple Nearest neighborhood (SNN) based data association algorithm to associate target returns with the target being tracked. SNN data association algorithm gives a better result in tracking multiple targets when the targets being tracked are spatially separated. When multiple targets are very closer SNN algorithm gives poor result. It also fails in situation like targets cross over and co travelling of two targets.

To overcome this situation Probability based Data Association (PDA) methods like Joint Probability Data Association (JPDA) and Multiple Hypothesis Tracking (MHT) algorithms are used. Since these algorithms uses probability based algorithms these are complex incorporated to SNN. Hence these algorithms are mostly used in offline analysis.

This RESPOND proposal is to implement JPDA in Real time and MHT in near real time application of MOTR for tracking multiple targets.

Expected deliverables are the detailed study and simulation of PDA, JPDA and MHT algorithms in MATLAB, simulation results of above algorithms with MOTR radar data and implantation of these in C code.

SDSC - 012

1. Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2. Title of the research proposal

Space Debris RCS Estimation and dynamics Characterisation from MOTR Space Debris tracked data

3. Name of Co PI from ISRO Centre/Unit

Shri A.Vaidhyanathan

4. Contact Address of Co PI & e-mail id

MOTR - RO
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail : vaidhyanathan.a@shar.gov.in

5. Area of Research

Radar Data Processing

6. Summary of the proposed research and expected deliverables

Multi Object Tracking Radar (MOTR) is an L-Band Active Phased Array Radar designed to track multiple targets. It is a long range skin mode tracking radar capable of tracking 0.25m2 RCS target up to a range of 1000km. MOTR can track more than 10 simultaneous targets using single agile beam.

MOTR is the first sensor in India capable of tracking space debris up to an altitude of 800 km. MOTR has tracked and catalogued nearly 54 different space objects from an altitude of 400 to 900km which includes spent down stages of launch vehicles, debris, space station like ISS, Tiangong and live satellites. MOTR tracked the space objects in skin mode.

Studying the received signal from the target gives us the information of the target like its dynamics spin, its size and RCS. These characteristics of the debris need to be catalogued, to compute its drag coefficient, and its life time assessment.

This RESOND proposal is to study on the Dynamic characteristics and RCS estimation of Space debris from MOTR tracked data.

Expected deliverables are the detailed study and simulation of the required algorithms to be implemented in MATLAB, simulation results and implantation of the algorithms in C code.

SDSC - 013

1 Name of ISRO Centre/Unit

Satish Dhawan Space Centre -SHAR, Sriharikota

2 Title of the research proposal

Development of observer based robust controller for vibration mitigation designed for 3 storey benchmark structure and its force validation using Magneto Rheological damper

3 Name of Co PI from ISRO Centre/Unit

Shri G Meghanath,
Shri V Venkata Ramakrishna

4 Contact Address of CoPI & e-mail id

SMP&ETF,
Satish Dhawan Space Centre SHAR
Sriharikota, Andhra Pradesh.
e-mail: meghanath.g@shar.gov.in, vvrk@shar.gov.in

5 Area of Research

Vibration Control

6 Summary of the proposed research and expected deliverables

Natural hazards like earthquake, high wind and tsunami are threat all the times for the multi-storey structures. The environmental forces cannot be clogged but the structures can be prevented from these natural hazards by using protective systems for the structures. Therefore, a semi-active protective system, Magneto-Rheological (MR) damper for the earthquake forces is proposed in this work. Simulation studies have to be carried out to mitigate the vibration of the structure by using the semi-active system. The simulation results have to be validated towards developing a vibration control system which will drastically reduce the vibration of a benchmark structure even in presence of uncertainties like earth quake. This makes it a safety critical control system which makes the tall structures safer by reducing the vibrations.

SEMI-CONDUCTOR LABORATORY
CHANDIGARH

SCL - 001

1. Name of ISRO Centre/Unit
Semi-Conductor Laboratory, Chandigarh

2. Title of the research proposal
Design of Instrumentation Amplifier

3. Name of Co PI from ISRO Centre/Unit
Shri Mohd. Asim Saeed

4. Contact Address of Co PI and e-mail id
VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: asim@scl.gov.in

5. Area of Research
VLSI Design

6. Summary of the proposed research and expected deliverables
A High-Precision Instrumentation Amplifier with large CMRR is required for the Sensor Signal conditioning applications. Instrumentation amplifier is a versatile device used for amplification of small differential mode signals while rejecting large common mode signal at the same time. In a typical signal conditioning chain, the output of the sensor goes to the instrumentation amplifier. The instrumentation amplifier amplifies the small output signal of the sensor and give it to the ADC for digitization.

Target Specification:

- Supply Voltage: 3.3V
- Temperature Range: -40^{0}C to 125^{0}C
- Programmable Gain: 1 to 1000
- Low noise < 0.3µV p-p at 0.1 Hz to 10 Hz
- Low non linearity < 20ppm (Gain = 1)
- High CMRR (Common Mode Rejection Ratio) > 90dB (Gain=1)
- Low offset voltage < 100µV

• 3 dB Bandwidth: 1MHz (at Gain = 1)

The design of the proposed Instrumentation Amplifier is to be carried out in SCL 180 nm process.

SCL - 002

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design of 14 bit 500 MSPS DAC in SCL's 180nm Technology

3. Name of Co PI from ISRO Centre/Unit

Shri Rahul Tripathi
Shri Rajesh Kumar Shrivastava

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space,
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: rahul@scl.gov.in, rajesh@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

Digital to Analog Converter (DAC) is a device that transforms digital data into an analog signal. The digital data may be produced from a microprocessor, Application Specific Integrated Circuit (ASIC), or Field Programmable Gate Array (FPGA), but ultimately the data requires the conversion to an analog signal in order to interact with the real world. This DAC should cater test and Measurement, Imaging and high-Precision, high-Speed data acquisition applications with these features in Junction temperature range -40°C to +125°C.

Target Specification:

- Resolution 14 bits
- Speed 500 MSPS
- FSR Current 2 mA-20 mA
- SFDR >74 dBFS at 70 Msps
- DNL < ±0.5LSB
- INL < ±2LSB

- Gain Error < ±2 % of FSR
- Output Compliance range -0.5 to +1 V @ Full Scale Current = 20 mA
- Offset Error < ±0.01 % of FSR @ Mid Code
- Power Dissipation < 600 mW
- Power supply 1.8/3.3 V
- Technology SCL 180 nm

SCL - 003

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design of 8-Bit 1GSPS Flash ADC

3. Name of Co PI from ISRO Centre/Unit

Shri Ashutosh Yadav

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: ashutosh@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

The flash Analog-to-Digital Converter (ADC) architecture is the most popular topology for video processing, telecommunications, digital imaging etc. designs because its gives highest speed. This design of ADC should cater imaging as well as communication applications with these features in Junction temperature range -40°C to +125°C.

Target Specification:

- SNDR >46 dBFS at 1000 Msps
- SFDR >60 dBc at 1000 Msps
- DNL <±0.5LSB
- INL <±0.5LSB
- No missing Code

- Gain Error<±0.5LSB
- Offset Error<±0.5LSB
- Output data format in LVDS or CMOS

Deliverables:

i. Design Details along with all schematics and layout

ii. GDSII file of Design

iii. Test results and evaluation board

SCL - 004

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design of Radiation Hardened Dual port SRAM – Different Cuts

3. Name of Co PI from ISRO Centre/Unit

Shri Anuj Chawla
Shri Sanjeev Basra

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: anuj@scl.gov.in, basra@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

DPRAM Cuts of following variations are needed which can be used as Embedded Solution or Stand-alone Memory Chip

Voltage Levels – 1.8 V / 3.3 V

Access Time - < 5 ns

Address Bit Range – 4 Bits to 14 Bits

Data Bit Range – 4 bits to 72 Bits

Radiation Tolerance -

TID >300 Krad (Si), SEL > 80 MeV-cm2/mg, SEU > 50 MeV-cm2/mg

SCL - 005

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design of High Speed CMOS Standard Cell Library in 0.18um SCL process

3. Name of Co PI from ISRO Centre/Unit

Ms. Pooja Dhankar,
Shri Deep Sehgal

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: pooja@scl.gov.in, sehgal@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

Standard cell library contains a collection of components that are standardized at the logic or functional level, and consists of cells or macro - cells based on the unique layout. The importance of standard cell library design methodology is growing with Very-Large-Scale Integration (VLSI) technology advancement due to its usage in VLSI EDA flows.

In high performance standard cell library, the main objective is to increase performance of logic cells that satisfies the given specifications. The benefit of high performance cell library is used in processors, high computational IC's etc. designs where density will be neglected to meet the performance.

Target Specification:

The Standard Cell library should fulfil the following criteria:

1. Static CMOS Library
2. PVT variation: not more than 20%
3. D flip-flops in the library should be working upto 2GHz clock frequency
4. Library should have Multibit D Flip-flops: 2bits, 4 bits, 8bits
5. Tracks –> 9 or 12(any one for complete library)
6. Multiple drive strength of the cells
7. Multiple inputs and various cell combination
8. Supply Voltage 1.8V

9. Temperature range - 40°C to 125°C

10. Views and files required in the library:

Deliverables:

The delivery should have:

- cdl - cdl netlist for LVS with VDD and VSS defined as local and cdl netlist for LVS with VDD and VSS defined as global.
- doc - datasheets
- gds - gds for all cells
- lef - lef abstract
- liberty – 27 corners timing information (PVT combinations) in both CCS and NLDM (CCS-P, CCS-N to be included).
- spc - spice netlist for all cells
- spc_simple - spice netlist for all cells without parasitic.
- Verilog - Verilog model for all cells.

SCL - 006

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design of DSP Processor in 0.18µm SCL process

3. Name of Co PI from ISRO Centre/Unit

Shri Shubham Palod, Shri Varun Nehru

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: shubham@scl.gov.in, nv_vn@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

A digital signal processor (DSP) is a specialized microprocessor chip, with its architecture optimized for the operational needs of digital signal processing. They are widely used in audio signal processing, telecommunications, digital image processing, radar, sonar and speech recognition systems, etc. The goal of a DSP is to measure, filter or compress continuous real-

world analog signals. Most general-purpose microprocessors can also execute digital signal processing algorithms successfully, but may not be able to keep up with such processing continuously in real-time. Also, dedicated DSPs usually have better power efficiency, are more suitable in portable devices because of power consumption constraints. DSPs often use special memory architectures that are able to fetch multiple data or instructions at the same time. DSPs often also implement data compression technology.

DSPs are designed to execute complex math in parallel, which is common in many signal processing applications. By having hardware and an Instruction Set Architecture (ISA) optimally designed for the FFT, the FFT is executed with higher performance in shorter time—and at lower energy. Power is directly proportional to the clock frequency and voltage squared. To run the clock at a higher frequency requires a higher voltage, which leads to an exponential increase in power draw. Hence, it is desirable if DSP is able to run at low clock frequencies while delivering high performance through hardware multi-threading, and by maximizing work per clock cycle.

SCL - 007

1. Name of ISRO Centre/Unit

Semi- Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design and development of Power Analysis Attack Tolerant Cryptographic Processor for Security Critical Space Applications

3. Name of Co PI from ISRO Centre/Unit

Shri Deep Sehgal, Shri Uday Khambete

4. Contact Address of Co PI and e-mail id

VLSI Design Division
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: sehgal@scl.gov.in, udayk@scl.gov.in

5. Area of Research

VLSI Design

6. Summary of the proposed research and expected deliverables

This topic is targeted for design and development of Cryptographic processor which is power analysis attack (side channel) tolerant. It is relevant for our futuristic cryptographic development activities & as additional hardware security mechanism that may be an integrated feature of attack prone ASICs to be used in space applications.

SCL - 008

1. Name of ISRO Centre/Unit

Semi-Conductor Laboratory, Chandigarh

2. Title of the research proposal

Technology Development of High Power RF LDMOS Device

3. Name of Co PI from ISRO Centre/Unit

Shri Amit Kumar Singh

4. Contact Address of Co PI and e-mail id

Process Technology Development Division (PTDD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: aksingh@scl.gov.in

5. Area of Research

CMOS Process Technology

6. Summary of the proposed research and expected deliverables

SCL has initiated in-house development of high Power RF LDMOS devices. In this work development of two different RF LDMOS devices for 650MHz (~500Watt) and 325MHz (1kWatt) operations has been initially targeted. In this regard SCL requires support for following topics:

1. Device Design for state of the art and reliable, rugged High voltage (~50V) RFLDMOS.
2. Process & Implant conditions (must be supported with TCAD simulated results).
3. Test chip for RF LDMOS process integration.
4. RF characterization and Reliability analysis of developed devices.

SCL - 009

1. Name of ISRO Centre/Unit

Semi-Conductor Laboratory, Chandigarh

2. Title of the research proposal

Modeling of High Voltage (10-20, 40-60V) N /P LDMOS devices developed at SCL in 180nm CMOS baseline process technology

3. Name of Co PI from ISRO Centre/Unit

Shri Amit Kumar Singh
Shri Saahil Singla

4. Contact Address of Co PI and e-mail id

Process Technology Development Division (PTDD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: aksingh@scl.gov.in, saahil@scl.gov.in

5. Area of Research

CMOS Process Technology

6. Summary of the proposed research and expected deliverables

A Simple concise statement about the investigation/theme and the expected deliverables in around 250 words Process development work at SCL is in progress for the process integration of LDMOS (VDS: 10-20, 40-60V; VGS: 3.3-5V) devices (n and PMOS) in standard 180nm baseline process. Once the devices are enabled, SPICE device models are required for the above LDMOS devices for circuit design implementation. The developed models should be accurately predicting both DC and AC performance of the devices over a range of voltage, temperatures (-55 to 125°C) and frequencies.

Deliverables:

i. Device characterization (DC-IV, CV, RF) as required for Model parameter extraction.

ii. Industry standard LDMOS Device Models (Scalable /Binned).

iii. Model QA report complying IEEE/CMC model validation tests and accuracy.

SCL - 010

1. Name of ISRO Centre/Unit

Semi- Conductor Laboratory, Chandigarh

2. Title of the research proposal

Modelling of buried channel MOSFET

3. Name of Co PI from ISRO Centre/Unit

Shri Sudipto Das gupta

4. Contact Address of Co PI and e-mail id

Optical Process Development Division (OPDD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: sudipto@scl.gov.in

5. Area of Research

CCD Process Technology

6. Summary of the proposed research and expected deliverables

The existing CCD process development at SCL is based on buried channel technology to cater the need of high Charge Transfer Efficiency with high SNR. The output stage of CCD comprises of multiple stage source follower amplifier connected with sense node to produce voltage equivalent of collected charge with greater sensitivity. To design CCD output amplifier, modelling of n-buried channel MOSFET is required using SPICE.

SCL - 011

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Development of compound semiconductors based THz detectors for space applications

3. Name of Co PI from ISRO Centre/Unit

Shri Manish Kumar Hooda

4. Contact Address of Co PI and e-mail id

Technology Development Division (TDD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: manishk@scl.gov.in

5. Area of Research

Compound Semiconductor Technology

6. Summary of the proposed research and expected deliverables

- THz detectors are at the heart of THz astronomy. With the advent of III-Nitride (III-N) based devices, once can exploit its unique 2 Dimensional Electron Gas (2DEG) properties to realize broadband THz detectors. By designing appropriate antenna coupling with III-N based High Electron Mobility Transistor, the sensitivity and speed can be improved. The present project calls for the design and development of III-N based THz detectors in the potentially ranging from 0.3 – 0.9 THz.

  The scope of the project includes.

  - Identifying appropriate antenna architecture to be coupled with III-N HEMT device for desired frequency range.
  - Co-development of circuit level and system level design for THz detector.
  - Development and calibration of circuit and system level models.
  - Demonstration of prototype.

SCL - 012

1. Name of ISRO Centre/Unit

Semi-Conductor Laboratory, Chandigarh

2. Title of the research proposal

Epitaxial growth of InP on Si for mm wave communication applications

3. Name of Co PI from ISRO Centre/Unit

Shri Manish Kumar Hooda

4. Contact Address of Co PI and e-mail id

Technology Development Division (TDD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: manishk@scl.gov.in

5. Area of Research

Compound Semiconductor Technology

6. Summary of the proposed research and expected deliverables

- InP offers a clear performance advantage over conventional CMOS devices in terms of high frequency performance. However, the use of native InP substrates are usually of smaller size than commercial Si wafers, thereby limiting the number of devices realized on a single wafer. Additionally, the costs of InP substrates are much higher than Si substrates. On the other hand, epitaxial growth of InP layers on Si substrates offer an alternative route to integrate InP devices with well-established Si technology. In this aspect, this project calls for development of epitaxial growth of InP epitaxial layers on Si targeting mm wave applications.

  The scope of the project includes.

  - Understanding the fundamentals of InP growth on Si substrates.
  - Use of different nucleation techniques and methods such as aspect ratio trapping to reduce defects in the grown InP layers.
  - Using the understanding to realize the growth of device grade InP epitaxial layers on Si substrates.

SCL - 013

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design/Development/Testing of Silicon Nanowire based biosensor (BioFET) for clinical diagnostics in space

3. Name of Co PI from ISRO Centre/Unit

Shri Nishant Shukla & Shri Satyapal Singh

4. Contact Address of Co PI and e-mail id

Advanced Micro and Nano System Division(AMNSD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: nishant1@scl.gov.in, spsingh@scl.gov.in

5. Area of Research

MEMS Design & Process Technology

6. Summary of the proposed research and expected deliverables

Includes simulation of the response of a Si-nw BioFET sensor both as fabricated and when exposed to analyte. Identification, development, testing etc. of bio-markers/analytes alone, compatible for use in BioFETs, can also be considered.

Deliverables:

- Detailed documents on design, simulation, test etc.
- Simulation Code/model.

SCL - 014

1. Name of ISRO Centre/Unit

Semi -Conductor Laboratory, Chandigarh

2. Title of the research proposal

Optimization of electrical design in HTCC package with multidrop lines

3. Name of Co PI from ISRO Centre/Unit

Shri Rana Randheer

4. Contact Address of Co PI and e-mail id

VLSI Packaging Division (VPD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: randheer.rana@scl.gov.in

5. Area of Research

IC Package Design & Development

6. Summary of the proposed research and expected deliverables

In case of multichip substrate design having multidrop connections, it becomes paramount to optimize the floor plan to meet assembly & fabrication constraints while getting optimum

electrical performances. Parametric studies for varying dielectric thicknesses, trace widths, metallization thicknesses, via sizes, pin outlines CQFP or PGA etc.

Target Specification:

Design multi die package having processor, memory, digital ASIC, analog ASIC, MEMS sensor, Signal conditioner IC, power die etc.

- Power Distribution Network Impedance <= 0.2ohm
- Speed of operation 200MHz or better

Deliverables:

Design philosophy and layout and proof of concept through fabrication & testing

SCL - 015

1. Name of ISRO Centre/Unit

Semi-Conductor Laboratory, Chandigarh

2. Title of the research proposal

Design and Development of deposition type MultiChip module using Silicon

3. Name of Co PI from ISRO Centre/Unit

Shri Shokeen

4. Contact Address of Co PI and e-mail id

VLSI Packaging Division (VPD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: shokeen@scl.gov.in

5. Area of Research

IC Package Design & Development

6. Summary of the proposed research and expected deliverables

One of the promising multi die substrates are Deposition type (MCM-D) on semiconductor material. Design and realisation of this substrate on Silicon for ICs like Processors, ASIC and Analog ICs to be taken up with promising electrical performances of complete module.

Target Specification:

Design multi die package having processor, memory, ASIC, transceiver and power die on Silicon substrate.

- Design must follow 180 nm SCL Fab Design guidelines.
- Power Distribution Network Impedance <= 0.5ohm.
- operation frequency 100MHz or better

Deliverables:

Design & layout for substrate; Design validation through siliconisation using SCL fab & Testing.

SCL - 016

1. Name of ISRO Centre/Unit

Semi- Conductor Laboratory, Chandigarh

2. Title of the research proposal

Development of multi layer IC package using 3-D printing advanced technologies

3. Name of Co PI from ISRO Centre/Unit

Shri Shokeen

4. Contact Address of Co PI and e-mail id

VLSI Packaging Division (VPD)
Semi-Conductor Laboratory, Department of Space
Sector 72, SAS Nagar. (Near Chandigarh) Punjab.
e-mail: shokeen@scl.gov.in

5. Area of Research

IC Package Design & Development

6. Summary of the proposed research and expected deliverables

Custom development of multilayer substrate having buried power planes and vias using Additive technologies is an open area to meet the design evaluation requirements. In addition to high packaging efficiency the substrates to meet specifications as per performance specifications of MIL 38535 and test conditions of MIL883 for hermetic space grade reliability & applications.

Deliverables:

Technology know-how transfer including design and fabrication. 100 to 120 pin QFP package delivery for technology evaluation.

ISRO INERTIAL SYSTEMS UNIT
THIRUVANANTHAPURAM

IISU - 001

1. Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal
Series Elastic Actuator and Control Unit

3. Name of Co PI from ISRO Centre/Unit
Ms. Smitha Krishnan

4. Contact Address of Co PI & e-mail id
Spacecraft Actuator Systems Division (SASD),
Spacecraft Inertial Systems (SIS), ISRO Inertial Systems Unit (IISU)
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: smitha_krishnan@vssc.gov.in

5. Area of Research
Electro Magnetic Actuators, Smart Actuators for Robotics, Electromagnetic Analysis

6. Summary of the proposed research and expected deliverables
In general, actuators are built to be as stiff as possible to increase the bandwidth. When a robot works in a structured environment, its automation is easier than in a non-structured environment in which its modeling is quite difficult and presents a high computational effort. To overcome this difficulty, Series Elastic Actuator (SEA) has been applied in compliant robotic grasping. SEA contains an elastic element in series with the mechanical energy source like drive motor. Such an elastic element gives SEAs tolerance to impact loads, low mechanical output impedance, passive mechanical energy storage, and increased peak power output. Series Elastic Actuators provide many benefits in force control of robots in unconstrained environments. These benefits include high force fidelity, extremely low impedance, low friction, and good force control bandwidth.

The aim of the project is to design and develop a series elastic actuator unit, which consist of drive motor, gear train unit, compliance element such as linear /torsional spring, position encoder. Motor is preferably a BLDC/PMSM motor with minimum cogging torque. Gear unit can be of harmonic/planetary type and preferably magnetic encoder as the position sensor. Actuator should have high torque resolution and required additional sensors can be incorporated in the design. Joint output position and spring detection are measured using absolute position sensors providing a high position accuracy. Actuator must have compliance element with controller unit. Communication protocol can be of one which support above functional requirements.

Specifications

- Maximum torque: 30 Nm
- Nominal Torque: 12 Nm
- Output speed: 10 RPM
- Supply voltage: 28 V to 42 V

IISU - 002

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

1KW High efficiency Rotary Transformer and associated electronics circuit for contactless power transfer

3. Name of Co PI from ISRO Centre/Unit

Shri Sreejith M R

4. Contact Address of Co PI & e-mail id

Spacecraft Actuator Systems Division (SASD),
Spacecraft Inertial Systems (SIS), ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: sreejith_mr@vssc.gov.in

5. Area of Research

Electrical Actuators Design and Development, Electromagnetic Analysis

6. Summary of the proposed research and expected deliverables:

The electrical connections between static and rotatable parts of different systems are realized by means of sliding contacts, usually slip rings. However, sliding contacts represent a common point of failure, because their life time is strongly related to the cumulated number of revolutions. Hence contactless rotary joints are preferred to significantly increase the overall system reliability. Among different wireless energy transfer media that can be employed, Rotary transformers use strong magnetic coupling to achieve high efficiency and relatively high power ratings.

The physical separation of the rotary transformer is ensured by adding a small air gap between the transformer cores. The air gap significantly reduces the coupling coefficient of the transformer. It is desirable to compensate for the leakage inductance in the switching power supply to improve the load regulation and overall system power factor. Zero-voltage commutations of the inverter switches may be incorporated to ensure low losses and to increase the overall system efficiency.

The specifications of the rotary transformer are as follows,

Configuration: Concentric cylinder/Axial/ Face to face/Pot core configuration
Input Voltage: 70 V DC +/-15%
Output Voltage: 70 V DC +/-5%
Maximum power: 1 KW
Preferred Air gap: 0.2 mm to 0.3 mm
Load regulation: 5%
Line regulation: 5%
Switching frequency: > 50 kHz
Overall efficiency: > 95 %

IISU - 003

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Dual speed rotating drive mechanism with Drive Motor and Magnetic gear

3. Name of Co PI from ISRO Centre/Unit

Shri Harikrishnan A

4. Contact Address of Co PI & e-mail id

Spacecraft Actuator Systems Division (SASD),
Spacecraft Inertial Systems (SIS), ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: harikrishnan_a@vssc.gov.in

5. Area of Research

Electromagnetic analysis, Electromagnetic actuator design and development, Magnetic Gear

6. Summary of the proposed research and expected deliverables

Gears and geared machines are widely used in a broad spectrum of industries, where the rotational speed of the input source have to be matched with the required rotational speed of the output source. Mechanical gears are often used for this purpose, but they are often subjected to wear, may overheat, get damaged in over-loaded conditions and requires periodic lubrication and maintenance. In recent years' magnetic gears are receiving increased attention in the field of research for its applications primarily in aerospace industries due its increased reliability. When compared to mechanical gears, magnetic gears offer reduced acoustic noise and vibration, reduced maintenance and improved reliability, precise peak torque transmission and inherent overload protection, physical isolation between input and output shafts.

This mechanism should consist of a BLDC motor coupled with magnetic gear driving two output shafts. One of the two output shafts is driven directly by the BLDC motor and the other shaft is driven through a magnetic gear.

Specifications:

- BLDC Motor torque: 4 Nm
- BLDC Motor Speed: 25 RPM
- Gear Ratio: 2:3
- Torque ripple introduced by Gear should be less than 1%
- Supply Voltage: 28 V to 42 V

IISU - 004

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Modelling of bias and scale factor and their compensation in Ring Laser Gyro using machine learning and development of suitable characterization methods

3. Name of Co PI from ISRO Centre/Unit

Shri Anish G S

4. Contact Address of Co PI & e-mail id

SED/ISG/AIS
ISRO Inertial Systems Unit (IISU)
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: anish_gs@vssc.gov.in

5. Area of Research

Artificial Intelligence and Machine Learning

6. Summary of the proposed research and expected deliverables:

The research involves analysis of sensor data, developing characterization framework, experimentation and selection of a suitable algorithm to compensate for bias and scale factor variations for Ring Laser Gyros.

The aim is to develop a bias variation model and scale factor error model in order to achieve the targeted specifications.

The targeted specifications include, but not limited to, achieving requirements in scale factor stability, bias stability, day to day stability, temperature sensitivity and alignment accuracy for the sensor.

The project also involves implementing the prediction part of algorithm in a specified TI DSP with PC based option for training it.

IISU - 005

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Indigenous Machine Learning/Artificial Intelligence (ML/AI) Hardware/Software Framework for Vyomnoids

3. Name of Co PI from ISRO Centre/Unit

Shri Karthik R

4. Contact Address of Co PI & e-mail id

SED/AIS
ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: karthik_r@vssc.gov.in

5. Area of Research

Machine Learning/Deep Learning/Artificial Intelligence/Accelerator Design

6. Summary of the proposed research and expected deliverables:

In future space exploration missions, autonomous systems (Robotics, Explorers, Subsystems in satellites, Ground segments etc) will be ubiquitous and self-intelligence will become an inevitable requirement of these systems. Already similar AI systems are employed in advanced space systems like Curiosity to select and analyze Mars rocks, CIMON (Crew Interactive Mobile companion) in International Space Station, etc. IISU has also proposed Vyomnoids with Dexterous manipulative abilities for both manned and un-manned missions. All these applications involve significant amount of intelligence or learning capabilities by doing large amount of computation, data crunching and analysis. Till recently majority of such implementations are based on non-optimized General-Purpose CPUs/GPUs and that too offline in a centralized work station. However, it is becoming necessary to have such systems on-board with real time learning capabilities rather than doing it on ground because sending huge amount of data itself is time/power/resource inefficient. Hence, it's the need of the hour to develop an AI/ML hardware/software ecosystem for future ISRO missions with a deployable hardware/software frame-work for immediate applications especially for Vyomnoids.

The proposal involves integrating an Indigenous Learning Accelerator to the already developed controller for smooth and efficient execution of AI tasks. The project also involves development of the entire software tool chain for supporting the FPGA based Accelerator SoC which is also very critical.

Objectives & Scope of the work

To design, develop and deploy the hardware/software framework for Artificial Intelligence/ Machine Learning algorithms for Vyomnoids. The key objectives involve

a) Indigenous Accelerator Design and Integration with existingShakti based RISC-V controller.

b) Software porting, developing required libraries and RISC-V toolchain for the Accelerator.

c) Validating the framework in FPGA and demonstration of AI/ML capabilities for a Vision processing task for Vyomnoid.

IISU - 006

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Design, analysis and mechanization of nonlinear dynamics for enhancing performances in Resonant Inertial Sensors

3. Name of Co PI from ISRO Centre/Unit

Shri Karthik R

4. Contact Address of Co PI & e-mail id

SED/AIS
ISRO Inertial Systems Unit (IISU)
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: karthik_r@vssc.gov.in

5. Area of Research

Nonlinear Dynamics, Coriolis Vibratory Gyroscope (CVG)

6. Summary of the proposed research and expected deliverables

Nonlinearities are typically considered to be unwanted behavior of sensors and actuators. However recent studies have shown that a critically controlled non-linear system can demonstrate performances many orders higher compared to conventional linear systems. Experimental demonstrations by multiple design teams have confirmed the same elsewhere. These are particularly applicable for inertial sensors like Coriolis Vibratory Gyroscopes (CVGs), Resonant accelerometers etc.

IISU has realized Hemispherical Resonator Gyroscopes (HRG) with Q-factors more than 4 Million. In a linearly operated gyroscope, the starting time or Time-To-Valid Data (TTVD) will be of the order of 4-6 minutes which is not acceptable for navigation sensors. By employing non-linear control schemes, the TTVD can be reduced to few seconds through self-excitation schemes or Vanderpol's oscillation. Similarly, the bias stability and Scalefactor performances can be improved by at-least 1 order by employing non-linear control schemes like parametric excitation with self-induced operation or by external means.

Objectives & Scope of the work

The objectives of the proposal include:

a) Designing and analysing non-linear control strategies in Hemispherical Resonator Gyroscopes (HRG) for the following performance improvements

   i. Lower excitation signals/power for same vibration amplitudes with stable operation (thereby increasing the dynamic range of the sensors).

   ii. Reducing Time to Valid data (TTVD) from 4-6 minutes to less than 1 minute.

   iii. Increasing bias stability, SNR and Scalefactor at-least by an order.

   iv. Controlling inherent electrostatic sensing and actuating non-linearities.

b) Simulation the control strategies in MATLAB/SIMULINK with Sensor Models and verifying the performance.

c) Mechanization of the control strategies for implementing in a Digital C.

IISU - 007

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Characterization of random noise implementations & implications in Ring Laser Gyroscope

3. Name of Co PI from ISRO Centre/Unit

Ms. Nisha S. Dathan

4. Contact Address of Co PI & e-mail id

SED/ISG/AIS,
ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: nisha_dathan@vssc.gov.in

5. Area of Research

Mathematics & Physics

6. Summary of the proposed research and expected deliverables

Ring Laser Gyroscopes are inertial sensors known for high accuracy, high bandwidth & high scale factor stability. However, RLGs are susceptible to lock-in effect at low input rates, necessitating a mechanical dither to sinusoidally move the optics. The additional problem of dynamic lock-in due to sinusoidal dithering is overcome by randomizing the dither. However, this adds to angular random walk which is a major noise source affecting Inertial navigation system alignment capabilities.

- Random noise requirement generation based on ISRO Ring Laser Gyro (ILG) specifications & INS (Inertial Navigation System) requirements. This involves deriving a performance metric for random noise for ILG for use in launch vehicles, spacecrafts & landing applications.
- Study on methods of random noise implementations in dither, including pseudo random sequence generator types & comparison with respect to performance metric.
- Implication of random noise in angle output specifically noise equivalent angle, INS alignment time& INS alignment accuracy.
- Study of compensation scheme for Random noise in ILG.

IISU - 008

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Software tool development for assessing impact of process parameters on performance of thin film coating in precision inertial sensing elements.

3. Name of Co PI from ISRO Centre/Unit

Shri Harshit Kumar Gupta

4. Contact Address of Co PI & e-mail id

Advanced Inertial Systems,
ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: hk_gupta@vssc.gov.in, hrshtgpt25@gmail.com

5. Area of Research

Material Science/ Mechanical Engineering/ Chemical Engineering/Physics/ Chemistry

6. Summary of the proposed research and expected deliverables

Sensing element in most of the inertial sensors comprises of thin film coating of Chromium- Gold, Yttrium Fluoride, SiO2, Aluminum, SiC etc. All deposited films have some internal or residual stress which will be present in thin films whether or not external loads are applied. This is mainly attributed to variety of reasons that are introduced during film deposition, which include differential thermal expansion of the film/substrate, mismatches between the lattice parameter of the film and the substrate, atomic peening, incorporation of foreign atoms, microscopic voids, variation of interatomic spacing with crystal size, recrystallization processes, crystallite coalescence at grain boundaries and phase transformations.

The presence of stress / stress gradients in thin films constitutes a major concern in applications related to inertial sensors as excessive stress levels can dramatically affect the performance,

reliability and durability of the sensor. Worst case scenarios sometimes lead to film cracking, peeling off, buckling or blistering. These stresses can significantly impact adhesion and fracture toughness of thin films, resonant frequency in case of microstructures used in advanced high precision gyroscope and accelerometers.

Therefore, there is significant motivation to understand origin of stress and related parameters as they can directly affect the design, processing and life time of advanced sensors. Easiest approach may be performing experimental sensitivity analysis of coating, substrate cleaning related parameters, surrounding environment conditions on grain structure and these properties. However most of the time exactly simulating and quantifying the contributing parameters may be difficult and is not cost effective and time effective approach. Other approaches used are performing computer based simulations like FEM, molecular dynamic simulation of the process using required force fields etc.

Using molecular dynamics tool gives flexibility of simulating fictitious conditions as well, which is almost impossible experimentally. Using this one can find all thermodynamic and mechanical properties.

Deliverables:

1. Development of Molecular Dynamics tool simulating thin film deposition process and operating conditions for various kind of coating processes like EB evaporation, sputtering, Atomic layer deposition etc.
2. Evaluation of thin film related mechanical and thermodynamic properties using developed tool.
3. Demonstration and validation of tool using appropriate experiments on sensing elements of IISU sensors.

IISU - 009

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Innovative thermal management for vibration isolated Inertial Sensors

3. Name of Co PI from ISRO Centre/Unit

Shri Harshit Kumar Gupta

4. Contact Address of Co PI & e-mail id

Advanced Inertial Systems
ISRO Inertial Systems Unit (IISU)
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: hk_gupta@vssc.gov.in, hrshtgpt25@gmail.com

5. Area of Research

Mechanical Engineering

6. Summary of the proposed research and expected deliverables

Inertial Navigation System (INS) is an integral part of any aerospace vehicle that uses sensors like accelerometer and gyroscope. Continuous autonomous estimate of position and attitude of an aerospace vehicle without any external aid is provided by INS. Navigation grade Performance of Inertial Sensors is dictated primarily by thermal environment in which these sensors are operated. A conducive thermal condition for inertial systems is constrained by spacecraft / launch vehicle main frame compartment design.

At system level because of structural limitations of the sensors used, usually these sensors are mounted in a cluster which is suspended using vibration isolators. Typically, elastomers-based vibration isolators are used to achieve desired dynamic characteristics for the cluster. These elastomers act as a thermal isolator because of their low thermal conductivity. This makes suspended cluster to act as an isolated heat source which does not sink heat to the mounting plane. Also, operating range of these sensors for getting best performance is limited typically within 70 deg.

So, an innovative thermal management is required to cater to thermal requirements without affecting suspension mechanism. Two phase flow based thermal solution are conventionally used for managing high heat flux dissipation requirement due to its latent heat extraction properties without any additional equipment requirement. However conventionally used systems effect the suspension mechanism as well. Hence additional constraint of low stiffness demands development of two phase thermal management solution with flexible elements.

Deliverables:

(a) Thermal design of Flexible two phase thermal management solution.

(b) Thermo Mechanical design of flexible two phase thermal management system considering mass, stiffness and space constraints.

(c) Process development for Fabrication of flexible two phase thermal management system.

(d) Standalone evaluation of performance of thermal management system under static environment.

(e) Demonstration of integrated level performance of thermal management solution with suspension mechanism for structural and thermal aspects under dynamic vibration and thermo vacuum environment.

IISU - 010

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Time of flight opto-electronic (LiDAR) system development

3. Name of Co PI from ISRO Centre/Unit

Ms. Nisha S. Dathan

4. Contact Address of Co PI & e-mail id

SED/ISG/AIS
ISRO Inertial Systems Unit (IISU)
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: nisha_dathan@vssc.gov.in

5. Area of Research

Optics, Opto-electronics

6. Summary of the proposed research and expected deliverables

Laser Image Detection and Ranging systems (LiDAR) are increasing being used for many applications like 3D imaging as in robotics, ranging, including providing three-dimensional elevation maps of the terrain, and even for atmospheric studies. LiDAR works on the time-of-flight technology. However, LiDAR technology is less discussed by the leading manufacturers. Since LiDAR augmented inertial systems at low cost are being pursued, it is proposed to develop a LiDAR system with customized time-of -flight ranging hardware cum algorithms. This includes pulsed laser with time to digital converters using time domain correlation, amplitude modulated and frequency modulated continuous wave lasers.

The following are the objectives:

- Study different time-of-flight measurement techniques with respect to minimum frame rate of 50 fps, range of at least 10m and resolution of 1cm, and electronics design requirements, keeping computational cost and power low.
- Explore feasibility of Differential Voltage Measurement of Charged Capacitors in a Photonic mixer device for achieving better resolutions at lower frame rates.
- Design single beam VcSEL or LED based laser and detector pair, and the drive and sense electronics.
- Design scalability to array laser or scanning laser, and array CMOS/CCD photodetectors also to be studied & ensured.

IISU - 011

1. Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

2. Title of the research proposal

Miniature High Performance GNSS ultra-Low Noise Amplifier with NavIC Signals

3. Name of Co PI from ISRO Centre/Unit

Shri C Radhakrishna Pillai

4. Contact Address of Co PI & e-mail id

Group Director, CSNG, LVIS,
ISRO Inertial Systems Unit (IISU),
Vattiyoorkavu PO, Thiruvananthapuram.
e-mail: c_radhakrishnan@vssc.gov.in

5. Area of Research

NavIC Receiver Systems

6. Summary of the proposed research and expected deliverables

The proposal is for design and realizing an ultra-low noise amplifier supporting multiple GNSS constellations. The amplifier shall support NavIC L5, S band signals, GPS L1, L2 and L5 band signals, GALILEO E1, E5 signals. The major constraints of the system are weight, power and performance. The systems shall be able to tolerate the launch vehicle environmental specification, thermal and EMI specification of standard ETLC document for launch vehicles. Pass band gain of 35±2dB and noise figure less 3.0dB at 70°C shall be met. Pass band and rejection frequencies will be specified in detailed specification, but spot frequency rejection (Frequencies will be given in detailed specification) of >50dB to be achieved in selected frequencies. The weight of the packaged amplifier including connector shall be less than 70gm and power shall be less than 250mW. The amplifier shall work in 5V DC.

INDIAN INSTITUTE OF REMOTE SENSING
DEHRADUN

IIRS - 001

1. Name of ISRO Centre/Unit
Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal
Assimilation of Satellite Data in Numerical Weather Predication Model for Tropical Cyclones Predication

3. Name of Co PI from ISRO Centre/Unit
Dr. Sanjeev Kumar Singh

4. Contact Address of Co PI & e-mail id
Marine & Atmospheric Sciences Department
Indian Institute of Remote Sensing,
Indian Space Research Organisation, Dehradun.
e-mail: sksingh@iirs.gov.in

5. Area of Research
Tropical Cyclone, Remote sensing data assimilation in the Numerical Weather Prediction model, Numerical Weather Prediction

6. Summary of the proposed research and expected deliverables
Improving the Tropical cyclone prediction is always an important research area and challenging task since it has a significant impact on human life, properties and environment. Tropical cyclone form over the oceanic region where traditional observations are limited or rare. Due to this, there is certain problem to define the accurately initial state of atmosphere in numerical models. The advancement of the assimilation techniques allow to use the high resolution satellite data in Numerical Weather Prediction (NWP) models to improve the initial condition for better prediction of tropical cyclones.

The tropical cyclones forecasting involves the prediction of several associated parameters, such as the cyclogenesis, track, intensity, landfall induced storm surges and rainfall. Among all these associated parameters, it is most important to know about the intensity, direction of a cyclone movement and landfall position so that the inhabitants of potentially affected areas can be warned well ahead of time and minimize the damage potential. Recently, NWP models have shown significant improvement in tropical cyclone forecasting due to high resolution, improved data assimilation techniques and more number of satellite data. The intensity forecast from numerical models is still challenging task. Satellite measurements are an important source of regional and global observations in support of NWP models. The use

of high spatial and temporal resolutions satellite observations in NWP models can improve the tropical cyclones forecasting. Therefore, in this project, it is proposed to utilization of satellite observations through advanced data assimilation techniques in the NWP model for better prediction of cyclogenesis, track, intensity and landfall position.

IIRS - 002

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Numerical simulation and modelling of rainfall triggered debris flows/ landslides in Uttarakhand Himalaya

3. Name of Co PI from ISRO Centre/Unit

Dr. Shovan L. Chattoraj

4. Contact Address of Co PI & e-mail id

Geosciences Department
Geosciences & Disaster Management Studies Group
Indian Institute of Remote Sensing,
Indian Space Research Organisation, Dehradun.
e-mail: shovan@iirs.gov.in / richa@iirs.gov.in

5. Area of Research

Landslide modelling using earth observation data

6. Summary of the proposed research and expected deliverables

The proposed project focuses on usage of EO and ground truth data for numeral modelling of different types of landslides. Debris flows and debris rushes have become a major natural hazard process in hilly regions which are complex, gravity-driven, water and sediments with extreme moveable capacity. Debris flow modelling is a dynamic area of research and the major principle can be applied to a variety of processes including debris flows, mud flows, snow slip and even rock falls. It has found significant role in disaster management and mitigation. In the current study state of the art of numerical simulation model to employed to predict the motion of a naturally occurring mass from head (release area) to base (deposition area) in 3D/2D. Digital Elevation Model (DEM), rheological inputs and secondary ground data i.e. geotechnical parameters are fundamental prerequisites for this type of model.

IIRS - 003

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

The assessment of seismic hazard in the Himalayan region through the identification of subsurface features and estimating the enduring strain build-up rate by the integrated study of GNSS and Geophysical methods.

3. Name of Co PI from ISRO Centre/Unit

Mr. Suresh Kannaujiya

4. Contact Address of Co PI & e-mail id

Geosciences Department
Indian Institute of Remote Sensing,
Indian Space Research Organisation, Dehradun.
e-mail: skannaujiya@iirs.gov.in

5. Area of Research

The application of Geophysical tools in identifying subsurface features, Acquiring GNSS data from GNSS stations to calculate the strain budget, seismic coupling and prevailing convergence rate along the Himalayan arc

6. Summary of the proposed research and expected deliverables

The aim of this project is to unveil the future seismicity by calculating and observing the current parameters of Himalaya. The primary characteristic that identifies the active tectonic zone is the presence of active faults or past faulting activity which studied by using geophysical methods. Once zone gets identified, the GNSS data estimates strain rate both regionally as well as locally and also the rate of prevailing plate convergence. This way on monitoring the surface deformation the future seismic hazard can get assessed.

The project shall be using the GNSS data to estimate the stress/strain in the Himalayan region. The successful strain modelling gives profound idea of the realm's future seismicity. Therefore, the aim of this study is to identify the subsurface features whose records are hard to find in some geological investigation, monitoring the crustal deformation and estimating strain rate build-up for enduring period.

IIRS - 004

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Assessment, Monitoring and Management of Wetland Ecosystem using Radar Remote Sensing

3. Name of Co PI from ISRO Centre/Unit

Dr. Hari Shanker Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Radar Remote Sensing (SAR), Wetland Ecosystem, Machine Learning Techniques, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, PolInSAR etc., & also multi-parametric SAR

6. Summary of the proposed research and expected deliverables

Wetland ecosystems have received little recognition on the vital role that they play for human wellbeing. As a result of this, there is an alarming loss of wetlands. It is required to arrest the losses and to achieve optimal resource use with balanced priorities of biodiversity conservation. This calls for meaningful and timely information and data on wetland ecosystem like various wetland habitats, its fauna, flora and socioeconomic variables of relevance. Traditionally, the source of the spatial information that captures dynamics of a wetland ecosystem has been that of optical remote sensing data. Although optical remote sensing data is found to be very useful for wetland monitoring, cloud cover restricts the availability of satellite data during rainy season, which is main source of water for most of the inland wetlands. Moreover, delineation of several classes of importance for wetland ecosystem is also not clearly differentiable on optical remote sensing data. Synthetic Aperture Radar (SAR) due to its unique sensitivity towards physical, geometrical and dielectrical properties of various components of a wetland ecosystem along with all-weather & penetration capabilities of SAR can play an important role to achieve above goals. Wetlands play an important role in ground water recharge and also provide unique habitats for wide range of flora & fauna. Therefore, wetlands have significant biodiversity resources. However, the recognition of biodiversity conservation values of the wetlands has been neglected for a long time. As a result of this, there is an alarming loss of wetlands. The alarming loss of wetlands all over the globe had initiated an inter-governmental treaty which provides the framework for National action and International cooperation for the conservation and wise use of wetlands and their resources. This treaty was signed in Ramsar, Iran, in 1971 and is known as ‘Ramsar Convention’.

In order to monitor wetlands, on local, regional and national levels, there is an urgent need to develop user friendly and cost effective tools. Remote sensing can play an important role for assessment, monitoring and management of wetland ecosystem. Lot of work has already been done in the field of wetland studies using data from conventional remote sensing sensors operating in optical and infrared region of the electromagnetic spectrum. However, for studies of wetland, optical remote sensing data exhibit a few limitations. In contrast to radar remote sensing, the major limitation with optical data is uncertainty of getting cloud free data during monsoon (rainy) season. The analysis during monsoon season is of prime importance as it is the main source of water that controls the ecosystem of most of the inland wetlands. Moreover, sensitivity of optical data for physical, geometrical, dielectrical and textural variation

of vegetation (both terrestrial and aquatic) is also limited as compared with Radar data operating in the microwave region of the electromagnetic spectrum, which is highly sensitive for these properties of various components of a wetland ecosystem. Capability of microwave signals transmitted from the Synthetic Aperture Radar (SAR) sensor to penetrate vegetation cover and to sense the moisture content of the earth materials, allows microwaves to monitor the wetland ecosystem more accurately as compared to optical remote sensing tools.

Development & validation of Methods / Methodology for efficient monitoring / assessment / management of a wetland ecosystem, Discrimination of various wetland habitats, Methods / Methodology should be developed and validated for a Ramsar Wetland Site.

IIRS - 005

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Forest species discrimination in mixed forest scenario & forest biophysical parameters retrieval using Synthetic Aperture Radar

3. Name of Co PI from ISRO Centre/Unit

Dr. Hari Shanker Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing,
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Radar Remote Sensing (SAR), Forestry, Machine Learning Techniques, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, PolInSAR, SAR Tomography etc., & also multi-parametric SAR

6. Summary of the proposed research and expected deliverables

Unique sensitivity of SAR data towards physical, geometrical and dielectrical properties of forest trees and plantations of various shapes, sizes and structures along with all-weather & penetration capabilities of SAR can successfully be used to retrieve various biophysical parameters of forest like forest above ground biomass, tree height etc. along with detailed species discrimination in mixed forest type scenario.

Penetration and all-weather capability of SAR along with sensitivity of SAR data towards physical, geometrical and dielectrical properties of forest trees and plantations of various shapes, sizes and structures along with all-weather & penetration capabilities of SAR can successfully be used to retrieve various biophysical parameters of forest like forest above

ground biomass, tree height etc. Availability of multi-parametric SAR along with advance SAR techniques like SAR Interferometry, Hybrid polarimetry, fully polarimetry, PolInSAR, SAR tomography etc. can be used successfully for various other forestry applications along with detailed forest type discrimination in mixed forest type scenario.

Development & validation of Methods / Methodology for biophysical parameters retrieval of forests using advance SAR techniques along with Machine learning techniques, Species discrimination in mixed forest scenario & efficient monitoring of Natural forests or large plantation areas.

IIRS - 006

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Advanced methods and algorithms for automatic information extraction for (online/offline) processing and analysis of images/data from various multi-source data

3. Name of Co PI from ISRO Centre/Unit

Dr. Vandita Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Automating Information Extraction; Image Processing and analysis

6. Summary of the proposed research and expected deliverables

Extraction of important information from a satellite image or a set of satellite images (such as 2D & 3D building parameters and individual trees, water bodies, roads and their types, tree plantations, parks, play grounds, built up area, in a habituated (urban or rural) area, in-land water bodies, information on cultural heritage and tourism sites, etc.) is important for various purposes (inventorisation, planning, management and decision making) at various levels. Availability of multi & hyper spectral (optical/ microwave), multi resolution/sensor, multi multi-temporal from multiple platforms (space based aerial/ ground based/ UAV/ LiDAR) coupled with appropriate automated methods could fulfil the requirement of information extraction from satellite images. Several potential methods such as neural networks & deep learning, natural intelligence based methods, object based methods considering spatial spectral classification analysis, contextual methods, appropriate fusion (at pixel/ feature level) of multi-source data, need to be explored for effective utilization of the huge amount of multi-source data available from remote sensing satellites.

The objective of the research project is to propose a methodology for automating information extraction, mapping and modelling of land and water features such as buildings, individual trees, tree plantations, parks & play grounds, other built-up features important for various planning, and social activities. The research would aim at working on methods and evaluating methods and working out a common framework for automating the processing of extraction and modeling from optical, hyper-spectral or microwave data, or a combination of these. Exploring advanced techniques, their performance evaluation for automated mapping, proper inventorization, building accurate databases and 3D models of man-made resources is the ultimate goal of this research. The input data could be multi-source such as multi & hyper spectral, multi resolution, multi temporal satellite images, 3D point clouds obtained from LiDAR, stereo images, from various platforms, ground observations for validation and verification and other sources of higher accuracies. The deliverables would be in terms of methods/ frameworks automating the process of extraction and modelling, along with performance evaluation of proposed techniques of extraction for their use in various domains such as urban & rural, vegetation, water, disaster management related applications. The research has potential to contribute for accurate inventorisation of human and natural resources at a suitable scale.

IIRS - 007

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Development of models and algorithms for geospatial modelling of various geographic phenomena

3. Name of Co PI from ISRO Centre/Unit

Dr. Vandita Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Geostatistics, Geospatial Analysis & Modelling

6. Summary of the proposed research and expected deliverables

Introduction:

Various algorithms for mapping and modelling of geographic phenomena have been/ are being developed. Their application potential needs to be evaluated on specific case/ scenario basis, with the constrained availability of input information.

Purpose of Research:

Investigating & evaluating methods for mapping, modelling of spatial phenomena is the final goal of this research. This requires development of models and algorithms for geospatial modelling of various geographic phenomena for understanding and describing underlying processes and studying distribution and spatial structures, relation with associated variables (various parameters of soil, water, land such as distribution of ground water level, variation of pollution levels in a region, study of electrical conductivity and PH of water/soil etc.), dispersion/ spread models and point spread.

Details:

For analysis & modelling of Geospatial phenomena such as pollution dispersion, disease spread, spatial networks of utilities, population distribution, land-use growth and change, exploring, developing and evaluating advanced methods of geospatial modelling (such as advanced methods of spatial modelling, geostatistical modelling, multi-dimensional modelling (surface modeling, time-series analysis and modelling), network modelling, etc.) is the need of time for utilizing huge information being derived from available repositories of satellite data. Proposals addressing investigation of models for modeling of such phenomena will enable appropriate and efficient use of the available space based, aerial and ground based data repositories. Geostatistics with its strong mathematical foundation, is a potential tool for studying spatio-temporal distribution, spatial properties such as spatial structure of geographic phenomena. Exploring advanced methods of geostatistics for modelling of geographic phenomena and their performance evaluation in real world situations which will lead to more precise, accurate as well as spatially informed mapping and modelling of such phenomena.

Development of models and algorithms for geospatial modelling of various geographic phenomena (various parameters of soil, water, land such as distribution of ground water level, variation of pollution levels in a region, study of electrical conductivity and PH of water/soil, etc., dispersion/spread models) would lead to better understanding of underlying processes and distribution and spatial structures, scales and range, their relation with associated variables.

IIRS - 008

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Crop growth monitoring & crop biophysical parameters retrieval using SAR

3. Name of Co PI from ISRO Centre/Unit

Dr. Hari Shanker Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Radar Remote Sensing (SAR), Agriculture, Machine Learning Techniques, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, PolInSAR etc., & also multi-parametric SAR

6. Summary of the proposed research and expected deliverables

All weather capability of SAR data which ensures uninterrupted data supply, when coupled with unique sensitivity of SAR data towards physical, geometrical and dielectrical properties of various crops along with penetration capability of SAR make it a perfect choice for crop growth monitoring and crop biophysical parameters retrieval for various crops. Use of multi-parametric SAR and advance SAR techniques like SAR Interferometry (InSAR), SAR Polarimetry (PolSAR) & PolInSAR allow to retrieve various crop biophysical parameters like LAI, Crop height, Crop volume, Crop water content, Crop fresh biomass, crop density etc. Use of various Machine Learning Techniques can further improve the retrieval accuracy.

Development & validation of Methods / Methodology for biophysical parameters retrieval of various crops using advance SAR techniques along with Machine learning techniques, Species discrimination in mixed crop scenario & efficient monitoring of agricultural crops.

IIRS - 009

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Soil moisture retrieval using microwave remote sensing

3. Name of Co PI from ISRO Centre/Unit

Dr. Hari Shanker Srivastava

4. Contact Address of Co PI & e-mail id

PPEG,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Radar Remote Sensing (SAR), Agriculture, Machine Learning Techniques, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, PolInSAR etc., & also multi-parametric SAR

6. Summary of the proposed research and expected deliverables

Large difference between dielectric constant of water and dry soil & penetration capability of Radar signal are the key factors behind the fact that microwave remote sensing is the best tool for large area soil moisture retrieval / mapping. However, along with dielectric constant/ water content of soil, SAR is also sensitive towards many other target properties like surface

roughness, vegetation cover and soil texture. These parameters act as noise while retrieving soil moisture using microwave remote sensing data. Therefore, it is necessary and also challenging to retrieve soil moisture with high accuracy by incorporating the effects of noise parameters in the soil moisture retrieval model. Use of multiparametric SAR along with advance SAR techniques like Interferometric coherence, Hybrid polarimetry, fully polarimetry, PolInSAR can successfully retrieve soil moisture under variety of agricultural heterogeneities. Use of advance Machine Learning Techniques are expected to further improve the soil moisture retrieval accuracy.

Passive microwave remote sensing data can also be used for very large area soil moisture estimation but due to very poor spatial resolution, soil moisture retrieval accuracy is relatively lower than SAR data and it's also difficult to apply it on farmers' fields. However, advantage of fine temporal resolution of passive microwave RS data and advantage of fine spatial resolution of SAR RS data can be combined to generate daily soil moisture maps at relatively finer spatial resolution.

Development & validation of Methods/ Methodology for soil moisture estimation using active and/or passive microwave remote sensing under variety of agricultural heterogeneities. Methodology should be applicable to large area soil moisture estimation.

IIRS - 010

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Hydrological Parameters Retrieval using Remote Sensing (Evapotranspiration ET, Surface Runoff SR, Snow Physical Parameters, Glacier Facies, Glacier Velocity, Snow/glacier melt, change in Terrestrial Water Storage ΔTWS)

3. Name of Co PI from ISRO Centre/Unit

Dr. Praveen Kumar Thakur

4. Contact Address of Co PI & e-mail id

Water Resources Department, Indian Institute of Remote Sensing
4, Kalidas Road, Dehradun-248001, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Hydrological Parameters Retrieval

6. Summary of the proposed research and expected deliverables

The hydrological parameters such as Precipitation, Evapotranspiration (ET), Soil Moisture (SM), Surface Runoff (SR), Snow Physical Parameters, Glacier Facies, Glacier Velocity, Snow/glacier melt, change in Terrestrial Water Storage (ΔTWS) are essential for water balance

and hydrological quantification of any river basin or watershed. The traditional ground based methods of hydrological parameters estimation are mostly point based, and very good temporal resolution, but lack spatial coverage. The large spatial variation in hydrological parameters such as rainfall, SM, ET, Snow Water Equivalent (SWE) and (ΔTWS) can be easily overcome by remote sensing based hydrological parameters retrieval methods. The temporal variation of some of these parameters can be at sub-daily to hourly time scale, and some of the remote sensing satellites working in constellation mode can easily address such issues.

The present project can be used to develop and validate the remote sensing based hydrological parameters retrieval techniques with ground truth from existing and future planned set of ground instruments/observations for Indian conditions. The derived hydrological parameters can be used in data assimilation mode for improving the prediction and assessment capability of hydrological models.

The main deliverable from this project will be time series of hydrological parameters derived from various remote sensing based satellites, sensors and validated with ground based observations.

IIRS - 011

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Flood Prone Area Mapping, Modeling/Forecasting & Risk Assessment using Geospatial Tools (SAR, Optical, Satellite Altimetry, Topographic Indices)

3. Name of Co PI from ISRO Centre/Unit

Mr. Pankaj R. Dhote

4. Contact Address of Co PI & e-mail id

Water Resources Department,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Flood Studies

6. Summary of the proposed research and expected deliverables

Flooding during the monsoon season is a recurring problem in many parts of India. Different Indian states, especially North West Himalayan (NWH) states (J&K, HP and UK) have experienced large number of hydrometeorological disasters such as high intensity precipitation and subsequent flooding in downstream areas in the last few years. Few major flood disasters

associated with high intensity rainfall are Kerala flood 2018, Manali flood 2018, Leh flood 2010, Manali and Uttarkashi flash floods of 2012, Ukhimath flash floods and mud slides of 2012. The floods in entire Uttarakhand, part of Himachal and GLOF at Kedarnath during 15-17 June 2013 are worst ever for NWH region. Flood events leads to extensive socio-economic damages, as happened in Kedarnath area during 15-17 June 2013.

Therefore, scientific study of such flood prone areas will help to reduce vulnerability from such hazards and also enhance the disaster management capacity of various disaster management agencies of this region. Expected deliverables and theme of proposed research will be:

- Investigation of topography based indices (Ex. HAND, TWI, SP) for floodplain mapping
- Assimilation of satellite altimetry in hydrodynamic modelling for high flow monitoring
- Innovation in hydrological-hydrodynamic modelling input data preparation using integration of in-situ and satellite data
- Innovation in glacial lake outburst flood

IIRS - 012

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Climate Induced and Urbanisation Impact on Urban Flood Hazard and Risk Modeling

3. Name of Co PI from ISRO Centre/Unit

Shri Pramod Kumar

4. Contact Address of Co PI & e-mail id

Urban and Regional Studies Department,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Urban Planning
Sub-area: Urban Flood Hazard, Vulnerability Analysis and Risk Modelling

6. Summary of the proposed research and expected deliverables

Reliable and timely prediction of flood extents in urban catchments is a challenging issue. Various modelling approaches are available ranging from data driven to physically based, from conceptual to detailed 1D-2D modelling.

These approaches are then ensembled in wider context of flood risk assessment and disaster management. An integrated model that simulates the sewerage-network, river-network and 2D mesh-network are desirable to obtain flood extents in urban areas so that whenever overflows occur due to insufficient drainage capacity, the resultant surface flooding and/or levee break could be predicted.

As the cities generally are co-located along river/ waterbodies, studies are required to interlink space based observations driven hydrological and hydro-dynamic properties of SWD network and of entire catchment for integrated flood risk modelling. GIS coupled Storm Water Management Models are useful to estimate the runoff depth, extent, peak flow and intensity of flooding taking into consideration the remote sensing data- derived elevation, slope, land Use/Land Cover (LULC), rainfall conditions and the designed Storm Water Drain (SWD) infrastructure of the city.

IIRS - 013

1. Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

2. Title of the research proposal

Urban Micro- and Meso-Scale Climate
Modelling and Urban Canopy Parameters Estimation

3. Name of Co PI from ISRO Centre/Unit

Dr. Kshama Gupta

4. Contact Address of Co PI & e-mail id

Urban and Regional Studies Department,
Indian Institute of Remote Sensing
4 Kalidas Road, Dehradun, Uttarakhand.
e-mail: vandita@iirs.gov.in

5. Area of Research

Urban Planning
Sub-area: Urban micro-climate modeling

6. Summary of the proposed research and expected deliverables

Study of urban climate is important at local and global scale, which is influenced by several factors such as urban morphology and density, properties of urban surfaces, vegetation cover, etc. The urban built-form due to its dense development and high-rise character, and the increase in impervious and absorptive surfaces are responsible for the trapping of heat and reduction in evaporative cooling due to decrease in vegetated, soft, pervious surfaces in urban areas. The study of urban climate is also gaining further importance in the scenario

of climate change. Technology development is desirable for the generation of 3D urban database, urban parameterization in numerical weather models, urban canopy parameters estimation and understanding the micro- and meso-scale urban climate phenomena using space based observations. Such studies shall be helpful for micro-climate zonation of urban areas for climate oriented planning guidelines.

NORTH EASTERN SPACE APPLICATIONS CENTRE
SHILLONG

NESAC - 001

1. Name of ISRO Centre/Unit
North Eastern Space Applications Centre, Shillong

2. Title of the research proposal
Wetland biomass dynamics, carbon sequestration and ecosystem services of flood plain wetlands of NER

3. Name of Co PI from ISRO Centre/Unit
Dr. Kasturi Chakraborty

4. Contact Address of Co PI & e-mail id
North Eastern Space Applications Centre (NESAC),
Shillong, Umiam, Meghalaya.
e-mail: kasturi.c@nesac.gov.in

5. Area of Research
Wetland monitoring and ecosystem service

6. Summary of the proposed research and expected deliverables
Wetlands are transitional zones between terrestrial and aquatic ecosystems that experience seasonal or permanent surface water. Their soils are saturated and hydrophytic vegetation predominates. Knowledge of the amount of vegetation biomass is needed for understanding local carbon budget. The mass of living material is often used in the regional carbon pool models. Biomass changes can also be an indicator of wetland health and vegetation stress due to human caused disturbance. Typically, field based biomass measurements are carried out in geographic quadrat plots by harvesting to compute biomass. In this, direction remote sensing can play an important role to map and monitor the wetlands. This will help in spatial and temporal monitoring of wetlands.

The study area is planned to be taken up in few important flood plain wetland ecosystems NER. These are the season wetlands showing high water fluctuations. Besides the biomass dynamics, the wetlands also provide tremendous ecosystem services.

Objectives:

(1) Temporal and spatial inventory of wetland biomass

(2) Ecosystem services provided by the selected wetlands

NESAC - 002

1. Name of ISRO Centre/Unit

North Eastern Space Applications Centre, Shillong

2. Title of the research proposal

Qualitative and quantitative classification of mixed bamboo forests using geospatial technology

3. Name of Co PI from ISRO Centre/Unit

Dr. K K Sarma

4. Contact Address of Co PI & e-mail id

North Eastern Space Applications Centre (NESAC),
Shillong, Umiam, Meghalaya.
e-mail: kk.sarma@nesac.gov.in

5. Area of Research

Bamboo Forest Resource management

6. Summary of the proposed research and expected deliverables

Identification of bamboo growing areas with their composition is very important for proper planning and management of the resources. The space technology has been playing a vital role in mapping and identification of natural resources. However, due to signature mixture of bamboo with other tree species when it growing together, it become difficult quantify the actual bamboo resources growing in any area.

Therefore, it is proposed to explore the possibility of segregating the mixed bamboo forests both in terms of qualitative as well as quantitatively. Study areas should be preferably in NE region.

NATIONAL ATMOSPHERIC RESEARCH LABORATORY
GADANKI, TIRUPATI (AP)

NARL - 001

1. Name of ISRO Centre/Unit
National Atmospheric Research Laboratory, Gadanki (AP)

2. Title of the research proposal
Mathematical Modelling and Numerical Simulations for Remote Sensing by Global Navigation Satellite System – Reflectometry (GNSS-R) Technique

3. Name of Co PI from ISRO Centre/Unit
Dr. T.V. Chandrasekhar Sarma

4. Contact Address of Co PI & e-mail id
National Atmospheric Research Laboratory
Gadanki, Chittoor District, AP.
e-mail: tvcsarma@narl.gov.in

5. Area of Research
Computational electromagnetic (CEM) simulations on High Performance Computing (HPC) platforms for GNSS-R applications

6. Summary of the proposed research and expected deliverables
Signals of opportunity from global and regional navigational satellite system constellations are being gainfully employed for remote sensing of soil moisture and biomass. Mathematical modeling and numerical solution of Electro-Magnetic (EM) wave propagation and scattering under varying levels of soil moisture and quantities of biomass is required for analysis of results from field experiments. As Maxwell's equations can be solved exactly using fast CEM algorithms without any approximations on latest HPC facilities, studies on radar scattering mechanism using surface and volume based CEM methods in the context of GNSS-R are needed. The objectives of this work are as follows:

a. Modelling the GNSS/IRNSS signal propagation and scattering from soil moisture and biomass.

b. Numerical simulation of the scattering process of GNSS/IRNSS signals from composite arbitrarily shaped bodies in the context of GNSS-R applications.

Deliverables:

i. Theoretical formulation of the scattering from low to high soil moisture levels and quantities of biomass.

ii. Algorithm and numerical solutions of the problem formulation.

iii. Software routine to generate scattered signal fields for various geometries of the source and target.

Software code(s) with detailed documentation including the specifications of the routines/ subroutines (input-output and mathematical description(s)) to carry out further studies on different soils and biomass quantities under varying moisture conditions.

NARL - 002

1. Name of ISRO Centre/Unit

National Atmospheric Research Laboratory, Gadanki (AP)

2. Title of the research proposal

Statistical dynamic noise background estimation and compressed sensing based signal detection in atmospheric radar

3. Name of Co PI from ISRO Centre/Unit

Dr. T.V. Chandrasekhar Sarma

4. Contact Address of Co PI & e-mail id

National Atmospheric Research Laboratory
Gadanki, Chittoor District, AP.
e-mail: tvcsarma@narl.gov.in

5. Area of Research

Atmospheric Radar Signal Processing

6. Summary of the proposed research and expected deliverables

Signal detection performance in atmospheric radar is determined by the noise, clutter and radio frequency interference (RFI) background. Present estimation schemes consider noise as Gaussian distributed, but studies have shown that its statistical characteristics vary with online radar signal processing parameters like coherent integration and incoherent integrations. Further, the distribution of noise background could evolve while simultaneously the echo signal level varies due to aperture degradation caused by failure of transmitters. Aperture degradation also leads to spurious echoes due to beam shape problems as well as reduced range coverage. Also, low reflectivity regions will return signals that could be below noise thresholds. Due to low SNR at certain ranges, signal detectability comes down leading to discontinuities in Doppler profiles in range and time. Competing RFI and clutter further exacerbate the problem. In order to solve these problems, it is proposed to investigate noise distribution in long data sets and arrive at improved noise estimation and removal algorithms. Using statistical maps of evolution of distribution of noise, it is proposed to improve the signal detectability in low SNR regimes like far off range gates as well as low reflectivity intermediate ranges. Compressed sensing methods are ideally suited to reconstruct the missing signal from the available samples.

Main objectives and deliverables of this work are:

a. Development of algorithm to estimate dynamic noise distribution.

b. Development of a new algorithm for estimation of noise signals based on the revealed distribution.

c. Algorithm for excision of RFI and clutter.

d. Compressed sensing based algorithm for reconstruction of missing signals.

Software code(s) with detailed documentation including the specifications of the routines/ subroutines (input-output and mathematical description(s)).

NARL - 003

1 Name of ISRO Centre/Unit

National Atmospheric Research Laboratory, Gadanki (AP)

2 Title of the research proposal

(A)Study of Space weather/climate and lower atmospheric forcing on equatorial and low latitude ionosphere and variabilities using GNSS and NavIC

(B) Study of Equatorial Plasma bubbles: Scintillations and depletions and its impact of Satellite Navigation

3 Name of Co PI from ISRO Centre/Unit

Dr. Nirvikar Dashora

4 Contact Address of CoPI & e-mail id

National Atmospheric Research Laboratory
Gadanki, Chittoor District, AP.
e-mail: ndashora@narl.gov.in

5 Area of Research

(A) Space Weather, Ionosphere, lower atmospheric forcing on ionosphere

(B) Applications of GNSS/NavIC in precise point positioning (PPP) and effect of ionosphere

6 Summary of the proposed research and expected deliverables

Brief about Themes

(A) Variations in ionospheric electron density and TEC during solar storms causing space weather changes and its impact of magnetosphere-ionosphere coupling

(B) Extreme Lower atmospheric forcing events such as Cyclones, lightning, Earth quakes and SSW and its direct relation with ionospheric perturbations

(C) Equatorial plasma bubbles (EPBs): its triggering, growth, drift and decay related variabilities and impact on satellite navigation and PPP and differential positioning

Annexure-1

Application for Grant of Funds

1.	Title of the Research Proposal	
2.	Name of the Principal Investigator (Address/Phone/E-mail)	
3.	Name(s) of other investigator(s) with the name(s) of their Institution	
4.	Name of the Institution with Full Address	
5.	Whether the Institution/University is a Government Institution or Non-Government Institution?	
6.	Is the Institution/University/Society managed by an NGO/Trust/Society If yes, provide the details	
7.	If the Institution/society is Non- Government: NGO Darpan Unique ID of the Institution* : PAN Number* : *(It is mandatory for all institutions/ professional societies other than Central/State Govt. Institutions / Departments)	
8.	Proposed duration of Research Project	
9.	Amount of grant requested (in Rs.) 1st Year, 2nd Year, 3rd Year & Total	
	Manpower	
	Equipment	
	Satellite Data/Data	
	Consumables & Supplies	
	Internal Travel	
	Contingency	
	Others	
	Overheads	
	Total	

10.	a) Bio-data of all the Investigators (Format-A). b) Brief description of the Research Proposal with details of budget (Format-B). c) Declaration (Format-C).
11.	I/We have carefully read the terms and conditions for ISRO Research Grants and agree to abide by them. It is certified that if the research proposal is approved for financial support by ISRO, all basic facilities including administrative support available at our Institution and needed to execute the project will be extended to the Principal Investigator and other Investigators.

Name	**Institution**	**Designation**
Principal Investigator		
Co-Investigator(s)		
Head of the Department/Area		
Head of the Institution		

Form A

Bio-data of the Investigator(s)

(Bio-data for **all the investigators** should be given, each on a separate sheet)

1.	Name	
2.	Date of Birth (dd/mm/yyyy)	
3.	Designation	
4.	Degrees conferred (begin with Bachelor's degree)	

Degree	Institution conferring the degree	Field(s)	Year

5.	Research/training experience (in chronological order)

Duration	Institution	Name of work done

6.	Major scientific fields of Interest	
7.	List of publications (Only the journal papers to be listed)	
8.	Email id and Telephone number of PI with STD Code	
9.	Email id of the Head of the academic institution	

Form B

1.	Title of the research proposal	
2.	**Summary of the proposed research** A Simple concise statement about the investigation, its conduct and the anticipated results in no more than 200 words.	
3.	**Objectives** A brief definition of the objectives and their scientific, technical and techno-economic importance.	
4.	**Major Scientific fields of Interest** A brief history and basis for the proposal and a demonstration of the need for such an investigation preferably with reference to the possible application of the results to ISRO's activities. A reference should also be made to the latest work being carried out in the field and the present state-of-art of the subject.	
5.	Linkages to Space Programme and Deliverables to ISRO on successful completion of the project.	
6.	**Approach** A clear description of the concepts to be used in the investigation should be given. Details of the method and procedures for carrying out the investigation with necessary instrumentation and expected time schedules should be included. All supporting studies necessary for the investigation should be identified. The necessary information of any collaborative arrangement, if existing with other investigators for such studies, should be furnished. The principal Investigator is expected to have worked out his collaborative arrangement himself. For the development of balloon, rocket and satellite-borne payloads it will be necessary to provide relevant details of their design. ISRO should also be informed whether the Institution has adequate facilities for such payload development or will be dependent on ISRO or some other Institution for this purpose.	
7.	**Data base and analysis** A brief description of the data base and analysis plan should be included. If any assistance is required from ISRO for data analysis purposes, it should be indicated clearly.	
8.	**Available Institutional facilities** Facilities such as equipments, etc, available at the parent Institution for the proposed investigation should be listed.	

9.	**Fund Requirement** Detailed year wise break-up for the Project budget should be given as follows:

Fellowships*	**1st Yr**	**2nd Yr**	**3rd Yr**	**Total**
Research Scientist				
Research Associate				
Research Fellows				
Total				
*Note: please specify the designation, qualification and rate of salary per month for each category				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
Equipment**				
Total				
Please specify the various individual items of equipment and indicate foreign exchange requirement, if any				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
Satellite data/data				
Total				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
Consumables & Supplies				
Total				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
Internal Travel				
Total				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
	Total			
Contingencies				
Total				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
	Total			
Others				
Total				
	1st Yr	**2nd Yr**	**3rd Yr**	**Total**
	Total			
Overheads(Overhead Expenses of 20% of Total Project Cost not exceeding ₹3.00 lakhs				
Total				

10.	Whether the same or similar proposal has been submitted to other funding agencies of Government of India. If Yes please provide details of the institution & status of the proposal.	Yes/No

**Justify each equipment. If computer is proposed, only desktop has to be purchased but not laptop.

Annexure-2

Form –C

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		

Annexure-3

One hard copy and a soft copy of the proposal shall be sent to the respective ISRO/DOS Centre to the addresses given below with a copy to Respond Office, ISRO HQs.

Sl. No	ISRO/DOS Centre	Name & Designation	Contact details
1.	VSSC	Shri S Sridharan, Respond Coordinator Vikram Sarabhai Space Centre, ISRO PO Thiruvananthapuram: 695 022	Tel: 0471-2564620 e-mail: s_sridharan@vssc.gov.in respond@vssc.gov.in
2.	SAC	Dr. (Smt.) Parul Patel Respond Coordinator Space Applications Centre Ambavadi Vistar PO Ahmedabad: 380 015	Tel: 079-26913338 e-mail:parul@sac.isro.gov.in
3.	URSC	Shri S Ganesan Respond Coordinator, U R Rao Satellite Centre HAL Airport Road Vimanapura PO Bengaluru: 560 017	Tel: 080- 23026427 e-mail: ganeshan@ursc.gov.in
4.	NRSC	Shri P Krishnaiah Head, TMD Respond Coordinator National Remote Sensing Centre, Balanagar Hyderabad: 500 037	Tel: 040-23884051 e-mail: krishnaiah_p@nrsc.gov.in
5.	LPSC	Shri Arun S Respond Coordinator, PPEG, MSA Entity Liquid Propulsion Systems Centre, Valiamala PO Thiruvananthapuram: 695 547	Tel: 0471-2567007 e-mail: arunsadanandan@lpsc.gov.in, respond@lpsc.gov.in
6.	IPRC	Shri Nagarajan C Engg. SF; Manager, HRD Respond Coordinator ISRO Propulsion Complex Mahendragiri: 627 133	Tel: 04637 281776 e-mail: nagarajan.c@iprc.gov.in

7.	PRL	Dr. Nandita Srivastava Professor and Deputy Head (Admin), Udaipur Solar Observatory Physical Research Laboratory Badi Road, Dewali Udaipur-313001 Rajasthan	Tel: 0294-2457211 e-mail: nandita@prl.res.in respond@prl.res.in
8.	SDSC-SHAR	Shri Bala Narayanan N R, Engineer, PPEG / MSA Respond Coordinator Satish Dhawan Space Centre-SHAR: 524 124 Sriharikota, Andhra Pradesh	Tel: 08623 22 6382 e-mail: nrbala@shar.gov.in
9.	SCL	Shri Ashwani Kr. Tuknayat Group Head – PPG/Respond Coordinator Semiconductor Laboratory Sector 72, SAS Nagar - 160071 (Near Chandigarh) Punjab	Tel: 0172 2236102 e-mail: gh_ppg@scl.gov.in
10.	IISU	Shri S Sivasubramony DD, MISA/ Respond Coordinator ISRO Inertial Systems Unit (IISU), Vattiyoorkavu PO Thiruvananthapuram: 695 013 Kerala	Tel: 0471 2569340 e-mail: s_sivasubramony@vssc.gov.in
11.	IIRS	Dr. Vandita Srivastava Scientist “SF” Respond Coordinator Indian Institute of Remote Sensing, 4 Kalidas Road Dehradun-248001 Uttarakhand	Tel:0135 2524137 e-mail: vandita@iirs.gov.in
12.	NESAC	Dr. K K Sharma Respond Coordinator Sci/Engr. SG North Eastern Space Applications Centre, Umiam: 793 103 Meghalaya	Tel : 0364 2570138 e-mail: sarmakk@gmail.com

13.	NARL	Dr. S. Sridharan Respond Coordinator National Atmospheric Research Laboratory, Gadanki-517 112, Pakala Mandal, Chittoor District, Andhra Pradesh	Tel: 08585-272124 e-mail: susridharan@narl.gov.in

RESPOND Office, ISRO HQs

14.	ISRO HQs	Director, Capacity Building Programme Office Indian Space Research Organization HQs Antariksh Bhavan, New BEL Road, Bengaluru-560 094. Karnataka	Tele: 080 2341 5269 e-mail: respond@isro.gov.in

RESPOND & AI

Capacity Building Programme Office

ISRO HQ, Bengaluru