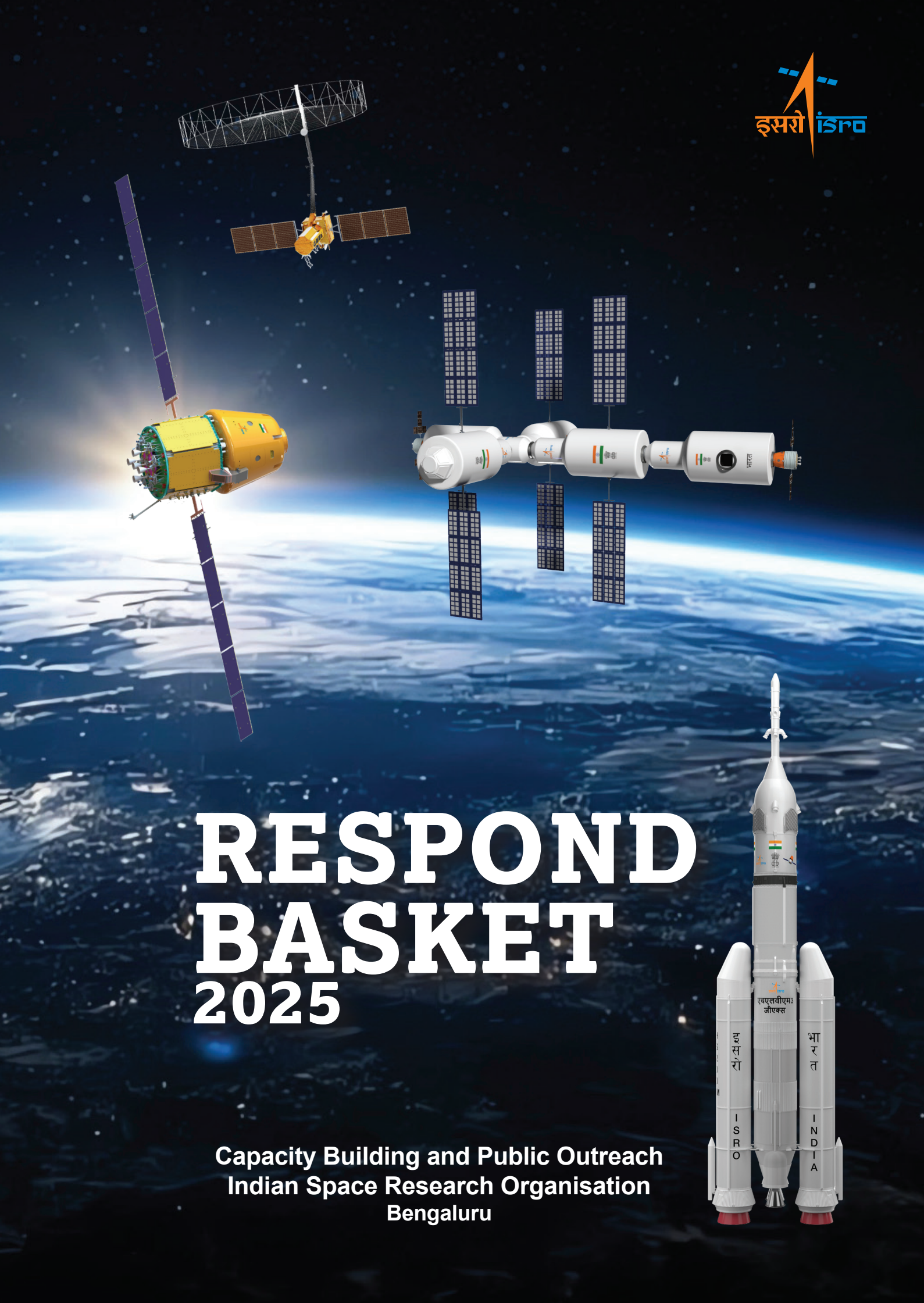


RESPOND BASKET 2025

Capacity Building and Public Outreach
Indian Space Research Organisation
Bengaluru

RESPOND BASKET 2025

Capacity Building and Public Outreach
Indian Space Research Organisation
Bengaluru

Technical Guidance

Shri. G. Harikrishnan
Director
Capacity Building and Public Outreach (CBPO)

Shri. K Sathis Kumar
Deputy Director
Capacity Building and Public Outreach (CBPO)

Technical Support and Compilation

Smt. Nirupama Tiwari
Deputy Director, RESPOND, CBPO, ISRO HQ

Shri. M Uday Kumar
Programme Manager, RESPOND, CBPO, ISRO HQ

Shri. Arun G S
Sr. Assistant, CBPO, ISRO HQ

Shri. Ritu Raj
Assistant, CBPO, ISRO HQ

For any queries please contact

Shri. G. Harikrishnan
Director
Capacity Building and Public Outreach (CBPO)
Indian Space Research Organisation HQ
Department of Space
Government of India
Antariksh Bhavan
New BEL Road
Bengaluru-560094
e-mail: dir.cbpo@isro.gov.in

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

भारतीय अंतरिक्ष अनुसंधान संगठन
अंतरिक्ष विभाग
भारत सरकार
अंतरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूरु – 560 094, 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, Bengaluru - 560 094, India
Telphone: +91-80-2341 5241 / 2217 2333
Fax : +91-80-2341 5328
e-mail : chairman@isro.gov.in
secydos@isro.gov.in

डॉ. व. नारायणन / Dr. V. Narayanan
अध्यक्ष / Chairman

Message

Academic institutions form the backbone of Research and Development in Science and Technology, and their contributions to the Indian Space Programme have been both significant and enduring. The phenomenal support and innovative inputs from academia toward ISRO's missions have always been remarkable and momentous. ISRO has established a strong interface with academia, through its Sponsored Research (RESPOND) Programme. Over the years, various initiatives have been conceived to channelize and harness the potential of Indian academia in support of the National Space Programme. These efforts have significantly advanced space R&D, fostered the development of skilled human resources in advanced technologies, and strengthened institutional capacities across the country.

As ISRO sets its sights on ambitious goals for the coming decades, including establishing the Bharatiya Antariksh Station, the Chandrayaan-4 Moon Sample Return Mission, Gaganyaan continuation missions, a Venus orbiter, and ultimately, a human landing on the Moon, the role of academia will be more vital than ever. With the announcement of the Space Sector Reforms academia can play a pivotal role in preparing and upskilling human resources through programmes like RESPOND, enabling them to become future-ready for the growing space industry.

In this context, the Capacity Building and Public Outreach (CBPO) office at ISRO Headquarters, with the support of all ISRO Centres and Units under the Department of Space, has compiled a document titled "RESPOND Basket–2025", outlining key R&D areas where academic institutions can actively contribute. I am pleased to announce the release of this document and invite R&D proposals on the listed thematic areas.

I am confident that through sustained collaboration between ISRO and the academic community, we can collectively overcome the challenges in developing cutting-edge technologies and explore new frontiers of knowledge. I look forward to witnessing the innovative outcomes emerging from this partnership.

.

13.12.2025

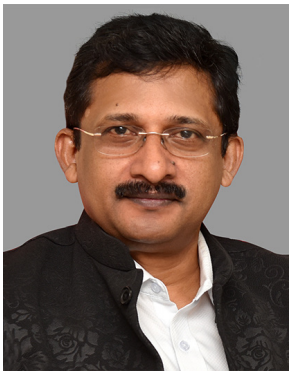
(V. Narayanan)

भारतीय अन्तरिक्ष अनुसंधान संगठन
अन्तरिक्ष विभाग
भारत सरकार
अन्तरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूरु - 560 094, भारत
दूरभाष : +91 80 2341 6356
फैक्स : +91 80 2341 5298

Indian Space Research Organisation
Department of Space
Government of India
Antariksh Bhavan
New BEL Road, Bengaluru - 560 094, INDIA
Tel (Off) : +91 80 2341 6356
Fax : +91 80 2341 5298
E-mail : scientificsecretary@isro.gov.in

एम. गणेश पिल्लै/M. Ganesh Pillai
वैज्ञानिक सचिव, इसरो / Scientific Secretary, ISRO

Preface



Industry and academia have always played a vital role in the journey of the Indian Space Programme. Since its inception, ISRO has been partnering with academia through the Sponsored Research Programme (RESPOND), which was initiated in the early 1970s. The primary objective of the RESPOND Programme is to provide financial and technical support to academic institutions to carry out R&D activities in areas relevant to ISRO.

To address specific and focused research challenges of ISRO, the first RESPOND Basket was released in 2018 at IIRS, Dehradun. Since then, a total of 871 research problems under the RESPOND Basket have been identified and shared with academia. Over the years, institutions across the country have been active participants in this programme, carrying out research in the fields of space science, space technology, and space applications, thereby contributing to national development.

'RESPOND Basket 2025', the sixth in the series, marks an important new step forward. It focuses on reinforcing prototype development and enhancing Technology Readiness Levels (TRLs). This document is intended to facilitate academia in proposing research solutions aligned with ISRO's requirements. It outlines the research problems with their scope, linkages, and expected deliverables, thereby establishing stronger connections between academia and domain experts from ISRO.

I acknowledge the continued enthusiasm and contributions of academic institutions across the nation, whose commitment has driven the success of previous RESPOND Baskets. With RESPOND Basket 2025, we look forward to deeper research collaborations and the development of world-class capabilities that will further strengthen India's scientific and technological leadership.

December 13, 2025

(M. Ganesh Pillai)

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), Regional Academic Centre for Space (RAC-S) and Space Technology Incubation Centre (STICs) 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 and the list of publications to be uploaded in the portal at the time of submission of proposal. 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. Proposals from individuals not affiliated to any recognized institution/ R & D institutions will not be considered.

5. The signed "Declaration Form" shall be uploaded in the portal at the time of submission of proposal in the prescribed format. Format is given in the Annexure -1.

6. 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/SponsoredResearch.html).

7. The last date for submitting the proposals online under "RESPOND BASKET-2025' is January 31, 2026.

8. 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.

CONTENTS

INDEX

Research Topics from ISRO/DOS Centres | Page No

VIKRAM SARABHAI SPACE CENTRE 1-39

Research Topics from ISRO/DOS Centres | Page No

INDEX

Research Topics from ISRO/DOS Centres | Page No

INDEX

Research Topics from ISRO/DOS Centres — Page No

Research Topics from ISRO/DOS Centres | Page No

INDEX

Research Topics from ISRO/DOS Centres | Page No

Research Topics from ISRO/DOS Centres | Page No

INDEX

Research Topics from ISRO/DOS Centres | Page No

Research Topics from ISRO/DOS Centres | Page No

INDEX

VIKRAM SARABHAI SPACE CENTRE

THIRUVANATHAPURAM

RES-VSSC-2025-001

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Paintable Solar Cell Technology – Solar Paint

Area of Research

Materials, Micro-electronics

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

Shri. Dominic George Joseph
Shri. Sabin S Babu
Smt. Mini Sreekumar

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

dominic@vssc.gov.in

Summary of the Proposed Research

Paintable Solar Cell Technology – Solar Paint is a photovoltaic technology.

The concept involves a liquid containing light sensitive materials like quantum dots or perovskites, that can be applied to surfaces like a regular paint for converting light into electric power.

Activities involved:

1. Explore probable technologies for the development of Paintable Solar Cell Technology
2. Define
   a. number of different layers required to make solar cells
   b. materials to be used for each layer
   c. method to convert the materials to a paint form
3. Experiment with probable materials and methods to generate sample paints
4. Develop prototypes using the sample paints applied to various surfaces
5. Carryout the following analyses
   a. Electrical
   b. Optical
   c. Thermal (cycling & shock)

d. Structural
e. Mechanical
f. Material (morphological & microstructural) analyses tests to evaluate the sample & prototype
g. Shadow effects

6. Improve the technology by incorporating ideas inferred from the above analyses.
7. Deliver prototypes to VSSC for testing and evaluation
8. Deliver flight worthy systems for use in technology demonstration space missions of VSSC/ISRO

Various aspects to be considered for the technology development are:

1. Materials (probable)
   i. Perovskites
   ii. Quantum dots
   iii. Or anything else which serves the purpose

b. Methods
   i. Paint technology development
   ii. Paint manufacturing
   iii. Paint application
      1. Brush
      2. Roller
      3. Spray

c. Performance parameters
   i. Efficiency (Power conversion)
      1. Reflectance
      2. Thermodynamic
      3. Charge carrier separation
      4. Conductive
   ii. Fill factor: ratio of the actual maximum obtainable power to the product of the open-circuit voltage & short-circuit current
   iii. Optimum ambient temperature
   iv. Maximum ambient temperature
   v. Optimum frequency of light
   vi. Minimum frequency of light
   vii. Minimum intensity of light
   viii. Power generated per unit area at maximum efficiency

ix. Range of angle of incident light

d. Number of different layers of paint to be applied

e. Product life cycle

f. Resilience to environmental conditions like temperature, pressure, vacuum, aerodynamic load, moisture.

g. Outgassing

h. Adhesion

i. between base material and first layer paint

ii. between different layers of paint

i. Elasticity – All layers (especially undercoat) should have good elasticity to take care of the thermal expansion/contraction of the layers below and above them.

j. Probable options for base material

i. Electrical conductivity - Undercoat is required for standardization of the layer directly above the undercoat. For Conductors, a non-conducting undercoat will be required. Separate undercoats may be required for conductors based on surface finish.

1. Conductors

a. Metals

b. Alloys

2. Insulators

a. Plastics

b. Composites

ii. Thermal conductivity

Conductors may provide higher efficiency to the power generation due to cooling effects

iii. Mechanical rigidity

Flexible base material may create damage to the solar cell structure unless the painted layers are sufficiently elastic

k. Weight per unit area

l. Costs involved

i. Technology development

ii. Product cost per unit area

m. Compatibility with existing thermal protection systems (TPS) coatings on spacecrafts

Scope of the work:

The scope of the proposed research includes the following

- Material Research: Comparative study of various materials with respect to the performance parameters.

- Process Development: Process steps design for various layers of solar paint.
- Prototype Development: Realization of solar panels using the paint developed.
- Prototype Testing: Testing of the solar panels developed.
- Process Improvement: improvements in process learning from the test results.
- Product Development: Realization of the solar panels using the improved paint.
- Ground Testing: of the improved solar panels.
- Flight Testing: applying solar paint to space craft structures for putting them into technology development space missions.

Linkages to Space Programme:

The proposed solar paint can be used for power generation in applications like

- Ground systems
- Rockets
- Satellites
- Interplanetary/Deep space missions
- Rovers
- Landers
- Orbitors
- BAS (Space station)

Expected Deliverables:

- Solar paint (Covering 1m2 area).
- Solar paint coated on a surface to make a panel and its detailed characterization.
- Technology Transfer including Complete documentation on design, development, realization and testing.

RES-VSSC-2025-002

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development and implementation of adaptive meshing algorithm with distortion control

Area of Research

Finite element method

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

Shri. G. Sarangapani

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

g_sarangapani@vssc.gov.in

Summary of the Proposed Research

In general, the finite element mesh has an associated mesh discretization error. This error can be reduced by using iterative mesh refinement strategies. It is basically a iterative mesh optimization procedure and can be validated with a problem having known closed-form solution. The user shall be able to specify the target error in the mesh and the adaptive mesh algorithm shall achieve the final mesh discretization meeting the set target error. The adaptive meshing technique shall be based on widely used error indicator variables such as element energy density, von Mises stress, and equivalent plastic strain.

In large deformation simulations, the finite element mesh gets distorted severely. Due to this element distortion, the error in the solution variables, especially error in stress evaluation becomes larger which in turn affects the further solution process and accuracy in the load incrementation / iterative scheme. The adaptive meshing algorithm shall be able to provide a good quality mesh as the deformation occurs. During the iterative mesh optimization process, the solution variables from the previous mesh to the current mesh (remeshed) shall be mapped without any error.

Scope of the work:

- Scope is for two and three dimensional continuum finite elements

Linkages to Space Programme:

- FEAST software development.

Expected Deliverables:

- Source code in Matlab / C++ along with detailed documentation.

RES-VSSC-2025-003

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Secure and Accurate Retrieval-Augmented Generation Framework for Domain-Adaptive Applications

Area of Research

Artificial Intelligence / Machine Learning / Knowledge Systems for Multi-Domain ISRO Applications

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

Shri. Saju S
Dr. Roy Thankachan

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

s_saju@vssc.gov.in
roy_thankachan@vssc.gov.in

Summary of the Proposed Research

This proposal aims to develop a multi-domain, domain-adaptive RAG framework optimized for high

accuracy in knowledge systems, leveraging open LLMs as the generation backbone. The research focuses on optimizing the RAG process itself rather than modifying the LLMs, ensuring:

- Optimized retrieval: combining dense and lexical embeddings for precise document selection.
- Reranking and grounding: ensuring evidence-backed outputs for factual reliability.
- Hallucination prevention: employing confidence scoring, multi-layer verification, and cross-validation with trusted ISRO knowledge bases.
- Domain adaptation: tailoring outputs for diverse ISRO operational areas, including technical and administrative, applications.
- Offline deployment and data privacy: maintaining confidentiality and secure usage of sensitive internal data.

The system will support interactive, evidence-based analysis of QA reports, procurement manuals, GFR rules, telemetry data, and other technical documentation, enabling accurate decision support, operational analysis, and knowledge synthesis across ISRO centers.

Scope of the work:

1.End-to-End Framework Development:

- Modular RAG architecture covering ingestion, indexing, retrieval, reranking, grounding, and generation.
- Offline deployment for secure, air-gapped environments.

2.RAG Process Optimization:

- Optimize retrieval, reranking, and grounding layers for high factual accuracy.
- Implement confidence scoring, multi-layer verification, and iterative tuning to minimize hallucinations.

3.Evaluation & Validation:

- Measure retrieval accuracy, grounding fidelity, hallucination reduction, and domain relevance using publicly available space research related datasets and expert reviews.

Linkages to Space Programme:

- The proposed framework aligns with ISRO's Space Vision 2047, providing secure, evidence-based AI assistance across technical, operational, and administrative workflows. Offline deployment ensures data privacy, while RAG optimization guarantees high accuracy and reliability. By enabling automation in activities such as failure analysis, procurement verification, audit support, and knowledge-driven decision-making, the framework enhances efficiency and effectiveness across all ISRO centers.

Expected Deliverables:

- End-to-End RAG Framework: Modular, optimized, offline-compatible, and privacy-preserving.
- Multi-Domain Implementations: Open LLMs with fully optimized RAG pipelines.
- Curated Knowledge Bases: Verified datasets for grounded retrieval and reasoning.
- Prototype Deployment: Demonstration of secure and reliable offline RAG operation using publicly available space research related datasets.
- Documentation & Guidelines: Detailed reports on RAG optimization, hallucination prevention, domain adaptation, and deployment strategies.

RES-VSSC-2025-004

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Synthesis of chlorotrifluoroethylene (CTFE) gas

Area of Research

Materials

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

Shri. Srirangam Siripothu
Shri. Bhatt Tushar Shriram

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

s_srirangam@vssc.gov.in
bhatt_tushar@vssc.gov.in

Summary of the Proposed Research

CTFE is used as a raw material for synthesis of aqueous polychlorotrifluoro ethylene (PCTFE) emulsion. PCTFE emulsion is used for coating metallic seals for low temperature application (semi-cryo applications) The proposal should include complete development of lab scale synthesis route for CTFE (1kg level) and detailed characterization. During the development, further scale up of the process to be ensured.

Scope of the work:

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

The activity involves:

- Parameter study during the synthesis and their optimization.
- Detailed characterization of CTFE.

Linkages to Space Programme:

- Semi-cryo Project.

Expected Deliverables:

- Report submission on experimental studies carried out for the development and its outcome.
- Report submission on synthesis of CTFE with details on optimized process parameters and characterization results.
- Submission of CTFE gas (purity > 99%) required for synthesis of 1 ltr. PCTFE emulsion with 20% solid loading.

RES-VSSC-2025-005

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Study of signatures of heavier species (> 100 amu) observed in the space borne mass spectrometers and identification of species based on the expertise on molecular cracking patterns and laboratory mass spectroscopy

Area of Research

Planetary and space science

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

Dr. Dhanya M B

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

mb_dhanya@vssc.gov.in

Summary of the Proposed Research

Neutral gas mass spectrometers are used for the in-situ measurement of composition of a gaseous medium. Mass spectrometers have been flown in space based platform to sample the exospheres of planetary objects. The observations yield the mass spectra over a range of masses, where peaks could be seen for several mass bins, indicating the presence of a given mass group. Neutral gas mass spectrometers have been flown in the lunar/planetary missions of ISRO. In the proposed work, it is planned to analyse the mass spectra for heavier species (> 100 amu), characterise their variation and identify possible sources.

Scope of the work:

- The results will enhance the outcome from lunar and planetary missions of ISRO.

Linkages to Space Programme:

- Lunar and Planetary exploration programs.

Expected Deliverables:

- Scientific Results and reports.

RES-VSSC-2025-006

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Design and Development of Deployable FRP Booms for Solar Array, Antenna and Magnetometer Boom Payloads for Spacecrafts

Area of Research

Structures & Materials

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

Shri. Kalyanaraman R

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

r_kalyanraman@vssc.gov.in

Summary of the Proposed Research

The project shall focus on the design and development of the Deployable FRP Booms for Solar Array, Antenna and Magnetometer Boom Payloads for Spacecrafts which can be rolled & stowed to the spacecraft with minimum volume and deployed in orbit using stored elastic strain energy in the system. The mounting configuration, deployment scheme, holding mechanism requirement and all design study will be carried out to meet the launch and deployment loads. Various boom configurations for storing elastic strain energy for deployment include. Tape Springs, STEM, Slit Tubes, Lenticular Booms etc.

Scope of the work:

- Detailed Literature Survey for existing technologies worldwide
- Parametric Studies & Design Finalization for Geometry/Material/Layup for 3.0m FRP Boom
- Detailed FE analysis for stowage & deployment for 3.0m FRP Boom
- Parametric Studies & Design Finalization for Geometry/Material/Layup for 10.0m FRP Boom
- Detailed FE analysis for stowage & deployment for 10.0 m FRP Boom.

Linkages to Space Programme:

- For Deployment of Solar Array, Antenna and Magnetometer Booms of Science Payloads for Interplanetary Missions.

Expected Deliverables:

- Parametric Studies & Design Data for the finalization for Geometry/Material/Layup for 3.0m and 10.0m Boom
- Detailed FE analysis Models & Codes for stowage & deployment of 3.0mand 10.0m long Booms
- Mathematical models for 3.0m and 10.0m Slit Tube/Tape Spring Boom

RES-VSSC-2025-007

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

High fidelity CFD computations for pitch damping derivative characterization of re-entry modules

Area of Research

Aerodynamics

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

Shri. Ankur Nagpal
Shri. Saravanan R

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

ankur_nagpal@vssc.gov.in
saravanan_ram@vssc.gov.in

Summary of the Proposed Research

Re-entry modules are typically characterised by low lift to drag ratios(L/D~0.2). Hence, inherent aerodynamic stability is essential for controlled atmospheric descent. Dynamic pitch instability at low supersonic and subsonic speeds has been observed, which leads to undesirable undamped pitch oscillations. The data for pitch damping has been predominantly from experimental methods, owing to large separated flows requiring accurate modelling. Conventional CFD methods employing RANS have limitations in modelling massively separated flows in module base. High fidelity CFD methods as DDES & LES, has potential to accurately predict massively separated flows. The application of high fidelity CFD methods to module motion during re-entry can bring out the physical mechanism of pitch instability. Further understanding of mitigating strategies can bring change in the design.

Scope of the work:

- The scope of proposed research includes developing and validating a high fidelity unsteady CFD framework using a reliable CFD solver(open source/in-house). Numerical accuracy needs to be verified by performing DDES/LES simulations at typical angle of attack conditions. Further, the physical mechanism behind pitch instability has to be investigated through detailed unsteady analysis of flow around re-entry module. Mitigation strategies including geometrical changes need to be studied.

Linkages to Space Programme:

- Highly relevant to understanding pitch instability in re-entry modules. Further ISRO programmes will include many re-entry modules from the Moon/outer space and interplanetary missions. The development of proposed computational methodology will pave way for improved designs.

Expected Deliverables:

- Validated high fidelity CFD work flow and working programs for pitch damping derivative characterization of re-entry module.
- CFD based results for a range of angle of attack and Mach numbers.
- Detailed post-processing to bring out physical mechanism behind pitch instability during oscillations.
- Detailed technical report.

RES-VSSC-2025-008

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of high speed electronically gated camera with beam splitting optics for ballistic applications

Area of Research

Sensors and Optics

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

Shri. Bishwajyoti Dutta Majumdar

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

mr_bishwajyoti@vssc.gov.in

Summary of the Proposed Research

Functioning of pyro ordnance systems as well as hyper velocity impacts due to micro meteorite are highly transient phenomenon. Such dynamic systems require thorough understating as they play mission critical operations of space vehicles. In order to study the physical signature of such systems while functioning, high speed imaging camera is the crucial system that can evaluate micro second events. The proposed research should focus on development of high speed camera with beam splitting optics with independent multiple CCD/CMOS sensor and image intensifier. The camera should produce high quality images at 100 million frames per second frame rate. With the use of beam splitting optics and electronic gating of individual sensors higher frame rate can be obtained without compromising resolution of Images. The image intensifier shall compensate the light intensity reduction due to lesser exposure due to higher frame rate as well as beam splitting.

Scope of the work:

This proposal envisages following activities:

- Design of Image Intensified High Speed Camera with beam splitting optics and individual image sensors.
- Development of Electronic gating with variable exposure ranging from 5ns -10ms (typical).
- Proto fabrication, characterization and demonstration using standard tests/experiments for single channel configuration.
- Realization of multi-channel (16 frames) system with beam splitting optics and image intensifier.
- Performance demonstration of the high speed cameras using functional test of the ordnance systems in VSSC.

Linkages to Space Programme:

- The developed camera will be a critical technology for ISRO and can be used extensively to predict and

study various mechanical systems that involve high transient events. The dependency on imported technology can be avoided through such indigenous effort.

Expected Deliverables:

- Design Report (PDR) on the proposed configuration of the camera and specification of the image sensors, beam splitting optics, Image Intensifier, Lens etc.
- Performance demonstration of the high speed cameras using functional test of the ordnance systems in VSSC.
- Supply of Camera with all necessary accessories to VSSC.

RES-VSSC-2025-009

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Functionally Graded Polymer Sandwich Cores for Lightweight, High Energy Absorbing Space Panels

Area of Research

Composite Structures and AI

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

Shri. Vinod G

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

g_vinod@vssc.gov.in

Summary of the Proposed Research

Lightweight, impact-resistant sandwich composites are critical for next-generation space structures where every gram of mass saved translates to improved payload efficiency and mission reliability. This project proposes the design, fabrication, and characterization of functionally graded (FG) polymer sandwich cores optimized for high energy absorption and low peak impact loads. Building upon advances in hierarchical and auxetic lattice architectures, the research will develop graded-core configurations that exhibit multi-plateau crushing responses, enabling controlled deceleration under impact.

The work integrates experimental testing (quasi-static and low-velocity impacts up to 50 m/s), finite element modeling, and machine learning-based inverse design tools to establish predictive relationships between architecture, process parameters, and performance metrics such as Specific Energy Absorption (SEA), Mean Crushing Force (MCF), and initial peak load. Additive manufacturing (3D printing) will be employed to realize graded polymer cores bonded with glass- and carbon-fiber thermoplastic/thermosetting skins, while interface toughening through stitching, Z-pinning, and 3D-woven reinforcements will be explored to mitigate delamination.

Expected outcomes include validated FG core recipes with ≥30 % lower initial peak forces, ≥100 % SEA improvement, and process–architecture–property maps enabling environment-resilient designs. The

project will deliver a demonstration panel and a rapid design toolkit (FE + ML) to support ISRO's structural design teams in achieving safer, lighter, and more adaptive spacecraft structures.

Scope of the work:

- To Design, fabrication, and characterization of functionally graded (FG) polymer sandwich cores optimized for high energy absorption and low peak impact loads.
- To develop the graded-core configurations that exhibit multi-plateau crushing responses, enabling controlled deceleration under impact useful in landing experiments.
- Validate the expected outcomes include FG core recipes with ≥30 % lower initial peak forces, ≥100 % SEA improvement, and process–architecture–property maps enabling environment-resilient designs.

Linkages to Space Programme:

- The developed sandwich systems are directly applicable to ISRO's lightweight and shock-critical subsystems such as payload adapters, fairing panels, lander impact modules, re-entry shock absorbers, and satellite equipment decks.

Expected Deliverables:

- Design Optimaztion (FE analysis): - Select core topologies: re-entrant, hybrid chiral/re-entrant, hierarchical; sequences LMS/SML/SMM at equal areal mass.
- Prototype Fabrication: Print polymer cores via AM; laminate GF/CF thermoplastic skins; implement interface variants (surface treatment, Z-pin, stitching, 3D-woven).
- Characterisation & Testing Quasi static compression to identify plateau behaviour. Drop/air gun tests at 1, 10, 25, 50 m/s: record force–time, displacement, SEA, MCF.
  - NDT (C-scan/CT) to assess delamination/damage; residual flexural tests (ASTM D7137 analog).
  - Multi-hit (N = 3) and oblique impact (15°, 30°) trials on lead designs.
- Parametric Mapping Variables: topology, grading order, wall thickness/print speed, face sheet stiffness, interface type. Map responses: peak load, MCF, SEA, damage.
- Modelling & Toolkit • FE: explicit simulation of core crush + skins + interface damage; calibrate vs tests. and Closed form models: derive plateau/peak stress predictors for graded/hierarchical cells.
- Demonstration & Environmental Evaluation - Environmental conditioning (humidity/thermal cycles).
- Fabricate demo panel with embedded sensors; test under mission relevant loads/angles for demonstration.

RES-VSSC-2025-010

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

AI-Powered Analytics Platform for Requalification of Avionics from Recovered Vehicle Stages

Area of Research

Data Analytics, AI/ML pipelines

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

Shri. Syamlal L S
Ms. Anjana S J

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

syamlal_ls@vssc.gov.in
sj_anjana@vssc.gov.in

Summary of the Proposed Research

- The proposal is to design and implement an AI/ML-based tool for data analytics, Avionics subsystem health assessment and requalification of a recovered launch vehicle stage. High volume of flight data to be analyzed includes sensor data and health data of recovered Avionics subsystems.
- Dataset for training and validation can be sourced from ground and flight tests of packages and subassemblies, excluding data of confidential nature. Data corresponding to subsystem faults and synthesised data from simulation test beds after fault injection can be provided as inputs.
- Pattern checking can be applied for fixed data like health bytes available in telemetry.
- Variable data like vibration, acoustics and shock from sensors shall be subjected to bound checks.
- Outliers in measurements shall be detected and conditional clearance based on decisions made during the past missions can be given with human confirmation.
- The platform shall support Extract, Transform and Load (ETL) pipelines as data processing tools for accepting, transforming and storing data from multiple sources. It shall also support image processing algorithms.
- AI/ML pipelines shall be supported to implement and improve custom analytics solutions as per specific requirements.
- Dashboarding capabilities shall be built in for visual displays in specific areas and for generating an executive overview of the recovered stage, complemented by reporting, summarizations & detailed views. Slicing & dicing features shall be provided for analysing data in multiple dimensions to gain deeper insights and aid in decision-making.
- A data warehouse capable of storing terabytes of flight data is required.

Scope of the work:

- The proposed solution shall be capable of handling high-volume data of the order of 64GB. The platform implemented shall support deterministic bound checks & ML-based solutions, complementing each other.
- Focus areas are requalification of flight-deployed Avionics systems for severe damage, performance deviations, and minor anomalies. This shall enable fast and accurate recertification of subsystems for reuse. It shall also minimize manual inspection time and human errors.
- Assessments will have to be integrated to subsequent launch vehicle missions also, on a continuous operational basis. For this, data shall be fed forward from previous simulations, flights etc.

Linkages to Space Programme:

- The platform can be deployed for analysis of flight and health data from past missions.
- It can aid fast and accurate decision-making regarding reuse of recovered Avionics subsystems (as planned for future missions like NGLV) with minimal refurbishment, significantly reducing launch costs and increasing mission frequency.

Expected Deliverables:

- AI-Powered Analytics Platform – source code, executables, lifecycle documentation, reference manuals.
- Platform deployed internally at VSSC, in a server cluster, with required computing, communication & storage capability.
- Demonstration of data warehouse, ETL pipeline & AI/ML pipeline.

RES-VSSC-2025-011

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Energy harvesting in Space Station using Nitrile rubber based triboelectric nanogenerators (TENGs)

Area of Research

Materials

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

Dr. Remyamol T

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

remyamol@vssc.gov.in

Summary of the Proposed Research

Proposal is for energy harvesting in space Station by integrating TENGs at locations where mechanical motion, vibration, or friction regularly occur. To counteract the effects of microgravity astronauts perform daily mandatory exercises using treadmills, stationary bicycles, and resistance devices. By integrating tribonanogenerators into exercise equipment—under treadmill belts, within pedal mechanisms, or in the frames of resistance bands—mechanical energy from these workouts can be captured. The generated power can support station's low-power electrical needs. For Eg. Powering the display of exercise equipment, Sensing the number of steps and speed of the movement without need of external power supply. The generated power can also be used capacitors for powering or charging small monitoring devices and sensors

Scope of the work:

- Material selection and optimization targeting power density of 5 W/m^2 (min.), Voltage 80 V/cm^2 (min.), Current 16$\mu A/cm^2$.

  - Nitrile rubber based composite material with appropriate nanofillers shall be used tribopositive layer due to its outstanding durability and abrasion resistance in treadmill conditions.
  - Tribonegative shall be chosen by the investigator targeting maximum power generation with a combination of nitrile rubber based triboposite layer.
- Evaluation of TENG performance and iterations.
- Demonstration in similar conditions (Eg: under treadmill belt, shoe soles, etc.).
- Demonstration of sensing no. of steps, and speed of movement and display of the same without using external power.
- Demonstration of charging of 1 mF capacitor.

Linkages to Space Programme:

- Well suited for space station since it is self powered and inherently light weight.
- Conventional electromagnetic generators are less suitable due to the heavy weight of permanent magnets and metal coils and high launch costs.

Expected Deliverables:

- 10 numbers of TENG device.
- Characterization results and TENG performance report.
- Technical report including detailing step by step procedure for the fabrication o f the device and optimized process parameters.
- Performance demonstration report in treadmill conditions.

RES-VSSC-2025-012

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development and implementation of robust hexahedron and tetrahedron finite element mesh generation algorithms for complex 3D CAD geometry

Area of Research

Finite element method

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

Dr. P Deepak

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

p_deepak@vssc.gov.in

Summary of the Proposed Research

In general purpose finite element software, mesh generation algorithms play a vital role in creating a good

quality mesh. FEAST software already has hexahedron and tetrahedron mesh generation capabilities. However, it is proposed to develop and implement state of the art mesh generation capabilities as in popular or renowned mesh generators.

The algorithm should provide the following operations to update the geometry in Open Cascade representation.

- Geometry healing/Cleaning up or repairing operations like
  - ➢ Merging the edges
  - ➢ Extend the edges
  - ➢ Project the edges
  - ➢ Join surfaces and so on.
- De-featuring options like
  - ➢ Removal of fillet, chamfer and round edges
  - ➢ Filling up of small holes (with diameter specified
  - ➢ Removal of embossed objects (like alphabets)

The 3D mesh generation for a given 3D CAD complex shape in Open Cascade representation.

- Mesh the domain with good quality pure hexahedron as well as with pure tetrahedron elements.
- The meshing algorithm shall be robust enough to identify the region for coarse mesh and the region for fine mesh.
- The mesh generation should work for the following shapes.
  - ➢ Highly curved shapes
  - ➢ Topologically complex shapes
  - ➢ Thin-walled shapes
  - ➢ Shape Branching
  - ➢ Intersecting features
  - ➢ Non-manifold

Scope of the work:

- Scope is for three dimensional mesh generations using hexahedron and tetrahedron finite elements.

Linkages to Space Programme:

- FEAST software development.

Expected Deliverables:

- Source code in C++ along with detailed documentation.

RES-VSSC-2025-013

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Modelling of Hypervelocity Impact on Micro-Meteoroid and Orbital Debris (MMOD) shields

Area of Research

Materials, Structures and Hydrocode modelling of hypervelocity impact

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

Smt. Priyanka Chaudhary
Shri. Bishwajyoti Dutta Majumdar

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

priyanka@vssc.gov.in
mr_bishwajyoti@vssc.gov.in

Summary of the Proposed Research

With the ongoing development of Bhartiya Antariksh Station (BAS) and future interplanetary missions, the design of MMOD shields for protecting the inner wall of spacecrafts from space debris impact up to 15km/s velocity is underway. These shields consist of layers of various kinds of materials – including isotropic as well as fabric layers. Methodology to numerically simulate hypervelocity impact of projectile on these targets up to impact velocity of 15km/s is crucial for robust design of these shields. Expected outcomes of the proposed research are to adequately model the hypervelocity impact of a projectile on metallic as well as fabric targets, simulating fragmentation, phase change of materials in subsequently formed debris cloud and assessment of damage potential of the particles in debris cloud on next layer of shield.

Scope of the work:

This proposal envisages following activities:

- Detailed literature survey on the various methodologies for numerical simulation of hypervelocity impact of projectile on metallic and fabric targets.
- Generation of fabric geometry for a given weave type to the level of tow.
- Implementation of material models in terms of equation of state and constitutive relations to simulate loading of metallic and fabric targets (in tow level modelling) under hypervelocity impact.
- Generation of material model parameters for given metallic and fabric target materials based on experiments.
- Hydrocode simulation of hypervelocity impact of spherical projectile on various types of target and validation of features of debris cloud using experimentally obtained images/radiographs available in open literature.

Linkages to Space Programme:

- Design of Micro-Meteoroid and Orbital Debris (MMOD) Shield for Gaganyaan, Bharatiya Antariksh Station and future interplanetary missions.

Expected Deliverables:

- Report on various material models for metallic materials and fabrics suitable for the present application and details of experimental techniques to evaluate parameters in each material model. Details of experiments conducted for various materials and the methodology to evaluate material model parameters shall also be reported.
- Report on validation studies on the simulation methodology by quantitative comparison of debris cloud features with experimentally obtained images/results.
- Delivery of the numerical code in the form of executable sub-routine in commercial hydrocodes like Autodyn, LS-Dyna etc.

RES-VSSC-2025-014

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Material Property Prediction Using Machine Learning & Deep Learning Models

Area of Research

Structures and AI

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

Shri. Vinod G

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

g_vinod@vssc.gov.in

Summary of the Proposed Research

For fabrication of thin-shell structures in aerospace launch vehicles Tungsten Inert Gas (TIG) welding is used extensively due to its superior control over heat input and weld quality. The mechanical behavior of welded joints which is based on stress strain characteristics depends on various parameters like current, voltage, weld speed, filler composition, and heat-affected zone (HAZ) morphology.

LSLF (Longitudinal Seam Start and Finish) weld coupons in maraging steel motorcases are decidedly relevant specimens weld along the longitudinal seams of cylindrical shells. LSLF coupons are under R0 condition are used to qualify TIG-welded joints for thin shell structures used in inter tankages for structural design of launch vehicles. The objective of the proposal is generation and prediction of material properties for each repair (R1,R2 etc) out of the LSLF coupons which is under R0 condition.

The recent advances in machine learning and deep learning in material property prediction of welded joint has helped researchers and scientists to capture complex nonlinear correlations. The advances in AI techniques have also ability to model the stress strain characteristics of novel welded structural configuration based on the experimental data enabling predictive and optimization capabilities for weld quality and structural reliability

Scope of the work:

- To investigate the stress strain characteristics of TIG welded structure using Machine Learning models.
- To implement ML models to evaluate the unknown stress-strain properties of a novel TIG welded structure from the experimental data.
- To develop an AI framework for structure relations of LSLF coupons, and to investigate and benchmark different ML and DL methods using Generative AI approach for predicting mechanical characteristics like yield stress, ultimate stress and elongation at break and further model can be validated by real time experimental data.
- From the experiments R0 and R1,R2 values from LSLF coupons are generated for welded specimens and using ML model properties of new specimen can be predicted.
- To envisage the fracture toughness of welded specimens and implementing explainable AI (XAI) to evaluate the factors contributing to the mechanical characteristics.

Linkages to Space Programme:

- The predicted stress strain curve can be used for the exact assessment of stress and margin of safety instead of present stagey with the specified stress strain data in the analysis.

Expected Deliverables:

- Source code and GUI of the AI program.

RES-VSSC-2025-015

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Data-driven Fault detection/ classification in electronic circuits

Area of Research

Avionics, Artificial Intelligence and Machine Learning, Fault tolerant PMSM motors and drives

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

Shri. Denil V. Robinson
Shri. Narayanan Nampoothiry V
Dr. Anish Gopinath

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

narayanan_nv@vssc.gov.in
denil_vr@vssc.gov.in
anish_gopinath@vssc.gov.in

Summary of the Proposed Research

Present fault detection and isolation (FDI) schemes that works on conventional signal processing pipeline operates on parameters like threshold based over current detection, hard failure of commutation sensors etc. This was adequate when the operating duration of the system is for a few minutes and operating stresses are lower. With the increased migration to motor and power drive based system with very high power levels along with requirements of longer duration of operation extending to months and years, the necessity of algorithms to predict the life of the systems are essential.

Parameters like harmonic currents, signatures in voltage and current associated with wear of mechanical elements, degradation of the insulation etc. are not covered in present FDI schemes which needs to be incorporated in the systems targeted for the future.

The aim of this proposal is to develop a hardware block using Machine Learning algorithms capable of classification /detection of health of electric motors and drives with emphasis on aerospace application applications. This development is primarily for usage in electric motor drive system which is designed to operate in mission critical applications for very high power and also for longer operating durations. The forecasted requirements of high power as well as the longer duration of operation necessitate the availability of such algorithms to enable early diagnosis of system health to avoid breakdown.

Electric motor drive systems consist of interconnection of electrical, electronic and mechanical elements. The dynamics of this system is governed by complex physical principles. So, ML based temporal pattern identification techniques are preferred over threshold-based conventional schemes to enable early detection of the symptoms of degradation. the intelligence built-in should identify the degradation initiation along with classification and localization of the fault with minimal instrumentation.

Also, the system should be deployable on an embedded computing device rather than high-end servers.

Scope of the work:

- The research should focus on the understanding of various probable faults in an electric motor and associated drive system, simulating those faults, generation of datasets, development of Machine Learning model for detecting those envisaged faults, training the devised ML model and validating the accuracy of the model. Datasets should be generated as much as possible from the corresponding physical systems rather than simulation alone. The entire system shall be demonstrated using real-world inputs with an average accuracy (over 1000 inputs) over 90%. A simulation model in MATLAB/ PYTHON should be done and validated before prototyping in hardware.

Linkages to Space Programme:

- A successful development of this fault detection/classification scheme can be used for the implementation of optimized FDI logic in control electronics packages. This improved FDI system

can be inducted either as an Application-Specific IC (ASIC) or soft-core in FPGA in control electronics package of launch vehicles and spacecrafts. This system will be a necessary element for long duration missions like Gaganyaan orbital modules, Bharatiya Antariksh Station programs etc. and reusable launch vehicles like NGLV/LMLV.

- The incorporation of this fault prognosis hardware into the conventional control actuation hardware helps in faster and efficient fault detection and isolation in addition to predicting the life of the systems.

Expected Deliverables:

- ML model/architecture capable of predicting/detecting the fault and its location. The output should be in standard format like tensorflow, pytorch etc.
- Labeled datasets used for training, validation and testing.
- Hardware implementation of the system on embedded platforms.

RES-VSSC-2025-016

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Surface Treatment of Hollow Glass Microspheres for Enhanced Adhesion with Polymer Matrix

Area of Research

Materials

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

Shri. Elbin George

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

elbin_george@vssc.gov.in

Summary of the Proposed Research

Hollow glass microspheres (HGMs) help reduce weight and improve insulation in rubber and polymer composites. However, poor bonding between glass and the polymer matrix weakens mechanical performance. This project aims to improve adhesion through surface treatment methods such as silane coupling, plasma activation, and sol–gel coatings. Treated HGMs will be characterized (FTIR, XPS, SEM) and then blended with elastomers like EPDM, NBR, PU, and silicone rubber. Composite samples will be tested for strength, tear resistance, resilience, and dynamic behavior. The goal is to develop a simple, scalable surface-modification process that enhances filler–matrix bonding and overall durability. The results can lead to lightweight, high-strength materials useful in aerospace, automotive, and industrial applications.

Scope of the work:

- The work shall begin with untreated HGMs to set baseline properties. Various surface treatments—silane, plasma, sol–gel, and PU-compatible primers—will be applied. Treated samples will be analyzed

(FTIR, SEM, XPS), and then incorporated into rubber and polyurethane matrices using standard mixing and curing. Mechanical, thermal, and dynamic tests will evaluate adhesion improvement and dispersion. The study will end with selecting the best treatment considering cost, performance, and ease of processing. The outcome will support lightweight, high-performance rubber and PU composites for aerospace and industrial use. VSSC will provide support for material testing, characterisation and product level processing trials.

Linkages to Space Programme:

- This project supports India's Space Vision 2047 by developing lightweight, high-strength polymer composites for future missions like Gaganyaan and the Bharatiya Antariksh Station. Treated microspheres can reduce weight and improve insulation and durability in solid motor insulation, crew modules, and thermal barriers. Through the use of this material, the payload capacity of SSLV can be improved by up to 25%. The technology promotes indigenous capability in advanced materials, enabling safer, lighter, and more efficient space systems.

Expected Deliverables:

- Optimized surface-treatment method for HGMs.
- Database on chemical and surface properties.
- Prototype composites showing improved performance.
- Comparative performance results (mechanical, thermal, dynamic).
- Scale-up feasibility and cost study.
- Technical report and documentation.

RES-VSSC-2025-017

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Prediction of solar flares using physics based approach and including the AI/ML techniques

Area of Research

Space Science

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

Dr. Dhanya M B
Shri. Aneesh A N
Dr. R. Satheesh Thampi

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

mb_dhanya@vssc.gov.in
an_aneesh@vssc.gov.in
satheesh_thampi@vssc.gov.in

Summary of the Proposed Research

Solar flares are sudden release of energy from the Sun in the form of electromagnetic radiation. In many instances, they are accompanied by coronal mass ejection. These phenomena are associated with the dynamics happening on Sun and result in modulating the solar wind and hence manifest in the observations at L1 point. Also, they initiate interesting phenomena around planetary environment. Hence it is important to predict their occurrences. In the proposed work, it is planned to predict solar flares by employing AI, ML techniques and using the data (magnetograms and UV images) from the space based observations, which are available in public domain.

Scope of the work:

- These predictions will help to monitor such events and assess their impact in the planetary environments by planning space based observations.

Linkages to Space Programme:

- Space/Planetary exploration and space weather programs.

Expected Deliverables:

- Model for prediction.

RES-VSSC-2025-018

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Understanding process/design of Effervescent atomisation

Area of Research

Propulsion

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

Shri. M Jathaveda
Shri. Joshi Yash Kishorbhai

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

m_jathaveda@vssc.gov.in
joshi_yash@vssc.gov.in

Summary of the Proposed Research

Effervescent atomising is a method to obtain smaller droplets by introduction of a small quantity of gas. The droplet size and the flow features are dependent on the geometry of the atomiser like length of mixing chamber, no of inlet of gas, GLR and the flow parameters like pressure and mass flow rates. Multi phase CFD studies on the dependence of geometric and flow parameters on the flow inside the atomiser and the impact of the same on the droplet diameter and flow velocities as it exits the atomiser. This is required to understand the sensitivity of the parameters to enable design. The flow outside the atomiser (Co Flow) also has a role in the formation of droplets. The effect of the same also shall be studied.

Scope of the work:

- Multi phase CFD simulations shall be carried out with supersonic co flow using Open Source CFD codes with additional subroutines if required for this application. The methodology shall be validated with test data. The proposed research shall study the sensitivity of various geometric and flow parameters in the process of atomisation. The effect of medium used for atomisation shall also be a parameter in the study. The impact of the flow parameters including co flow and geometric parameters on the Droplet diameters shall be studied.

Linkages to Space Programme:

- High fidelity Multi Phase simulations.

Expected Deliverables:

- Delivery of developed code based on existing open source software.
- Methodology to obtain flow features inside the atomizer and droplet diameter using the developed software.
- Validation studies for literature cases.

RES-VSSC-2025-019

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvannathapuram

Title of the research proposal

Development of ductile Superconducting materials for Active Magnetic Shielding in Space Exploration

Area of Research

Materials

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

Shri. Saravanan TT

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

tt_saravanan@vssc.gov.in

Summary of the Proposed Research

Deep space exploration demands active magnetic shielding to protect sensitive equipments from microwave and high energy charged particles. Magnetic shielding with superconductors has emerged as one of the most promising active methods to date, as it provides total protection by reflecting entire magnetic field of higher order than the field prevailing in the Earth. Superconductor alloys such as NbTi and NbSn are being explored for magnetic shielding.

Proposal aims for

- Identification of appropriate combination (Nb, Ti, Sn binary or ternary alloys) of materials through suitable computational techniques,
- Development of materials through suitable processing techniques and

- Characterization of developed materials for phase, microstructure, mechanical and superconducting properties.

The rationale for the material and process selection to be clearly brought out along with the critical temperature achievable, in the proposal.

Scope of the work:

- Prediction of composition zone with potential superconducting phases through suitable thermo-chemical calculation.
- Processing of potential alloy system through suitable non-equilibrium process such as rapid solidification technique.
- Phase analysis, micro-structural characterization at different length scales, mechanical properties evaluation and evaluation of superconducting properties.

Linkages to Space Programme:

- Magnetic Shielding Materials for deep space exploration and space habitation missions by protecting sensitive electronic circuits and navigation sensors from deep space high intensity magnetic fields.
- Also, the developed superconductors shall be explored for applications such as magnetohydrodynamic (MHD) thermal protection and magnetic field generation in electric propulsion system.

Expected Deliverables:

- Complete protocol/recipe of producing the indigenous alloy.
- A detailed correlative microstructural and thermo-chemical composition database evaluation in Nb-Ti-Sn system.
- Detailed correlation study with microstructural effect on critical super conducting temperature (Tc),Current Densities (Jc), Critical Magnetic Fields (Bc1, Bc2), and flux pinning qualities (FP) and mechanical properties of the evolved alloys.
- Sufficient quantity of materials (wires or sheets) for further studies at VSSC.

RES-VSSC-2025-020

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of mathematical model of parachute dynamics from simulation and inflation videos

Area of Research

Structural Mechanics, Fluid Structure Interaction, Computer Vision, Machine Learning, Mathematics

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

Shri. Shanbhag Sushanth Suresh

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

shanbhag_sushanth@vssc.gov.in

Summary of the Proposed Research

Parachute is a flexible deployable structure. The instrumentation of parachute affects its deployment characteristics. Hence, test videos and the load at the confluence point are the only available data from tests. In this research, we want to develop a mathematical model to use video data and estimate the dynamics of parachute system. The model will take a video as an input along with necessary details like the size and material properties. It will output the deformation at desired locations, canopy shape, breathing modes of parachute, deployment dynamics, member force distribution and cluster efficiency under subsonic and supersonic re-entry conditions.

Scope of the work:

- To develop a small parachute FSI model for an already tested parachute with videos available and carry out simulations under different deployment conditions and clustered condition.
- To extract the characteristic temporal and spatial deformation features from parachute inflation video and simulation by processing the computer vision data using Singular Value Decomposition, Principal Component Analysis, Dynamic Mode Decomposition techniques. Validate the Numerical Model.
- Train a physics informed machine learning algorithm using simulation data to predict key dynamic features of parachute like member force distribution, breathing frequency, etc. from the video data input and the total load at the parachute confluence point. This will be similar to Reduced Order Model.

Challenges:

- Deformations are large due to flexible nature of parachute. Hence, Mapping Techniques will be required.
- The videos may not be available in all views. Hence, mathematical reconstruction also may be necessary.

Linkages to Space Programme:

- Parachutes for GAGANYAAN, Supersonic Re-entry missions like MARS landing.

Expected Deliverables:

- Python/MATLAB Code of mathematical Model to handle any generic video data and estimate dynamics of parachute.
- It will output the deformation at desired locations, canopy shape, breathing modes of parachute, deployment dynamics, member force distribution, cluster efficiency and characteristic dynamic features using SVD, POD DMD, PCA, FFT techniques. It should be capable of handling clustered parachute system too.

RES-VSSC-2025-021

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Computational investigation of combustion instabilities in kerosene fueled strut based scramjet combustor

Area of Research

Combustion

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

Shri Amit Kumar Singh
Shri. Ankur Nagpal

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

amitkumar_singh@vssc.gov.in
ankur_nagpal@vssc.gov.in

Summary of the Proposed Research

Combustion instability remains a critical barrier to the reliable operation of scramjet engines, especially under high-speed, high-enthalpy conditions. Scram-mode combustion shows in general smaller oscillation and a more stable flame structure. However, regardless of the supersonic bulk flow, subsonic flow regions, such as the recirculation zone and boundary layers, do allow for upstream propagation of acoustic waves that are induced by unsteady combustion. Coupling between the flow oscillations at the reaction zone and unsteady heat release causes combustion instabilities. Other sources of instability include upstream-traveling shock waves, interaction between main flow and boundary layer, flame flashback, flow separation triggered by backpressure and shock-flame interactions.

Understanding the mechanism for combustion instability in a strut based scramjet combustor is essential to ensure operability of the scramjet. The onset of instability in terms of equivalence-ratio and inlet conditions needs to be identified. Further, mitigation strategies need to be evolved for long duration scramjet flights powered by kerosene fuel, injected in droplet form into the engine.

Scope of the work:

- The scope of proposed research includes developing and validating a high fidelity(Large Eddy Simulation) unsteady reacting CFD framework using a reliable CFD solver(open source/in-house). Methodology needs to be validated with literature data. Unsteady simulations are to be carried out to predict combustion instabilities in scramjet engine.

Linkages to Space Programme:

- Highly relevant to development of long duration scramjet engines in ISRO.

Expected Deliverables:

- Validated high fidelity CFD work flow and working code for combustion instability characterization in a strut based scramjet engine.
- CFD based results for a range of equivalence ratio and inlet conditions.
- Detailed post processing to bring out physical mechanism and identification of mitigation strategies.
- Detailed technical report.

RES-VSSC-2025-022

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development and characterization of magnetic materials for high resolution planar hall effect based magnetometer

Area of Research

Materials, Sensors

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

Shri. Saravanan TT

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

tt_saravanan@vssc.gov.in

Summary of the Proposed Research

High-resolution magnetometers are of great importance for space applications to unlock precise information on orientation sensing of small satellites, mapping of Lunar and Martian crustal magnetism.

Planar Hall Effect based magnetometers (PHE sensors) is a low-cost, magnetic sensor system capable of high-sensitivity magnetic field mapping in the nanotesla (nT, 10−9 Tesla) range.

The proposal aims at design and development of materials for realization of proto-type high resolution PHE sensor.

Scope of the work:

- The scope of the proposed work include detailed design of the sensors outlining the fabrication and computational design modelling, suitable materials development (magnetic thin films) and characterization, performance demonstration.
- The rationale for the material and process selection to be clearly brought out in the proposal.

Linkages to Space Programme:

- Compact magnetometer for crustal mapping (Lunar, Martian and planets geo-mapping).

- PHE sensors for satellite orientation determination (by measuring direction and strength Earth's magnetic field).

Expected Deliverables:

- Recipe for materials development and synthesis protocol.
- Indigenous Materials properties (structural, transport, magnetic etc.).
- Sensor design and fabrication recipe.
- Computational models for future design optimization.
- Working prototype of sensor with associated electronics assembly.

RES-VSSC-2025-023

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of Polyimide Fiber & Fabric from PAA resin

Area of Research

Material development

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

Shri. Koilakonda Sai Praneeth

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

ks_praneeth@vssc.gov.in

Summary of the Proposed Research

- Polyimide fibre possess high thermal stability, good chemical resistance, excellent mechanical properties & AO/UV radiation resistance properties.
- PI fibre finds application in structural components in spacecraft and LV's, insulation for high temperature areas, sealing materials and protective layers for wires and circuits.
- It is synthesised via wet spinning/ dry-jet wet spinning of Polyamic acid followed by chemical imidisation, vacuum drying and hot drawing.

Scope of the work:

- To develop a scalable polyimide fiber synthesis route using two stage wet spinning/ dry jet wet spinning method along with material and equipment support for fiber production.
- Joint optimization trials by varying the process parameters and targeting key performance parameters to realise Polyimide fibre with following properties.

Linkages to Space Programme:

- Structural composite and sealing materials for BAS & Interplanetary spacecrafts.

- Cryogenic Tankages.
- Fuselage of RLV.

Expected Deliverables:

- Synthesis of PI fibres via Wet Spinning/ Dry- Jet Wet Spinning Setup.
- Characterization of Fibers & Fabric.
- Preparation of PI fibre spool of 50m length (minimum).
- Potential co-development of application-specific fiber variants.

Polyimide fibre with the properties as defined as given table.

Property	Typical Value
Tenacity (cN/dtex)	3.8
Elongation at break (%)	30
Shrinkage at 240°C	<3
Limiting Oxygen Index (%)	38
Glass Transition Temperatue (°C)	315
Density (g/cm^3)	1.41

RES-VSSC-2025-024

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of Waste to gas reactor (WTG) technology for Interplanetary Manned Missions

Area of Research

In-situ Resource Utilization

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

Shri. Anjani Kumar Sharma

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

anjani_kumar@vssc.gov.in

Summary of the Proposed Research

Waste generated from a manned mission is one of the foremost problems confronting future space exploration. With sustained human presence in space as a near future reality, this issue has to be solved.

This work is a step in the direction to solve this problem. A chemical reactor to convert the waste (human waste and mission waste) into useful gases is proposed. The reaction sequence will start with

segregation of waste followed by feeding the segregated waste to the reactor. The reactor will be a back pressure controlled reactor which will have an input for feed, O_2 and H_2O. The reaction is a steam reforming reaction (in the presence of oxygen and water) or pyrolysis reaction (in the absence of oxygen). The steam reforming reaction will provide CO_2, CH_4 and CO as products and H_2O as by product. CO_2 and CO can be converted to CH_4 using a Sabatier reactor and then total CH_4 can be used for propulsion and in a fuel cell to generate electricity. H_2O can be fed to the electrolyser. The temperatures of the reactor have to be around 900-1000°C. The total energy generated from the reactor should be more than that utilized for using to heat the reactant waste in the reactor. The energy balance can be carried out considering the gas generated from the reactor is being fed into a fuel cell or is used for propulsion. The proposal to be submitted should include preliminary details of the mass and energy balance.

Scope of the work:

The scope of this work will include:

- Segregation strategy of the waste.
- Finding out the kinetics of the reaction using a lab-scale reactor for conversion of waste to gas reaction only.
- Mass balance and energy balance of the reactor and the feasibility of the total energy generation.
- Design of the reactor using COMSOL (or related software) for the waste to gas reaction.
- Demonstrating the feasibility of the reactor using the reactor mass and energy balance.
- Demonstrating the batch scale lab-level reactor with gases as products and net energy output.

Linkages to Space Programme:

- The reactor will aide in managing the waste generated onboard space station by providing useful gas and water.

Expected Deliverables:

- Kinetics of the waste reaction
- Prototype design of the reactor

RES-VSSC-2025-025

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Solution of inverse heat transfer problem using physics based AI and ML techniques

Area of Research

Inverse Heat Transfer, AI and ML

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

Shri. Philip George
Shri. Divyansh Prakash

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

divyansh_prakash@vssc.gov.in

Summary of the Proposed Research

The objective is to solve inverse heat transfer problem to determine time varying heat transfer boundary or temperature varying thermo-physical/optical properties of the material using temperature measurements in flight or ground tests. Physics based AI and ML techniques shall be used.

Scope of the work:

- The solution techniques developed will be used in future missions for material characterisation and validation of methods for quantification of planetary entry heating.

Linkages to Space Programme:

- Gaganyaan, RLV, NGLV, Interplanetary Entry Missions like Venus, Mars etc.

Expected Deliverables:

- Problem independent methodology.
- Methodology formulated should support.
- Different material class and types: isotropic and orthotropic; conductors, insulators and ablative materials.
- Perturbation of all types of properties and thermal boundary conditions.
- Perturbation of more than one set of parameters simultaneously (e.g. time-varying heat flux and temperature dependent emissivity).
- Better accuracy and computation time compared to optimization methods.
- Validation with test data available in literature. Acceptance after validation with lab tests in VSSC.
- Should be available as a library for integration with other in-house software.
- The detailed mathematical formulation along with the code shall be provided.

RES-VSSC-2025-026

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Physics Informed Neural Network (PINN) based Cohesive Zone Modelling (CZM) / Extended FEM(XFEM) frame work to model fatigue crack initiation and growth in Abaqus

Area of Research

Fracture mechanics

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

Shri. Sayeesh T M
Shri. Ayyappadas P

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

sayeesh@vssc.gov.in
ayyappadas_p@vssc.gov.in

Summary of the Proposed Research

Fatigue crack initiation and growth modelling in Abaqus using in-built cohesive zone module is computationally expensive if the structure geometry and loading is complex. Using PINN as a surrogate model to simplify the crack initiation and propagation under fatigue loading to be studied and a framework to be developed which uses PINN and CZM/XFEM for crack initiation and propagation. PINN also can be used to get cohesive law curve from specimen tests for different geometry, material, loads. The framework of PINN based CZM/XFEM to be integrated to Abaqus. Initially the PINN based CZM/XFEM framework can be used to predict initiation and crack growth in specimens followed by experimental validation. After validation, this framework can be extended to launch vehicle structures.

Scope of the work:

- Generation of PINN based CZM / XFEM framework, which can be integrated with Abaqus for fatigue crack initiation and growth prediction in launch vehicle structure. This framework need to be validated at specimen level with experiments.

Linkages to Space Programme:

- BAS and NGLV/LMLV structures are under fatigue loading and the steady state crack initiation and growth prediction is essential to plan any preventive maintenance or repair.

Expected Deliverables:

- PINN based CZM/XFEM framework in pytorch which is integrated to Abaqus.
- Experimental validation of PINN based CZM/XFEM framework in Abaqus for fatigue crack initiation and growth prediction in Compact Tension (CT), Middle Tension(MT) and Surface Crack Tension (SCT) Aluminum specimen.

RES-VSSC-2025-027

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Quantum Linear Solvers and Hybrid Quantum Classical algorithms for CFD solvers

Area of Research

Computational Aerodynamics

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

Shri. Harichand M V
Shri. Ebenezer Rajadurai T

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

harichand_mv@vssc.gov.in
ebenezer_rajadurai@vssc.gov.in

Summary of the Proposed Research

Simulations in Computational fluid dynamics involves solving large sparse linear equation, which may need preconditioning depending on the flow regime. Proposals are invited to apply quantum linear solvers for faster solution or acceleration of linear solver. Hybrid quantum classical algorithm or quantum inspired techniques are welcome. Proposals that study the applicability or feasibility of current quantum techniques to CFD problems are also invited.

Scope of the work:

- Quantum techniques to solve large sparse linear systems typically seen in CFD.
- Feasibility study to explore application to problems of interest to ISRO.
- Study the performance advantage over classical methods.

Linkages to Space Programme:

- Development of CFD software used for aerodynamic design, data generation and analysis.

Expected Deliverables:

- Study report with details of algorithms, source code and demonstration.

RES-VSSC-2025-028

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of finite element based interface sub-routine to include the effect of thermo-chemical decomposition in axi-symmetric thermo-structural analysis of an ablative material

Area of Research

Thermal Protection System (TPS), Ablative material, Structures

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

Dr. Chitaranjan Pany
Ms. M Mehreen Sana

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

p_chitaranjan@vssc.gov.in

Summary of the Proposed Research

Ablative materials (such as Carbon Phenolic, Silica Phenolic, etc.,) are widely used as thermal protection system (TPS) of launch vehicles in rocket nozzle liners, re-entry vehicles etc. Requirement of assessing the thermo-mechanical behaviour of ablative materials subjected to high thermal loads (under varying heating rate), considering pore pressure from thermo-chemical decomposition.

A finite element based mathematical interface program/code has to be developed which shall be linked to 2D axi-symmetric FE model to perform thermo-mechanical assessment of ablative materials including the effect of pore pressure for given specified thermal loads.

Scope of the work:

- Development of a finite element based mathematical interface program/code to carry out thermo-mechanical analysis of ablative composite material subjected to high thermal loads with varying heating rate including the effect of time varying pore pressure for a 2D axi-symmetric FE model problem.
- This developed mathematical subroutine (Python, MATLAB etc., script based) using UEL, UMAT, VUEL etc., shall be applicable as a plug-in to standard FE software (eg. Abaqus/ANSYS) to carry out thermo-structural assessment of a typical rocket nozzle system idealized using 2D axi-symmetric FE model for given specified thermal loads and mechanical loads & boundary conditions.

Linkages to Space Programme:

- Thermal protection system of rocket nozzle systems and re-entry vehicles.
- Gaganyaan, BAS, HRLV, Chandrayaan, LVM3, TVP, PSLV, GSLV, etc.

Expected Deliverables:

- Subroutine (Python, MATLAB etc., code based) developed for standard FE software (ANSYS/Abaqus).
- Detailed documentation and report.

RES-VSSC-2025-029

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Development of Carbon Nano Tube (CNT) Fiber

Area of Research

Materials

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

Shri. Shyam S Nair
Shri. Bhatt Tushar Shriram

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

shyam_sn@vssc.gov.in
bhatt_tushar@vssc.gov.in

Summary of the Proposed Research

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

CNT's are ideal multifunctional materials that combine the best properties of polymers, carbon fibers and metals with an outstanding combination of mechanical strength and stiffness, electrical and thermal conductivity, and low density. Primarily two different methods are reported in literature for realizing CNT fibers – (1) solid-state process wherein CNTs are either directly spun into a fiber from the synthesis reaction zone or from a CNT forest & (2) Wet spinning method in which premade CNTs are dispersed in a fluid, extruded out of a spinneret, and coagulated into a solid fiber by extracting the dispersant grown on a solid substrate.

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

Scope of the work:

- Development of process for CNT fibre synthesis.
- Characterisation of fibre.
- Post synthesis treatments if required to improve properties.

Linkages to Space Programme:

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

Expected Deliverables:

- Detailed development report on experimental studies carried out for the development, characterization and its outcome.
- Process report on finalized CNT fibre synthesis process route.
- One CNT fibre roll with fibre of dia. 150 – 250 micron & length 20 m approximately and of desirable properties (Tensile strength > 1 GPa and Electrical conductivity ~ 3 MS/m).

RES-VSSC-2025-030

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Lightweight Aramid Nanofiber (ANF) Aerogel threads for thermal Insulation.

Area of Research

Materials

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

Dr. Suresh Kumar A

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

a_sureshkumar@vssc.gov.in

Summary of the Proposed Research

Silica aerogel currently in use suffers from the drawback of mechanical stability during continuous operation cycles (crack formation). Development of lightweight, flexible, and structurally adaptable thermal insulator is envisaged through the proposal.

Aramid nanofibre (ANF) aerogel threads are realised via wet spinning of the aramid fibre suspension in solvent followed by super critical drying or oven drying. The thread can be used to prepare fabric having low thermal conductivity, better mechanical properties. The ANF aerogel threads can be further functionalised to obtain smart textiles with properties of hydrophobicity and electrical conductivity.

Scope of the work:

- The development of ANF aerogel thread can have a positive impact on the weight reduction and mechanical stability in flexible insulation areas of the Launch vehicle.
- Scope of work: Preparation of resin, Procurement of fibre and dispersion methods, Preparation of ANF aerogel threads.
- Party shall also conduct necessary tests for the developed ANF aerogel threads and provide the test reports. Property evaluation of developed samples shall also be carried out at VSSC.

Linkages to Space Programme:

- Mechanically stable, highly insulating flexible thermal insulation material.

Expected Deliverables:

- Flexible, light weight and mechanically stable ANF aerogel having the following properties:
  - Density: 1.40 – 1.43 mg/cm3
  - Thermal conductivity at RT: 0.025 W/mK (max)
  - Porosity ≥ 90%
  - Ultimate tensile stress: 3 - 5 MPa.
  - Breaking strength: 250 N (minimum)
- Party shall supply 50 to 100 m of aramid nanofibre aerogel threads.

RES-VSSC-2025-031

Name of ISRO/DOS Centre/Unit

Vikram Sarabhai Space Centre, Thiruvanathapuram

Title of the research proposal

Numerical simulation of residual stress, study on influence of residual stress on crack growth of ductile materials (Maraging steel, Aluminum alloys, Ti alloys etc.) and experimental validation

Area of Research

Structures, Process improvements

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

Shri. Ayyappadas P
Shri. Lokesh Rishabh

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

ayyappadas_p@vssc.gov.in
lokesh_rishabh@vssc.gov.in

Summary of the Proposed Research

All flight hardware shall be assessed and classified for fracture criticality from human rating point of view. Any part or component whose individual failure would result in a catastrophic event will be evaluated under Fracture Control. In launch vehicles, pressurized structures are there, such as motor cases, propellant tank, gas bottle etc. Pressure vessels are realized through weld route. Hence chance of residual stress accumulation near weld are very common. All pressure vessels are categorized into fracture critical. Hence, Fracture control plan is mandatory. Study on the crack growth behaviour of the structures in presence of residual stresses become essential in this scenario. Currently conservative design approaches are used to include the effect of residual stresses. This can lead to non-optimal hardware design. Detailed numerical study such as thermal analysis to simulate temperature changes and structural analysis to determine the resulting stresses and strains, simulations account for material properties, which can change with temperature, and phenomena like plastic deformation and phase transformations etc are to be carried out. Hence, Numerical simulation of residual stress, study on influence of residual stress on crack growth of ductile materials and experimental validation is proposed.

Scope of the work:

- Numerical simulation of residual stress during welding, machining or additive manufacturing etc.
- Study on influence of residual stress on crack growth of ductile materials
- Experimental validation such as X-ray diffraction (XRD), neutron diffraction, and hole-drilling to ensure accuracy.

Linkages to Space Programme:

- Programme linkage includes, Gaganyaan, NGLV, BAS, Orbital Module, HRLVM3 etc.

Expected Deliverables:

- Numerical simulation procedure, programme / code, experimental results

SPACE APPLICATIONS CENTRE

AHMEDABAD

RES-SAC-2025-001

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Application of joint Source and channel coding for Gaganyaan Mission other deep space mission

Area of Research

Communication

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

Dr. Deepak Mishra,
Shri Purushotham Tammali,
Shri Neeraj Mishra

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

deepakmishra@sac.isro.gov.in
purushotham145@sac.isro.gov.in
neerajsci@sac.isro.gov.in

Summary of the Proposed Research

Space missions rely on robust, efficient communication systems to transmit data from spacecraft or satellites back to Earth. Traditional space communication methods separate “source coding” (data compression) and “channel coding” (error correction). However, “Joint Source-Channel Coding (JSCC)” integrates these two processes to optimize bandwidth usage and error resilience, which is especially valuable in space communication where resources like bandwidth, power, and latency are highly constrained.

This project aims to investigate, design, and prototype a JSCC system tailored for space mission communications, with a focus on enhancing the efficiency and reliability of data transmission over long distances. This approach is particularly important for missions involving satellite constellations, planetary exploration, or interplanetary communication, where the available communication channels are prone to high noise, interference, and limited bandwidth.

- Research JSCC methods like “Analog Coding”, “Slepian-Wolf Coding” for correlated data, and “Deep Learning-based JSCC” for potential real-time applications.

Scope of the work:

- Design an Optimal JSCC System: Develop an integrated system combining source coding and channel coding to maximize communication efficiency for space missions.
- Optimize Bandwidth Usage: Reduce the data rate requirements for transmission, making efficient use of limited bandwidth available in space communication channels.
- Enhance Error Resilience: Improve the reliability of data transmission even in noisy and unpredictable space environments by leveraging error correction strategies.

- Prototype a Working Model: Build and test a JSCC-based communication system using software simulations and hardware prototypes that mimic space communication conditions.

Linkages to Space Programme:

- Space Communication (Gaganyaan, Chandrayaan, Aditya, and Mars Missions)
  - ➢ Current communication systems rely heavily on "separate source and channel coding", which may not fully optimize bandwidth or handle high error rates caused by cosmic noise and signal attenuation.
  - ➢ JSCC can enhance telemetry and scientific data return efficiency by jointly optimizing compression and error correction, ensuring more data is successfully received on Earth within the limited communication window.

- Satellite Communication (INSAT/GSAT Series)
  - ➢ ISRO's INSAT and GSAT communication satellite series are essential for broadcasting, telemedicine, and disaster management.
  - ➢ These satellites operate under limited transponder bandwidth and variable link quality, especially in adverse weather conditions. JSCC can improve bandwidth utilization and link robustness, allowing **higher-quality data, video, and telemetry transmission** within existing spectral constraints.

- Small Satellite and Student Satellite Programmes (Anusat, STUDSAT, NIUSAT, etc.)
  - ➢ ISRO supports numerous students and small-satellite missions through its Small Satellite Programme and collaborations with academic institutions.
  - ➢ These satellites often use low-power, narrowband communication systems — ideal testbeds for deploying and validating JSCC algorithms. Integrating JSCC into such missions can demonstrate its effectiveness in low-cost, power-limited space communication systems and enhance student training in advanced space communication technologies.

- Indian Navigation Satellites (NavIC) and Earth Observation Missions* JSCC can improve telemetry, tracking, and command (TT&C) reliability in NavIC and Earth observation missions (like Cartosat, Resourcesat, and RISAT). By reducing the effective bit error rate and optimizing data transfer, JSCC can ensure faster, more reliable transfer of high-resolution imagery and navigation data.

Expected Deliverables:

- Enhanced Communication Efficiency: Achieve significant improvements in bandwidth efficiency by reducing the transmitted data rate while maintaining data integrity through integrated source-channel coding.
- Improved Error Resilience: Demonstrate the effectiveness of JSCC in maintaining low error rates even under challenging communication conditions typical of space missions.
- Prototype System: Deliver a working hardware prototype capable of simulating space communication environments and demonstrating JSCC's practical benefits.

- Scalability for Space Missions: Provide insights into how JSCC can be adapted for various space mission types, including satellite constellations, interplanetary communication, and low Earth orbit (LEO) communications.

RES-SAC-2025-002

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Kalman filter and genetic algorithms based steered clock reference generation for Navigation satellite

Area of Research

Navigation, Digital Signal Processing, Signals and Systems, Clock

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

Shri. Harsh Agarwal,
Dr. Deepak Mishra

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

harshagarwal@sac.isro.gov.in
deepakmishra@sac.isro.gov.in

Summary of the Proposed Research

In satellite navigation, the stability of clock source is utmost essential. Various class of clocks such as XO, TCXO, OCXO, Atomic clocks, offer different stability some short term stability and some long term stability. Generally, an atomic clock is used to guide a OCXO providing both short term and long term stability. However, the reliability and stability can be further enhanced by steering the clock with multiple internal and external clocks. The clock steering mechanism allows to generate a highly stable clock working under guidance of various clocks and immune to failure of internal clocks. The project shall focus on developing algorithms, and hardware demonstration to steer a local clock with multiple external clocks using Kalman filter enhanced with nature inspired genetic algorithms for fast and global minimization of errors.

Scope of the work:

- Modelling the various class of clocks.
- Mathematical formulation with proof of algorithm for steering clock.
- MATLAB/Simulink based proof-of-concept.
- Demonstration of developed algorithm on hardware and testing of steered clock.

Linkages to Space Programme:

- Indian Space Navigation Programme, NVS, MEO Constellation.

Expected Deliverables:

- White paper for formulation, derivation and proof of algorithm developed.
- MATLAB/Simulink simulation files.
- Software code for hardware.
- Testing results.

RES-SAC-2025-003

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Application of AI for Autonav parameter generation for onboard NSGU design for MEO satellite

Area of Research

Navigation

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

Shri. Anand Mohan Roy,
Shri. Vijay Kadam

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

roy.anand@sac.isro.gov.in
vvkadam@sac.isro.gov.in

Summary of the Proposed Research

Precise Orbit Determination (POD) is a cornerstone of high-accuracy GNSS applications such as satellite navigation, geodesy, and autonomous spacecraft operations. Traditional methods—based on dynamic models and Kalman filtering—require highly accurate force models and extensive ground-based tracking data. However, inaccuracies in modeling environmental perturbations (e.g., solar radiation pressure, atmospheric drag, Earth albedo) and hardware limitations still constrain estimation accuracy.

This research proposes a hybrid orbit estimation framework that integrates physics-based dynamic filtering (e.g., Extended Kalman Filter or Square Root Information Filter) with a Machine Learning (ML)-based residual learning network. The ML module will learn the systematic model errors or unmodeled dynamics from historical orbit determination residuals and real-time telemetry data. The hybrid estimator thus combines the physical interpretability of classical models with the adaptive learning ability of ML methods.

This "Physics + ML" approach aims to minimize orbit estimation error, improve long-term prediction accuracy, and enhance onboard autonomy for future NVS satellites in MEO orbit.

Scope of the work:

- Develop a hybrid orbit estimation algorithm combining classical dynamic models with ML-based correction terms.
- Implement residual learning networks (e.g., LSTM, GNN, or transformer-based architectures) trained on orbit prediction residuals to model unmodeled accelerations.
- Integrate the ML module within a real-time filtering framework.
- Validate the proposed approach using both simulated GNSS constellation data and publicly available precise ephemeris datasets (e.g., IGS).
- Evaluate performance improvements over conventional POD and dynamic filters in terms of orbit accuracy, robustness, and computational efficiency.

Linkages to Space Programme:

- NVS MEO Satellites.

Expected Deliverables:

Algorithmic Framework:

- A validated hybrid dynamic + ML orbit estimation framework for NVS MEO satellites.

Simulation Platform:

- MATLAB/Python-based testbed integrating orbit propagator, filter, and ML module.

Performance Report:

- Comparative analysis with traditional orbit determination techniques

Onboard Demonstration Concept:

- Architecture suitable for real-time processing on MEO onboard processors.

RES-SAC-2025-004

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

GNSS Resilience Framework: Spatio-temporal Hybrid Model for Multipath, Signal Blockage, and Spoofing Detection under Adverse Conditions

Area of Research

Navigation and AI/ML

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

Dr. Vimalkumar Bhandari

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

vbhandari@sac.isro.gov.in

Summary of the Proposed Research

Global Navigation Satellite Systems (GNSS), including India's NavIC, serve as the backbone for navigation, transportation, communication, and timing applications. However, their performance is often compromised in adverse environmental conditions and complex urban settings, where challenges such as multipath interference, signal blockage, and intentional spoofing or jamming can severely affect positioning accuracy and reliability.

To address these challenges, the proposed project envisions an AI-enabled spatio-temporal hybrid framework that leverages data-driven intelligence to model both spatial dependencies among satellites, receivers, and environmental factors, and temporal variations in signal behaviour.

By learning patterns from real and simulated GNSS data, the framework will dynamically assess signal integrity, detect anomalies, and predict positioning degradation before it impacts navigation performance.

Scope of the work:

The project aims to develop a comprehensive spatio-temporal AI framework to enhance the integrity, availability, and continuity of GNSS signals. The major components include:

- **Data Collection and Simulation:** Collection of GNSS and NavIC raw data under various environmental and operational conditions. Simulation of multipath interference, signal blockage, and spoofing scenarios using realistic models.
- **Feature Extraction and Modelling:** Development of a hybrid spatio-temporal model capable of learning spatial relationships among satellites and receivers. Modelling of temporal dynamics to predict and compensate for signal degradation over time.
- **Real time Anomaly Detection:** Real-time identification of degraded, blocked, or spoofed signals. Estimation of correction factors and recovery strategies to maintain navigation continuity.
- **Integration and Validation:** Integration of the developed framework into a GNSS processing pipeline compatible with NavIC.Testing and validation through both simulated environments and real-world field experiments.

Linkages to Space Programme:

- Developed framework will be used by NavIC-enabled GNSS receivers and enhance the quality of GNSS services in sectors like smart cities road transport, high speed railways, inland water navigation and spoofing threatened aerial environments.

Expected Deliverables:

- Developed framework with source code, technical details and reports.
- Curated datasets and simulation tools for training and testing.
- Demonstration of developed framework.
- Detailed performance evaluation highlighting improvements in accuracy, availability, and integrity, with recommendations for NavIC deployment.

RES-SAC-2025-005

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Adaptive Threshold Imaging Front-End based on Fusion of Neuromorphic and CMOS Sensors

Area of Research

Electro-Optical Sensors, CMOS Imaging Front-Ends, Neuromorphic Sensing

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

Shri. Chunduri Sai Abhishek

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

abhishekch@sac.isro.gov.in

Summary of the Proposed Research

Neuromorphic imaging has emerged as a promising paradigm for high dynamic range, low-latency optical

sensing. Event-based cameras detect brightness changes asynchronously at the pixel level, enabling µs temporal precision and >120 dB dynamic range. However, current devices employ globally fixed or bias-programmed thresholds, which limits performance in varying illumination conditions.

This proposal investigates a hybrid electro-optical front-end architecture capable of operating in both conventional CMOS frame mode and event-driven mode in a closed loop. In the first phase, a baseline CMOS frame is captured to measure per-pixel or per-frame intensity statistics. From this frame, adaptive ON/OFF thresholds are derived using noise and contrast models, and programmed into the analog event comparators. During the subsequent event phase, the sensor streams asynchronous events tuned to the local scene characteristics. This loop (frame threshold synthesis event capture fusion) ensures improved event fidelity, reduced spurious activity, and dynamic adaptation to varying radiance and noise conditions.

The research will address circuit architectures for per-pixel or per-tile threshold storage, bias programming schemes, and event readout integration. Fusion algorithms for HDR imaging, motion deblurring, and adaptive exposure will also be studied. The outcome will be a front-end concept and prototype suitable for space borne imaging payloads.

Scope of the work:

The scope includes the design, modeling, and prototyping of a frame-guided event imaging front-end. This includes:

- Development of analog front-end circuits: photodiode log-readout, change detector, dual comparators (ON/OFF events), and per-pixel/tile threshold programming using capacitive storage or DAC biasing.
- Algorithms for adaptive threshold synthesis from baseline frames, incorporating shot/read noise models, local contrast measures, and SNR-based threshold tuning.
- Integration of frame and event capture loops with programmability, enabling dynamic adjustment of event capture window lengths.
- Laboratory validation using a dual-sensor (CMOS + event) rig and FPGA-based controller, followed by a test-chip front-end prototype.
- Evaluation under simulated test scenes for dynamic range, latency, false event rate, and bandwidth reduction.

Linkages to Space Programme:

This work directly supports ISRO's future Space Vision 2047 by enabling advanced electro-optical sensors with higher agility and resilience. Potential applications include:

- Star trackers and optical navigation: blur-free star acquisition during rapid slews.
- Planetary landing and descent imaging: event-driven edge detection fused with absolute frames for terrain-relative navigation.
- Earth observation payloads: high-dynamic-range imaging of limb regions and transient events such as lightning and glints.
- On-board data reduction: event-driven output reduces bandwidth and storage requirements in small satellites and deep-space missions.

The proposed adaptive front-end enhances robustness under extreme illumination, radiation, and dynamic conditions, making it directly relevant to ISRO's navigation, EO, and planetary exploration programs.

Expected Deliverables:

- Concept design and simulation results of frame-guided threshold adaptation.
- FPGA-based dual-sensor demonstrator for laboratory validation.
- Prototype analog front-end (test chip) with per-pixel threshold control.
- Performance evaluation datasets under test scenes (HDR, motion, low-light).
- Design recommendations for CMOS + event hybrid front-ends.
- Technical reports, design documents, and interface specifications for integration into EO-imagers.

RES-SAC-2025-006

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Particulate Monitoring System for microgravity environment

Area of Research

Sensors

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

Shri. Jayesh Jayarajan
Ms. Shikha Tomar

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

jayeshj@sac.isro.gov.in
shikha_tomar@sac.isro.gov.in

Summary of the Proposed Research

The proposed research would be aimed at design and realization of particulate monitor for usage in microgravity environment based on optical scattering. An instrument is to be developed which samples the air and measures the particle concentrations per unit volume of air and reports the same.

The unit has to be DC supply operated, Low power, miniaturized, with Ethernet data interface for data retrieval and logging.

Particulate monitoring is essential because for human health, total particulate matter has to be limited to <3mg/m3 and respirable fraction (<2.5um) has to be limited to <1mg/m3. Monitoring of particles sizes are from 5nm to 20um is essential.

Scope of the work:

- The scope of the research would include sampling the air, followed by passing it through a laser beam. The scattered light is to be detected through a photodetector and intensity measurement to be carried out. The amount and pattern of scattered light are to be correlated with particle size and count.

- Monitoring of particulate matter is to be done in space microgravity spacecraft environment with targeted particles sizes are from 5nm to 20um. Crew members as well as various equipment are source of airborne particles. Microgravity results in higher particulate count due to absence of gravitational settling of larger particles. Particulate monitoring is important especially for long term missions.
  - The targeted range for particle count is
  - PM10 : 0-5mg/m^3
  - PM2.5 : 0-2mg/m^3

Linkages to Space Programme:

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

Expected Deliverables:

- Particulate Monitoring System prototype hardware along with checkout system.
- Software and Hardware design details.

RES-SAC-2025-007

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of Ultra-Sensitive Optical Receiver System for Free Space Optical Links

Area of Research

Optical Communication

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

Shri. Vikas Agrawal
Shri. Saurabh Tandan

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

vikasagl@sac.isro.gov.in
saurabh_tandan@sac.isro.gov.in

Summary of the Proposed Research

Optical Communication receiver is very critical subsystem for any optical communication link. Its detects extremely weak signal (~<1 nW) , amplifies it and processes the incoming signal to extract data and clock information. This research is aimed to realize optical receiver system which can detect the incoming laser beam (~ 1550 nm range) in free space and after amplification and suitable detection , it extracts baseband and associated clock signal.

Incoming Signal Specs:

- Wavelength : 1530-1565 nm
- Received Beam Diameter: 2-5mm (Collimated)
- Received Signal Levels: <-55 dBm

- Data rate : 50 Mbps-10Gbps
- Modulation Format: On-Off Keying, DPSK.
- Target BER : ~10-6 (without channel coding)
- Output Interface : LVDS (low data rate) / CML (High data rate) i/f with serial / SerDes data format compatible with Xilinx- Kintex FPGA

Scope of the work:

- This research is aimed to develop an integrated solution for optical receiver system to be used in space based optical communication terminals. Optical receiver sensitivity is governed by multiple sub systems used in the optical receiver chain. A novel solution combining Optical, photonics and RF/ mixed signal & digital technologies to be developed to realize the Optical receiver system.
- In this research the free space optical signal with given specifications need to be coupled to a low noise optical amplifier with variable gain to amplify and filter the signal with desired OSNR to maintain the BER. This amplified signal is to be detected with suitable optical detector in free space/ fiber coupled mode and finally process the signal in Optical/RF/Digital/ Mixed signal domain to recover data and clock signals.
- Since this technology is to be developed for space based optical terminals so, requirement of space based system like radian, vacuum, temperature range etc. to be considered while design and component selection.
- Usage/ development of new technologies like photonic integrated circuits , integrated submodules/ components etc. are to be attempted.

Linkages to Space Programme:

- Free- Space Optical communication terminals for Space.
- TDS-02/ BAS/ Inter-planetary Missions.

Expected Deliverables:

- Study report of various architectures for receiver system.
- Design details of selected optical communication receiver system(s).
- Simulation/analysis of complete receiver system.
- Hardware development and testing results.
- Developed Hardware.

RES-SAC-2025-008

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Ka-Band and W-Band Extended Interaction Klystron (EIK) Development

Area of Research
RF and Microwave

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Ms. Harshita Tolani

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

Summary of the Proposed Research
Ka-Band Radar Interferometer (for global high resolution ocean Altimetry and surface wave studies) and mm-wave Cloud profiling Radars (for measuring vertical structure and vertical velocity of cloud particles) require transmitters with very high RF output power typically >1.5kW (peak). Extended Interaction Klystrons (EIK) are suitable candidate for use in this required application.

Indigenous development of EIK is required to be taken up to meet the requirements.

Scope of the work:
Design, Simulations and hardware development of Ka-Band and W-band EIK with following major specifications:

- Ka-Band EIK:
  - Center Frequency 35.75GHz
  - Bandwidth 200MHz
  - Output Peak Power 1.7KW (typ.)
  - Pulse Width 6.4µs (typ.)
  - PRF 4420 Hz (nom.)
- W-Band EIK:
  - Center Frequency 94.05GHz
  - Bandwidth 7 MHz (typ.)
  - Output Peak Power 1.8KW (Typ.)
  - Pulse Width 3.3µs (typ.)
  - PRF 6100Hz to 7500 Hz

Linkages to Space Programme:
- Future Ka-Band Radar Interferometer and W-Band Cloud Profiling Radar Applications.

Expected Deliverables:
- Ka-Band and W-Band EIK.

RES-SAC-2025-009

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Gridded Cathode based pulsed X-band TWT

Area of Research

RF and Microwave

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

Shri. S K Garg
Shri. Tuhin Paul

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

garg_sk@sac.isro.gov.in
tuhin@sac.isro.gov.in

Summary of the Proposed Research

The aim of this project to design and development of X-Band pulsed 300W TWT based on an efficient and precisely controllable electron source utilizing a gridded cathode configuration.

This project focuses on leveraging the unique physical properties of a gridded cathode in pulsed Traveling-wave Tube Amplifiers (TWTAs). The control grid, positioned directly adjacent to the electron-emitting surface, provides a means of modulating the electron beam's current without the need for complex, high-voltage equipment. Alternate pulsing methods, such as modulating the Beam focus electrode (BFE), require modulators capable of swinging thousands of volts at high speeds. Gridded cathode improves overall system reliability, and significantly reduces the size, weight, and power requirement of the final amplifier system. The developed technology is ideally suited for high power demanding and agile satellites, such as synthetic aperture radar (SAR) payloads on observation satellites, where reliable, efficient and lightweight high-power solutions are critical for mission success and longevity.

There is globally only one vendor providing space grade pulsed TWTAs and there are export control issues especially at strategic frequencies, necessitating indigenous development of this technology for self-reliance. Major specifications of proposed X-Band TWT are:

Center Frequency	9.6GHz
Bandwidth	1GHz
Output Peak Power	300W (typ.)
Pulse Width	60µs (typ.)
Duty Cycle(max)	25%
PRF	2500 to 7000 Hz

Scope of the work:

- Design and development of electrostatic model of gridded cathode-based electron Gun with control grid.

- Design and development of SWS, Collector, RF coupler.
- Fabrication and assembly of Gun, SWS, Collector and integrated assembly of TWT.
- Characterization and integrated testing of TWT.

Linkages to Space Programme:

- Future X-Band VHR-SAR payloads

Expected Deliverables:

- Gridded Cathode based pulsed X-band TWT

RES-SAC-2025-010

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Photonic Integrated Circuit Based Beamformer for X-Band Radar: Design & Simulation

Area of Research

RF and Microwave

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

Shri. Nitesh Sharma

Dr. Piyush Sinha

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

niteshs@sac.isro.gov.in

piyush@sac.isro.gov.in

Summary of the Proposed Research

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

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

The hybrid design siumlation will integrate passive photonic components for optical signal processing and an optical beamforming network. Active components, such as semiconductor optical amplifiers (SOAs) and Mach-Zehnder modulators, will handle signal amplification, modulation, and downconversion. The optical beamforming network will ensure precise control with amplitude error kept below 5% and phase error constrained to less than 10% to minimize pointing error and reduce the impact on SNR.

This hybrid integration of passive and active photonic components will enable compact, lightweight, and high-performance radar systems suitable for next-generation SAR platforms. This photonic solution offers significant SWaP-C advantages over digital FPGA-based systems, making it ideal for spaceborne SAR missions.

Scope of the work:

- The research will focus on the design and simulation of a photonic integrated beamforming receiver capable of processing signals from 12 input channels and synthesizing up to 3 beams.
- The hybrid photonic integrated circuit (PIC) will have low-loss passive components, including optical delay lines and tunable couplers, and components for signal amplification, modulation, and downconversion. The receiver will downconvert X-band signals to intermediate frequency (IF) using an optical heterodyne detection technique, providing a wideband, low-power alternative to digital solutions.
- The integration of photonic and electronic components into a single, compact assembly will be a key focus, delivering a high-performance, low-power solution for SAR missions.

Linkages to Space Programme:

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

Expected Deliverables:

- Design and Circuit Simulation Results of a photonic integrated beamforming receiver with IF output and capable of synthesizing up to 3 beams from 12 input channels, using a real-time beamforming.

RES-SAC-2025-011

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of technology independent RTL NvMe Controller IP with File system for FPGAs

Area of Research

Storage Protocol & File system, FPGAs, NvMe Protocol

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

Shri. Vikas Singh

Shri. Ritesh Kumar Sharma

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

vikassingh@sac.isro.gov.in

ritesh@sac.isro.gov.in

Summary of the Proposed Research

Microwave remote sensing & high-res optical payloads generate huge amount of data onboard during imaging. There is a need for fast storage of the data in high capacity memories, which can be retrieved later in non-imaging duration for onboard/edge processing. SSD offer high capacity storage, which can be used for this purpose. Thus there is need to develop NvMe IP for FPGA platforms with integrated support for file system management.

The developed IP should meet the following requirements ;

- NVMe Protocol Compliance Implement full NVMe command set (Identify, Read, Write, Flush, etc.)
- Support both PCIe (PCI Express) Gen3/Gen4 interfaces for host communication.
- PCIe Interface (Link Width: Support for x1, x4, x8 link width configurations).
- Support for popular file systems such as FAT32/NTFS/ext4 etc.
- Implement Direct Memory Access (DMA) for efficient data transfer between host memory and NVMe storage.
- Implement mechanisms for error detection and correction (e.g., CRC for data integrity).
- Provide mechanisms for burst data transfer, pipelined processing, and other techniques to minimize latency and maximize throughput.
- Provide a set of configurable parameters (e.g., number of queues, queue depths, etc.).
- Expose control registers to configure operational parameters (e.g., read/write size, block alignment)
- The IP must target popular FPGA families from vendors such as Xilinx/Microsemi

Scope of the work:

The proposed research involves;

- RTL Development of NvMe controller IP for SSD
- Functional Verification
- Comprehensive testbenches to validate all NVMe commands and controller functionalities using simulation-based verification using tools such as ModelSim/Questasim.
- Performance Testing
- Test the throughput (Better than 10Gbps), latency, and data integrity under various workload conditions. Use standard benchmarking tools and test vectors for NVMe compliance.
- Integration Testing
- Verify the interaction of the NVMe IP with a host system (e.g., FPGA platform connected to SSD or NVMe-based storage).Perform end-to-end system testing including boot-up, command processing, and error handling and file system integrity

Linkages to Space Programme:

- RTL Code (VHDL/Verilog)
- Testbenches and Simulation Models
- Documentation:
- Detailed functional description
- Integration guidelines
- Configuration guide
- API documentation for interfacing with file system

- Example reference designs for various FPGA platforms (Xilinx/Microsemi).
- Performance analysis and benchmarks.

Expected Deliverables:

- SAR and EO payloads for LEO missions

RES-SAC-2025-012

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design of processing algorithms and raw data simulation for Synthetic Aperture RADAR in Elliptical Orbit (ELO-SAR) amenable for Real time processing

Area of Research

SAR, Algorithms, Digital Signal Processing, Signals & Systems

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

Shri. Samrat Sinha
Shri. B Saravana Kumar

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

samrat1997@sac.isro.gov.in
saravana@sac.isro.gov.in

Summary of the Proposed Research

Space-borne SAR missions with highly elliptical orbit add complexity in SAR image generation due varying imaging geometry.

This proposal is for development of theoretical basis, mathematical formation and image generation algorithm for ELO-SAR data along-with necessary raw data simulation to back the algorithm. The algorithm must be implemented in any programming language (python, MATLAB, etc.) and should clearly bring out the additional changes required with current circular orbit based processing algorithms. For raw data simulation, one can assume an elliptical orbit of 200 Km x 600 Km.

Scope of the work:

- Literature survey for current state-of-the-art SAR processing algorithms.
- Simulation of Elliptical Orbit based raw data using multiple point targets and distributed target.
- Study of orbital parameters (Velocity, Range, Altitude) affecting processing of raw data acquired in Elliptical Orbit.
- Verification of algorithm with generated raw data and analysis of focused data in terms of PSLR and ISLR.
- Algorithm should be amenable for Real Time implementation (Eg: On a FPGA based processor) exploiting block processing efficiency.

Linkages to Space Programme:

- This algorithm will be used in ISRO's SAR missions.ks

Expected Deliverables:

- Algorithm and Theoretical Basis Document (ATBD).
  - ➢ Detailed mathematical breakdown/formulation of algorithm.
  - ➢ Analysis in every additional stage depicting its effect on the final focusing of data.
- Detailed comparison with Range-Doppler and Back-projection algorithms.
- Simulation and processor source code for Raw data and processing algorithm with all the analysis in a detailed report.

RES-SAC-2025-013

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design of fault tolerant eFPGA soft core with interface to RISC-V processor

Area of Research

Digital ASIC, VLSI

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

Shri. Himanshu N. Patel

Shri. B Saravana Kumar

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

hnpatel@sac.isro.gov.in

saravana@sac.isro.gov.in

Summary of the Proposed Research

On board digital systems for Interplanetary and small satellite missions requires to be miniaturized, energy-efficient, flexible and with adequate computing resources. System on Chip (SoC) with microprocessor soft core and embedded FPGA (eFPGA) provides best solutions for application demanding low power and flexibility.

This proposal is for development of eFPGA soft core and its integration with RISC-V microprocessor. The eFPGA should consist of array of basic logic unit (LUT, FF, etc), routing matrix, custom DSP block, memory etc. The eFPGA core should be developed as soft RTL core and interfaced with microprocessor through AHB/AXI bus. Various parameters like array size, I/Os, memory size etc should be configurable by user. Bit file generation flow for eFPGA core should be compatible to available/open source synthesis and P&R tools. This eFPGA core should have fault tolerant features suitable for use in space applications. This eFPGA is targeted for implementation of control & signal processing functionality for microwave remote sensing payloads.

Scope of the work:

- Literature survey to establish the current state-of-the-art in eFPGA.

- Study and establishment of design flow tools for open source IPs for RISC-V microprocessor (NOEL-V, Shakti, etc) and eFPGA (OpenFPGA, FABulous etc).
- Development of various design techniques for customization of eFPGA and its integration with main processor.
- Verification by simulation and FPGA proto-typing of developed IP cores.
- Integration of SoC and ASIC implementation on 65nm CMOS or lower process node.

Linkages to Space Programme:

- This eFPGA soft core will be useful for development various ASIC for future microwave remote sensing payload.

Expected Deliverables:

- Detailed Design and verification documents.
- VHDL RTL source code.
- Test bench (VHDL/System Verilog) and microprocessor firm wares (C code).
- Script & Log files.
- ASIC implementation front end files (post synthesis netlist, SDF, scripts, etc).
- ASIC implementation back end files (post P&R netlist, SDF, scripts, GDS-II, all reports and log, etc).

RES-SAC-2025-014

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Mathematical modelling, coding and simulation of Quantum Antenna Element and Array

Area of Research

Modeling of antenna expressing quantum behavior, Quantum emission control, High quantum efficiency and its optimization

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

Dr Pratik Mevada
Dr. V. K. Singh

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

pratik@sac.isro.gov.in
vksingh@sac.isro.gov.in

Summary of the Proposed Research

Quantum antennas leverage quantum emitters, such as quantum dots and NV centers, to enhance photon emission and facilitate quantum communication. However, a lack of robust mathematical frameworks limits our understanding of their behavior and optimization. Moreover, Quantum array antennas utilize multiple quantum emitters, such as quantum dots or superconducting qubits, arranged in an array configuration to manipulate electromagnetic fields at the quantum level. Currently, no models are available which adequately accounts for the complex interactions and collective behaviors of these emitters, limiting their practical applications.

Scope of the work:

- Model Development: Create a comprehensive mathematical framework that describes the electromagnetic behavior of quantum antenna element and its array, incorporating the effects of emitter spacing, phase relationships, and environmental factors.
- Collective Emission Dynamics: Investigate the cooperative phenomena arising from multiple quantum emitters in an array, focusing on enhancing photon emission rates and achieving desired radiation patterns.
- Optimization Strategies: Develop optimization algorithms to identify ideal configurations for quantum array antennas that maximize efficiency and control over emitted quantum states.
- Practical Applications: Explore how the model can be applied to real-world scenarios, such as quantum communication protocols and advanced sensing techniques, providing insights into design and implementation.
- Implementation: Program the developed mathematical model. Analyze and simulate the quantum array antenna using the same.

Linkages to Space Programme:

- Future quantum sensing and communication.

Expected Deliverables:

- Mathematical modelling, coding and simulation of Quantum Antenna Element and Array.

RES-SAC-2025-015

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and development of High Gain Antenna Array based on Spoof Plasmon Polaritron (SPP) excitation mechanism

Area of Research

Modeling of antenna expressing quantum behavior, Quantum emission control, High quantum efficiency and its optimization

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

Shri. Raksha Ram
Shri. Kaushik Kannan

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

raksharam@sac.isro.gov.in
kaushik153@sac.isro.gov.in

Summary of the Proposed Research

Surface plasmons are surface electromagnetic wave mode that can propagate on the surface of corrugated metal. Electromagnetic wave is tightly bound to the metal/dielectric interface in vertical propagation direction. This enables the electromagnetic wave to transmit along the periodic structure array of metal. TM mode can only propagate along the surface. This EM wave is called artificial surface

plasmons or spoof surface plasmon polaritron (SSPP). The functions and characteristics can be realized by using SPP, which can not be realized by using microstrip line/ coplanar waveguide structure.

The design of antenna array, which is based on SPP feeding mechanism, shows low loss at high frequency such as millimeter wave and Terra hertz applications bands. Therefore, by utilizing the concept of SPP, antenna array can provide high efficiency and high gain.

Scope of the work:

- Antenna Efficiency Enhancement : Exploring the ways to enhance antenna efficiency at high frequency in planner geometry of the antenna.
- Development of antenna: Design, simulation and development of array antenna using SPP excitation.

Linkages to Space Programme:

- SATCOM ground terminals and satellite antennas.

Expected Deliverables:

- High efficiency high gain (>33dBi) antenna array excited by SPP at Ka-bands (18-21GHz & 28-32GHz).

RES-SAC-2025-016

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Broad banding of NOLEN matrix BFN for simultaneous two beam generation in S-band in Tx and Rx

Area of Research

Multiple beam antenna

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

Shri. Atrish Mukherjee
Shri. Krishna prasad

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

atrish@sac.isro.gov.in
krishnaprasad@sac.isro.gov.in

Summary of the Proposed Research

In satellite communication due to limited available space, sometimes it becomes necessary to use same antenna aperture to generate simultaneous multiple beams to provide services at different coverage regions. There are multiple methods to generate simultaneous multiple beam from same aperture using RF and digital beamforming as well as using reflector antenna with focal plane feed array. While reflector antenna with focal plane feed array is good for higher frequency band (Ku or Ka band) and with large number of beams, it becomes very bulky at low frequency (L, S, C-band).

Generating multiple beams using array antenna with Digital beamforming is good for generating large number of beams or for reconfigurable beams. Digital beamforming is quite complex, costly and requires higher power to control the active elements.

In literatures different types of RF Beamforming network e.g. Butler matrix, Blass matrix, Nolen matrix etc. are reported. These beamforming networks can be used to generate simultaneous multiple beam from same array antenna. This is cost and power efficient compare to digital beamforming and requires less volume and mass compare to reflector based system

In SAC, work carried out for the development of RF beamforming network based on Nolen Matrix at S-band for generation of simultaneous two beams pointing at two different angle. This type of BFN can generate required amplitude and phase coefficients in very narrow frequency band. For TX/Rx operation, where both beams are dual band, the coupled BFN chain become very lossy and also beam pointing error occurs due to phase variation in the network.

The target of this proposal is to solve the above mentioned problem i.e. broad banding of Nolen matrix based RF beamforming network for dual band operation and development of an Array antenna at S-band to generate two simultaneous beams in Tx and Rx band.

Scope of the work:

- Selection of the optimum beamforming network to generate simultaneous two scanned beams at required angles (±3.5°).
- Both Beam is dual band i.e. each beam caters Tx and RX band.
  - Tx band: 2511 -2520 MHz and Rx band: 2680-2683 MHz
- Mathematical formulation and generalized code development for calculation of coupling coefficient for different stages of the beamforming network. Which can be used for similar requirement in future.
- Design of the array antenna with Beamforming network.
- Realization and characterization of the antenna.

Linkages to Space Programme:

- Design and Realization of the dual beam antenna.at S-band.
- Performance demonstration at SAC CATF.
- Complete research report with guide lines for development of future multiple beam antenna with RF beamforming.

Expected Deliverables:

- Spacecraft antennas for GEOSAT applications.

RES-SAC-2025-017

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design & development of Dual polarization, Wideband, electronically steerable Connected Array antenna at X and Ku band

Area of Research

Dual band Connected array, coupling analysis, Artificial dielectric layer.

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

Shri. Anand Singh
Shri. Devendra Sharma

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

asingh02@sac.isro.gov.in
devendrasharma@sac.isro.gov.in

Summary of the Proposed Research

The Connected arrays consist of arrays of either slots or dipoles which are electrically connected. They have the advantage of being broadband and achieve low cross-polarization levels with dual band operation. It Utilize ADL (Artificial dielectric layers) to eliminate scan blindness at larger scan angle. The connected array offers large operational bandwidth (octave), wide scan angle with good polarization purity. The expected deliverables are a low profile beam steerable antenna & Analysis Model for antenna Array with artificial dielectric layers.

Scope of the work:

- Design & devolvement of a low profile beam steerable antenna.
  - ➢ Wideband (octave bandwidth).
  - ➢ Wide Scan (± 60deg. elevation)
- Development of ADL (Artificial dielectric layer).
- Array Analysis with multilayered ADL.

Linkages to Space Programme:

- Single aperture antenna at X and Ku band for SAR and SATCOM Applications.

Expected Deliverables:

- Low profile beam steerable antenna.

RES-SAC-2025-018

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design & development of Reconfigurable Antenna using active Huygens's Cavity & Huygens Metasurface

Area of Research

Active Huygens's Cavity for plane/cylindrical wave generation & omega-bianisotropic Huygens Metasurface

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

Shri. Anand Singh
Shri. Sanjeev Kulshrestha

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

asingh02@sac.isro.gov.in
sanjeev@sac.isro.gov.in

Summary of the Proposed Research

Huygens' metasurface (HMSs) have demonstrated beamforming capabilities without complicated feeder network. The HMS when combined with a Huygens Cavity supported guided waves to excite a HMS and form leaky-wave structures with radiation controlled by the metasurface elements. It uses the concept that in a given region EM fields can be controlled by active or passive electromagnetic sources on the boundary surface of this region.

Scope of the work:

- Design and development of active Huygens cavity for arbitrary wave generation.
- Design & analysis of omega-bianisotropic HMS unit cell.
- Development of Code for Dynamic beamforming using HMS.
- Full Wave analysis and optimization for HMS aperture with active Huygens cavity.

Linkages to Space Programme:

- HTS ground terminal.

Expected Deliverables:

- Low profile reconfigurable antenna.

RES-SAC-2025-019

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of software/tool for simulation of full-polarimetric (HH, HV, VH and VV) Ground Penetrating Radar data for different subsurface scenarios

Area of Research

Remote Sensing, Signal Processing

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

Dr. Tathagata Chakraborty

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

tathagata@sac.isro.gov.in

Summary of the Proposed Research

Full-polarimetric ground penetrating radar (FP-GPR) technology characterizes the anisotropic characteristics, geometric structure and dielectric characteristics of the subsurface target body through the fully polarimetric scattering matrix, which significantly improves the target recognition accuracy and classification ability in complex media environments compared to single channel GPR. Hence, the novel FP-GPR technology is getting utilized in the fields of urban underground space digitization, geological

disaster warning and deep space and planetary resource exploration, to provide more adaptive solutions for high-precision shallow subsurface exploration. However, the behaviour of the radar responses in full-polarizations from different subsurface targets are ill-known. Hence, simulations of the full-polarization responses from the different subsurface targets in different frequencies will provide a first-hand information to understand the scattering behaviour of the targets. It will help to understand the typical radar scattering from complex targets with different shape, orientation, size and structures. However, the prevailing GPR simulation softwares have capability to mainly model the single-channel co-polarization GPR signatures. Hence development of software for simulations of FP-GPR responses from a complex subsurface target is necessary to interpret the real-life FP-GPR results. Such simulations can be done by solving Maxwell's equations in 3D using the Finite Difference Time Domain (FDTD) method, to simulate electromagnetic wave propagation. Hence, the software should have the capacity to carry out the simulation for a given GPR antenna configuration and subsurface model provided by the user.

Scope of the work:

- The proposed research aims to develop a software which can solve Maxwell's equations in 3D using the Finite Difference Time Domain (FDTD) method, to simulate electromagnetic wave propagation. The software should has the capability to numerically model the GPR radargram (complex radar reflection in time domain) corresponding to 4-polarization (HH, HV, VH and VV) in a given GPR antenna configuration for different subsurface scenarios comprising targets with different shape, size, structure and dielectric properties.

Linkages to Space Programme:

- The research aid to simulate polarimetric GPR data for different lunar and Martian scenarios to understand the sensitivity of GPR instruments and radar scattering behaviour of various targets present in the planetary near subsurface. The research has strong linkage with Chandrayaan-5 LUPEX mission and future Mars mission.

Expected Deliverables:

- Finite Difference Time Domain based electromagnetic simulation software for simulation of full-polarimetric GPR radargram.

RES-SAC-2025-020

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

AI-based Automatic Road Network Extraction from Satellite Imagery

Area of Research

Feature extraction for urban remote sensing applications

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

Ms. Kriti Rastogi

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

kritirastogi@sac.isro.gov.in

Summary of the Proposed Research

Road network extraction is a major requirement for policy-makers such as Ministry of Road Transport and Highways (MoRTH), urban local government bodies etc. This requires development of algorithms for automatic road network extraction leveraging the advantage of high-performance deep learning segmentation, on the Indian remote sensing satellite data such as 30 cm GSD Cartosat-2/3 data and 5 m GSD Resourcesat-2/2A LISS-4 data. The work involved development of an image recognition neural network model for road segmentation overcoming the challenges such as occlusion from buildings, trees, shadows etc. and abrupt changes in colour and materials along the same road. The developed neural network should not only identify road interiors and visible features of roads, but it should also be able to smooth the part of road not visible due to any occlusion. The segmented road needs to be converted into vector for road network reconstruction, removing the noise, preserving geometric features such as roundabouts, and identify road materials, using GIS and optimisation algorithms. The proposed project aims to provide geometrical regularity, topological correctness and material classes of roads.

Scope of the work:

- AI based road extraction from high-resolution Indian satellite imagery. It includes road segmentation to identify road interiors and road contours, road reconstruction via removing any noise in between the roads and road material identification (bituminous or black-top roads, concrete or white topped road, earthen road) to classify roads.

Linkages to Space Programme:

- Use of Indian remote sensing satellites (Resourcesat and Cartosat) data. It will be used as input for Ministry of Urban and Housing Development (MoUHA) and Ministry of Road Transport and Highway (MoRTH).

Expected Deliverables:

- A fully automated pipeline for extraction for road network from high resolution satellite imagery.

RES-SAC-2025-021

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of a Harmonized High Spatio-temporal Satellite Soil Moisture: Leveraging Merging Techniques and Uncertainty Estimation

Area of Research

RS & GIS

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

Dr. Dharmendra Kumar Pandey

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

dkp@sac.isro.gov.in

Summary of the Proposed Research

Soil moisture (SM) is vital for agriculture, hydrology, and climate. Accurate, high spatio-temporal SM data is essential for irrigation management, crop growth, drought forecasting, and flood prediction. Currently, Satellite-based soil moisture products from NISAR, Sentinel-1, and EOS-04 meet spatial resolution

(~100m) but are highly limited by temporal repeatability (12–17 days) of satellite. These revisit cycles hinder monitoring of rapid changes in SM, which is crucial for real-time decision-making.

Field-scale monitoring requires sub-weekly updates to track soil moisture dynamics during critical periods such as irrigation events, crop growth stages, and extreme weather. Current products fail to provide the temporal frequency needed for effective agricultural and hydrological applications.

To address this, there is a need to:

Develop advanced merging techniques to combine multiple satellite data into a harmonized high spatio-temporal soil moisture

Incorporate uncertainty estimation to quantify the framework reliability for operational decision-making.

This research will provide high-frequency, reliable SM data for real-time agricultural and hydrological decision-making, aiding water management and enhancing climate resilience.

Scope of the work:

- Development of Multi-Sensor Data Merging & Advanced Fusion Algorithms including ML/DL methods for high resolution Soil Moisture product.
- Unified Framework Development with uncertainty estimate and Validation over selected sites with ground-based measurements.

This research will deliver timely, reliable SM data supporting agriculture, hydrology, and climate resilience in India.

Linkages to Space Programme:

By developing a harmonized spatio-temporal satellite soil moisture, the research leverages data from NISAR (L & S band SAR), EOS 04 (C band SAR), and the future RISAT Series of C band SAR missions.

- NISAR provides global, high frequency soil moisture data, essential for real-time monitoring of hydrological processes across India.
- EOS-04, with its operational C band SAR, strengthens India's space-based EO infrastructure for agricultural and hydrological decision support.
- The RISAT Series (upcoming C band SAR missions) extends these capabilities, providing additional high-resolution data for real-time soil moisture estimates, which is key for water resource management.

By merging these multi-satellite datasets, this research enhances ISRO's contributions to climate resilience, agriculture, and hydrological decision support, aligning with the Vision 2047 goal of self-reliant, actionable space solutions for national development.

Expected Deliverables:

- Advanced Merging Algorithm and Models.
- Uncertainty Estimation Framework.
- A harmonized High Spatio-temporal Soil Moisture.

RES-SAC-2025-022

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Data assimilation for Improved Hydrological modeling over Himalayan river catchment

Area of Research

Modeling & RS

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

Dr. Amit Kumar Dubey

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

a_dubey@sac.isro.gov.in

Summary of the Proposed Research

Data assimilation play an important role in hydrological modeling as it greatly enhances our ability to understand the complex behavior of surface water dynamics. The Himalayan region, spanning diverse landscapes and encompassing towering peaks, vast plateaus, and intricate river systems, holds profound significance for Earth's hydrological cycle and water resources potential of India. However, the complex terrain, extreme climatic conditions, and unique land-atmosphere interactions within this region pose substantial challenges to accurate hydrological modeling. By assimilating satellite derived products such as snow cover or wet snow into Hydrology models, corrects model biases and significantly improves model accuracy.

Scope of the work:

Data assimilation methods in hydrology play a pivotal role in enhancing our understanding of complex water systems. Several important data assimilation techniques are employed in hydrology, including the Ensemble Kalman Filter (EnKF), Particle Filter (PF), and Variational Data Assimilation (VAR). EnKF and PF are particularly valuable for their ability to handle complex, non-linear land surface models and account for uncertainties through ensemble-based approaches. These methods enable assimilation of satellite data, such as discharge, soil moisture and snow cover, into a land surface hydrological model, leading to better estimation of hydrological variables. The specific objectives will be:

- Development of data assimilation framework for improved hydrological modeling
- Performance evaluation of the developed assimilation scheme for any selected Himalayan catchment

Linkages to Space Programme:

By developing a harmonized spatio-temporal satellite soil moisture, the research leverages data from NISAR (L & S band SAR), EOS 04 (C band SAR), and the future RISAT Series of C band SAR missions.

- NISAR provides global, high frequency soil moisture data, essential for real-time monitoring of hydrological processes across India.
- EOS-04, with its operational C band SAR, strengthens India's space-based EO infrastructure for agricultural and hydrological decision support.

- The RISAT Series (upcoming C band SAR missions) extends these capabilities, providing additional high-resolution data for real-time soil moisture estimates, which is key for water resource management.

By merging these multi-satellite datasets, this research enhances ISRO's contributions to climate resilience, agriculture, and hydrological decision support, aligning with the Vision 2047 goal of self-reliant, actionable space solutions for national development.

Expected Deliverables:

- Advanced Merging Algorithm and Models.
- Uncertainty Estimation Framework.
- A harmonized High Spatio-temporal Soil Moisture .

RES-SAC-2025-023

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Quantum Enhanced Algorithms Design and Development for Remote Sensing Data Processing

Area of Research

Quantum Computing, Remote Sensing, Data Processing, Artificial Intelligence, Earth Observation

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

Dr. Indranil Misra

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

indranil@sac.isro.gov.in

Summary of the Proposed Research

Quantum computing presents an exciting frontier for revolutionizing remote sensing data processing. The research will focus on exploring quantum algorithms to improve the efficiency, accuracy, and speed of processing large-scale Earth observation data from satellites. Specifically, it aims to integrate quantum computing techniques with existing remote sensing workflows for data classification, feature extraction, and image registration tasks. By leveraging quantum computing algorithms, this research will aim to solve complex optimization problems in remote sensing, such as multispectral image fusion, band-to-band registration, and atmospheric correction, which are computationally intensive on classical hardware. The expected outcome is a prototype quantum-enhanced processing framework that can be integrated with ISRO's Earth observation satellite data processing workflow for more efficient data analysis, helping in applications like climate monitoring, disaster management, and resource management.

Scope of the work:

This research will investigate the use of quantum computing algorithms in processing remote sensing data from ISRO's Earth observation satellites, including Resourcesat, Cartosat, RISAT, Nano & Micro satellites and others. Quantum computing will be used to optimize existing algorithms and explore new techniques for image processing, pattern recognition, and data fusion. The focus will be on:

- **Quantum Annealing for Optimization:** Exploring the potential of quantum annealers to solve optimization problems in image registration and geometric correction.

- **Quantum-enhanced Classification:** Leveraging quantum machine learning algorithms for more accurate and faster classification of remote sensing data.
- **Hybrid Quantum-Classical Algorithms:** Developing hybrid models that combine quantum computing with classical data processing methods for scalable solutions.
- **Scalability for Big Data:** Utilizing quantum parallelism to address the challenges of processing large volumes of satellite imagery and geospatial data.

The scope includes both theoretical studies and the implementation of practical prototypes for testing on ISRO's current and upcoming remote sensing satellite data.

Linkages to Space Programme:

- SDN Testbed with PQC based communication, A functional network with SDN controllers and switches and Secure, encrypted communication between controller and switches based on PQC.

Expected Deliverables:

- On successful completion of project, ISRO/DOS can explore it for SDN based network implementation.

RES-SAC-2025-024

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

OpenSAFE (Open Satellite Analysis for Feedback and Evaluation): A framework for Radiometric & Geometric Stability Analysis and Calibration of Multi-Sensor Optical Earth Observation Data

Area of Research

RS & GIS

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

Shri. Tushar Shukla

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

tushar@sac.isro.gov.in

Summary of the Proposed Research

OpenSAFE will be an end-to-end, web-accessible platform designed to automate radiometric and geometric calibration, cross-sensor harmonization, and stability/quality analysis for optical Earth Observation (EO) satellite imagery. The platform will support multiple sensors (e.g., Resourcesat-2/2A, Oceansat-2/3/3A, and other global satellites such as Sentinel & Landsat), provide reproducible processing pipelines, visual analytics, and APIs for integration with downstream applications. The platform targets remote sensing groups, data providers, and researchers needing standardized calibration and long-term stability assessment across sensors. Framework will be backed by agentic AI integration that will enhance calibration workflows, anomaly detection, and sensor stability predictions.

Scope of the work:

Multi-sensor imagery enables high revisit frequency and complementary spatial/spectral coverage, but differences in radiometric response, geometric accuracy, and temporal stability create biases that

affect downstream analyses. Existing calibration efforts are often tailored to specific sensors and lack centralized, shareable, reproducible workflows and interactive visualization. An open web-based framework will lower barriers to consistent calibration, allow continuous monitoring of sensor stability, and provide dashboard to monitor provenance for large-scale processing. The integration of AI will improve the efficiency and precision of calibration, increase automation, and enable predictive analysis for sensor stability.

Framework to include datasets from following sources:

- Optical multispectral imagery from multiple sensors (Resourcesat-2/2A, Oceansat-2/3/3A, and other global satellites such as Sentinel-2/3, Landsat, others via user upload).
- Auxiliary data: reference ground targets (RadCalNet or user-supplied), DEMs for orthorectification, precise orbit/attitude metadata, and GCP catalogs.

Project scope will include following development areas:

- Radiometric Calibration
  - ➢ Preprocessing: Cloud/shadow masking, atmospheric correction
  - ➢ Absolute calibration: Comparison with in situ reference targets (reflectance-based) and vicarious calibration methods.
  - ➢ Relative cross-calibration: Inter-sensor linear/robust regression, spectral response correction.
  - ➢ AI-driven correction: Machine learning models will optimize sensor calibration, learn inter-sensor relationships, and adjust spectral bands.
- Geometric Calibration
  - ➢ Metadata-driven checks: RPC residuals, GCP prediction vs. measured.
  - ➢ Co-registration: Feature matching using AI models for improved accuracy.
  - ➢ AI-based tie-point adjustment and RPC refinement.
- Stability & Time-Series Analysis
  - ➢ Temporal trend detection: AI models for detecting sensor drift, step changes, and anomalies.
  - ➢ Automated reports: Sensor-sensor bias history, drift rates, anomaly alerts, with AI-driven predictions for future calibration needs.

Linkages to Space Programme:

- ISRO plans to launch more than 100 EO satellites in next 15 years. The development of a framework for automated analysis and on-the-fly re-calibration of satellite data on these platforms is no longer an optional feature but a necessity that needs to be addressed. The framework will help establishing and improving the quality of ISRO EO data.

Expected Deliverables:

- Complete framework (UI + API) with documented installation/deployment guide.
- Radiometric and geometric calibration modules with a test suite.
- Sample workflows, validation results (reports + visualizations).

- User documentation, tutorials, and API docs.
- Final project report and demo.

RES-SAC-2025-025

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Investigation of the Baby Dragon Hatchling (BDH) architecture for satellite remote sensing image applications

Area of Research

Satellite Remote Sensing

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

Shri. Shriram T. G.

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

shriram@sac.isro.gov.in

Summary of the Proposed Research

Baby Dragon Hatchling (BDH) is a new Large Language Model (LLM) based on a biologically-inspired network of locally interacting neuron particles. It is a performant, state-of-the-art attention-based state-space sequence learning architecture which couples strong theoretical foundations and inherent interpretability without sacrificing Transformer-like performance. Although this model is proposed mainly for language related tasks, this proposal aims to investigate this model for some remote sensing applications, such as classification, super-resolution, segmentation, object detection, change detection etc. as done by Vision Transformers.

Scope of the work:

- To experiment with and develop interpretable Deep Learning models, demonstrating their capability over some of the various remote sensing applications aforementioned, on contemporary satellite image datasets.

Linkages to Space Programme:

- Linked with the vision to make AI as the driving technology for Satellite Image Processing and its downstream applications for the benefit of civilian and strategic users.

Expected Deliverables:

- Algorithms, Source Code (python), Model Architectures, Insights on model inference.

RES-SAC-2025-026

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Development of Thermal Link to achieve Thermal Contact at Cryogenic Temperature based on Differential Contraction for Cryostat of Ground Based Astronomical Application

Area of Research

Heat Transfer

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

Shri. Ashish Kumar Shukla
Shri. Vaibhav Kumar Upadhyay
Shri. Ulkesh B Desai

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

aks66058@sac.isro.gov.in
vupadhyay@sac.isro.gov.in
ulkesh@sac.isro.gov.in

Summary of the Proposed Research

Cryostat used for ground based astronomical telescopes consists of Cryogenically cooled front-end electronics to improve the system sensitivity. Cryostat for these applications consists of a vacuum enclosure and GM Cryocoolers are used to achieve cryogenic temperature.

Cryogenically cooled electronics is mounted on a separate structure having two or three stages to maintain different temperature inside Cryostat. These stages are separated using low thermal conductivity rods. This structure is assembled inside Cryostat and required thermal contact is made with Cryocooler to achieve temperatures at various stages of structure during operation.

Proposed thermal link will be used to achieve required thermal contact between Cryocooler Cold Head and Front-end electronics structure. Thermal link will be made of two parts, first part (external Housing) will be assembled inside Cryostat and second part (Internal Housing) will be integral to the structure over which electronics is mounted. External housing assembled inside Cryostat will be anchored with Cryocooler Cold head using Flexible straps. Internal Housing assembled on the electronics structure will be inserted inside Cryostat. External housing will receive the structure during assembly and structure will be connected with Cryostat vessel. During Cool down both parts of thermal link will contract to establish heat conduction path. Thermal path shall be established by achieving differential contraction by specific geometry of both parts of link or by selection of different combination of materials.

Scope of the work:

- Design and Development of Thermal Link based on thermal contraction at Cryogenic temperature for transfer of heat through conduction. Developed thermal link shall be compatible for operating temperature as low as ~ 3 K and thermal contact resistance of the link shall be in order of ~ 0.2 K/W @ 4 K and 0.5 K/W @ 80K~100K.

Linkages to Space Programme:

- This proposal has linkage with Cryogenic System of THz Telescope proposed for ground based Astronomical Applications.

Expected Deliverables:

- Design Methodology for Differential Contraction based thermal link as well as methodology to scale up and scale down the size of thermal link based on application requirements.

- Prototype of Designed and Developed Thermal Link along with measured results of Thermal Contact Resistance

RES-SAC-2025-027

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Defect Dataset Augmentation using Generative Adversarial Networks (GAN)

Area of Research

Automation, Machine vision

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

Shri. Riddhi Shah

Shri. Avnish Jain

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

riddhishah@sac.isro.gov.in

avnishjain@sac.isro.gov.in

Summary of the Proposed Research

MIC, MMIC & LTCC assemblies mainly constitute the RF circuits of microwave, communication and navigation payloads. These assemblies require stringent quality control to achieve zero defect. Defects such as micro-cracks, solder bridges, delamination etc. are critical for visual inspection which are human dependent on their skill and judgement. Improvemet in visual inspection accuracy can be achieved through AI. This project aims to create an AI-based inspection system that can automatically identify and classify microscopic defects in MIC, MMIC & LTCC assemblies using advanced Machine Learning(ML) and image processing techniques. It will identify, mark, and record common defects such as Deep tool mark, solder non-wetting, bond wire lift-off, bond wire break, die cracks, contamination, metallization peel-off in MIC/MMIC assemblies and ceramic micro-cracks, conductor breaks, solder/adhesive overflow, surface contamination in LTCC modules.

Scope of the work:

Developing and validating defects detection algorithm. It includes:

- Developing and training a suitable algorithm. Image enhancement, segmentation, pre-processing, and feature extraction.
- Development of user interface for image capture from microscope.
- Testing and comparing automated detection results with visual inspection.
- SAC will provide samples of assemblies, available defect images with description of defect types and their QC inspection criteria.

Linkages to Space Programme:

- All future payloads of ISRO

Expected Deliverables:

- Defects detection software that identifies and classifies MIC, MMIC, and LTCC defects with high

accuracy and minimal false alarms with User Interface, Documentation, Test Results, Defects Database.

RES-SAC-2025-028

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

SDN-Based Network with Post-Quantum Cryptography for Secure and Optimized Traffic Management

Area of Research

Administrative Area

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

Shri. Pravin K Choudhary
Shri. Amitesh Kirti
Shri. Yogesh Verma
Shri. Ajay Kumar Sharma

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

pravin.choudhary@sac.isro.gov.in
amitesh@sac.isro.gov.in
yogeshverma@sac.isro.gov.in
shaks@sac.isro.gov.in

Summary of the Proposed Research

Modern networks face growing challenges, including unpredictable traffic loads, complex configuration management, and increasing security threats. Software Defined Networking (SDN) addresses these issues by decoupling the control plane from the data plane, enabling centralized, programmable network management.

This project aims to implement an SDN-enabled testbed that demonstrates dynamic traffic management, flow-level security, and virtualized multi-tenant network isolation. Additionally, all communication between SDN controllers and switches will employ Post-Quantum Cryptography (PQC) to protect against future quantum-enabled cyberattacks.

This research proposal aims to combine the benefits of SDN for optimized traffic management with the security of PQC to enhance the overall network performance and security.

Scope of the work:

- Design an SDN-based Architecture: Develop an SDN architecture with dynamic adjustable traffic management, while being secure and scalable for a network size upto 100 end-point devices and 10-20 SDN-enabled network switches.
- Implement Post-Quantum Cryptographic Techniques: Integrate PQC algorithms into the SDN framework to replace or complement traditional cryptographic protocols. These algorithms must be compatible with existing SDN controllers and networking hardware. PQC-enabled controller-switch

communication for quantum-safe networks. Use hybrid encryption schemes that combine classical encryption for existing protocols (e.g., AES) with PQC-based key exchange and signatures for secure communication between SDN components.

- Optimize Network Traffic: Leverage SDN's programmability to develop intelligent traffic management mechanisms that can adapt to changing network conditions while ensuring post-quantum security. Automatic load balancing and QoS-based prioritization.
- Evaluate Performance and Security: Assess the performance impact of PQC algorithms on the SDN infrastructure, with a focus on latency, throughput, and resilience to quantum attacks. Flow-level detection and isolation of malicious or unauthorized traffic. Metrics on response times and security effectiveness.
- Framework for Network Operators: A set of guidelines and recommendations for network operators to seamlessly transition from traditional cryptographic methods to Post-Quantum Cryptography.
- Analytics Dashboard & Performance Report of Real-time network monitoring interface.
- Documentation: Detailed configuration, use-case demonstration and deployment guidelines for campus/ enterprise networks.

Linkages to Space Programme:

- SDN Testbed with PQC based communication, A functional network with SDN controllers and switches and Secure, encrypted communication between controller and switches based on PQC.

Expected Deliverables:

- On successful completion of project, ISRO/DOS can explore it for SDN based network implementation.

RES-SAC-2025-029

Name of ISRO/DOS Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Investigation on Heat Exchanger Configurations for Stirling- Type Pulse Tube Cryocoolers (SPTC)

Area of Research

Cryogenics/ Heat Transfer

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

Shri. Surendra Singh Sisodia
Shri. Vivek Kumar Singh
Shri. Sandip R Somani

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

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

Summary of the Proposed Research

Aftercooler (AC), Cold-end heat exchanger (CHX), Hot- end heat exchanger (HHX), and regenerator are the key thermal components in Stirling-Type Pulse Tube Cryocoolers (SPTCs). Their performance

governs the overall performance of SPTC. SAC is currently developing 80 K, 20 K, and 4 K class SPTCs for advanced space and scientific missions.

Worldwide, various heat exchanger configurations such as slit-type, wire-mesh-type, spiral-groove, and micro- channel designs are in use. However, the literature lacks systematic guidelines for selecting the most suitable configuration for specific operating conditions such as temperature level, frequency, working fluid, or geometric constraints. Additionally, comprehensive studies that define optimum parameters like porosity, hydraulic diameter, fin density, flow resistance, and thermal effectiveness are limited.

To address this gap, a structured investigation based on CFD-based simulations and development of simplified numerical modelling is required. Such an approach can provide insights into flow behaviour, pressure drop, temperature profiles, and overall thermal performance across different heat exchanger geometries. This study will help identify optimal configurations and design parameters tailored to each SPTC temperature range.

The optimized heat exchangers designs obtained from this analysis can be experimentally validated using the SPTCs currently under development at SAC, ensuring their practicality and contribution to performance enhancement.

Scope of the work:

Based on inputs given from SAC' analyze AC, CHX and HHX, and configurations for SPTCs.

- Compare feasible heat exchanger geometries such as slit-type, wire-mesh, spiral-groove, and micro-channel designs.
- Perform CFD simulations and develop simplified numerical model to study flow behavior, heat transfer, effectiveness, etc.
- Identify optimum parameters including porosity, hydraulic diameter, fin density, length, and material.
- Experimentally validate the optimized heat exchangers in SAC's SPTC systems and prepare practical design guidelines.

Linkages to Space Programme:

- Proposed research is directly related to ongoing SPTC development at SAC for various optical, Tera Hz Payloads, etc.

Expected Deliverables:

- Design guidelines to identify optimal configurations and design parameters for SPTCs of various temperature ranges, frequency, etc.

U. R. RAO SATELLITE CENTRE

BENGALURU

RES-URSC-2025-001

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Flying Robot for zero-Gravity Air environment inside Space station

Area of Research

Space Robotics
Flying robot/Drone

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

Shri. Vallury Sri Pavan RaviChand
Shri. K Balaji

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

sripavan@ursc.gov.in
kbala@ursc.gov.in

Summary of the Proposed Research

Robot assistants are needed inside space station to assist humans and improve productivity and safety. One such robot is 'flying robot'. This is a robot that functions under zero gravity and moves autonomously to the desired spatial position.

This proposal is on development of simulation and hardware prototype of free flying robot. The robot shall have a cube structure with around 40 cm side. It shall have propulsion system, cameras and sensors for autonomous spatial movement inside a room. It shall have interface on bottom face for connecting with a gravity compensation mobile system. This enables for 3 DOF hardware testing.

Scope of the work:

- Hardware prototype of flying robot having propulsion tank, impeller, nozzles, cameras and NGC sensors. This should have 6 DOF for spatial movement.
- Simulation for 6 DOF movement of robot under zero gravity involving below tasks.
  - Autonomous movement of the robot (with tool) to one of the three interfaces on walls of the room (may be based on a light indicator).
  - Placing the tool on the interface.
  - Autonomous movement of the robot (without tool) to one of the other two interfaces on the walls of the room (may be based on a light indicator). This wall interface has a tool already attached.
  - Attaching this tool to the robot.
- Hardware demonstration for 3 DOF movement of robot attached to gravity compensation system for same tasks as mentioned above for simulation for 6 DOF movement.

Linkages to Space Programme:

- Future Development for satellite missions. This has application in air environment under zero-gravity like space station and under low-gravity like lunar habitats for experiments.

Expected Deliverables:

- Hardware prototype of flying robot
- Simulation code and results for 6 DOF
- Gravity compensation mobile system for 3 DOF demonstration

RES-URSC-2025-002

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of Spectro-polarimetric radiative transfer model for planetary and exoplanetary studies with Venus Orbiter Mission and future Indian missions

Area of Research

Planetary and Exoplanetary Science

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

Shri. Bhavesh Jaiswal

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

bhavesh@ursc.gov.in

Summary of the Proposed Research

Detailed interpretation of spectro-polarimetric observations of Earth, solar system planets and even exoplanets, require polarimetric radiative transfer model. This is crucial especially to constrain cloud and aerosol properties in the planetary atmosphere along with the planetary surface properties. Therefore, in this project we will develop a polarimetric radiative transfer model capable of studying the properties of reflected light. In the immediate future, this model will be valuable to plan and interpret the observations from Venus Atmospheric Spectro-Polarimeter (VASP) instrument on ISRO's Venus mission. In the long term, the model will be valuable to perform sensitivity studies to design optimal instruments for future missions with polarimeters for other solar-systems planets, Exoplanets and even Earth. It has also been highlighted by some studies that ignoring polarization can lead to errors in total fluxes computed by unpolarized radiative transfer models, leading to inaccurate constraints on the atmospheric gaseous abundances. Therefore, this model development will also be valuable to obtain accurate constraints on gas mixing ratios and cloud top altitudes. The potential of polarimetry to assess the habitability of various exoplanets can also be explored with this model. In summary, the development of model proposed in this research project will have multiple applications to unravel the mysteries of planets.

Scope of the work:

- The degree and direction of polarization of the radiation scattered from a planetary atmosphere is dependent on the properties of constituents of the planetary atmosphere such as clouds, aerosols,

gases etc., as well as the planetary surface. Therefore, spacecraft observations specifically with polarization sensitive instruments will carry information of these planet properties. However, detailed polarized radiative transfer models are needed to interpret these observations and constrain the planetary properties. This includes solving radiative transfer equation with scattering and polarization for a range of cloud types, aerosols, particle sizes, gases, surface compositions etc., in the visible and infrared part of the electromagnetic spectrum. These calculations are computationally very expensive and therefore require quite extensive computational resources.

- Initially the model development will focus on the Venusian atmosphere and it will be linked to the development of the VASP payload on Venus mission.
- The forward model calculations will be able to make calculations of scattered polarized radiation in the continuum as well as absorption band of gases in the visible-NIR wavelength range and will be compared to the existing results.
- Further, we will create a database of refractive indices of different cloud and aerosol species that are commonly present in the planetary atmosphere and can be used in our model for scattering computations.

Linkages to Space Programme:

- The spectro-polarimetric radiative transfer model will be very helpful to perform model simulations for the Venus Atmospheric Spectro-Polarimeter (VASP) instrument on ISRO's Venus Orbiter Mission. This will aid in optimizing the instrument design and settings during the operations. Furthermore, it will also be valuable in the detailed interpretation of observations that we obtain from the Venus mission and therefore constrain various cloud and aerosol properties of the Venusian atmosphere and its vertical distribution.
- In the future, this development will be valuable for planning and interpreting the observations from ISRO's other spectro-polarimeter instruments used for observing any other solar system planets, exoplanets and even Earth. It is noteworthy that a polarimeter instrument has also been accepted for the Future Mars mission and the same model can be used for this instrument as well.

Expected Deliverables:

- The developed forward spectro-polarimetric radiative transfer model which will allow interpretation of polarimetric observations of Earth, solar-system planets (Venus, Mars, Jupiter etc), and exoplanets. The developed model should be compared to other standard polarimetric models and their outputs. The model should include a document and/or a user manual clearly mentioning the steps involved in utilizing the software package along with its limitations.
- The model should be able to:
  - Make calculations of scattered/reflected radiation with all 4 Stokes parameters.
  - Make calculations in the continuum as well as the absorption bands.
- Further:
  - Model should have flexibility of changing the pressure-temperature profiles, cloud optical thickness, cloud microphysical properties, cloud patchiness, etc.
  - Model should have flexibility of including the expansion coefficients of the scattering matrix inputs.
  - Model should be made in python language and the software should be OS independent.

RES-URSC-2025-003

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Pyro-electric effect-based x-ray generator for space applications

Area of Research

Planetary science, X-ray instrumentation

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

Shri. Koushal Vadodariya

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

koushalv@ursc.gov.in

Summary of the Proposed Research

The generation of X-rays conventionally requires bulky and high-power vacuum tube systems operated with high-voltage supplies in the tens of kilovolts range. Such systems, while reliable, present limitations in terms of size, energy efficiency, operational complexity, and safety. For applications demanding portability, low power consumption, or deployment in constrained environments, there is a need for compact alternatives to conventional X-ray sources.

The pyroelectric effect, exhibited by certain crystals such as lithium tantalate (LiTaO) and lithium niobate (LiNbO), provides a promising technology for developing miniature X-ray generators. When subjected to controlled temperature variations, these crystals spontaneously generate strong surface electric fields (several 10 – 10 V/cm). These fields can accelerate electrons without the need for an external high-voltage supply, enabling the direct generation of X-rays when the electrons strike a suitable target material via Bremsstrahlung mechanism.

A pyroelectric X-ray generator thus offers several advantages like Elimination of bulky high-voltage power supplies leading to Low electrical power consumption, Simplified system architecture, possibility of miniaturization, making such generators suitable for in-situ material analysis (e.g. XRF, XRD etc.) and space-borne instrumentation (like as an x-ray calibration source).

Scope of the work:

- Study and identification of suitable materials with pyro-electric effect for X-ray generation.
- Study and modelling of temperature dependent electron acceleration (X-ray cut-off), variation of flux etc. (~20keV and above)
- Design optimization and demonstration of pyro-electric X-ray generation in a suitable simulated environment (vacuum or controlled pressure of suitable gases).
- Configuration and realization of a sealed pyro-electric x-ray generator. (like TO-3 package)

Linkages to Space Programme:

- In the context of ISRO's requirements, such an instrument has applications in ISROs planetary

science missions (in-situ elemental analysis via X-ray fluorescence, X-ray diffractometry etc.), spaceborne diagnostics, and as an onboard compact calibration source. The development of a reliable pyroelectric-based miniature X-ray generator would represent a significant technological step towards lightweight, low-power radiation sources aligned with future space exploration needs.

Expected Deliverables:

- A Document with detailed Design aspects, experimental results and analysis of a pyro-electric effect-based X-ray source with various x-ray cut-off energy (≥20keV) and flux requirements (≥30 counts/second/mm2 at a distance of 40mm or ≥4.8x104 counts/second/steradian).
- Prototype of a working pyro-electric X-ray generator.
- Performance evaluation report emphasizing understanding of cut-off voltage, flux, spectrum etc. during temperature cycling of the pyro-electric materials.

RES-URSC-2025-004

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Development polarizing optics for EUV wavelength band (50nm – 120nm)

Area of Research

Solar Magnetic field studies at upper atmosphere of the Sun

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

Dr. K. Sankarasubramanian

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

sankark@ursc.gov.in

Summary of the Proposed Research

Solar atmospheric magnetic field measurements are critical for the understanding of dynamics in the solar atmosphere. The coupled dynamics of the plasma and magnetic field on the Sun are the pivotal for all the dynamics like flares, coronal mass ejections, and jets which do affect the local environment of Earth and other planets, called as terrestrial or planetary space weather. Though the photospheric plasma parameters including magnetic fields are measured regularly and the chromospheric measurements are getting to a matured level, coronal field measurements are missing. We all know that corona plays a pivotal role in all the dynamics - being easier to build the non-potential energy.

This research proposal is to address the following:

- Development of a polarimetric technique for magnetic field and plasma parameter measurements in EUV waveband. This study would also identify the spectral region of interest for the design. All the photons in this waveband originate from the coronal regions, providing a unique region to study the corona and no contribution from the photosphere.
- Design and develop the polarimeter optics to sense the polarization in the Identified waveband in the EUV.

- Carry out the laboratory characterization of the same and bring out the advantages and limitations of the developed system.
- Design a telescope-polarimeter system and study their sensitivity for coronal plasma parameters (including magnetic field) for future development.

Scope of the work:

- The scope of this proposal is to study and develop techniques to carry out solar atmospheric plasma diagnostics – especially in the solar corona. As we know that the coronal field measurements are the toughest to measure but they are essential to study any solar dynamical phenomena which affects the Earth.
- The proposal will address,
  - The spectral regions of interest for optimized study of solar coronal plasma parameters (including magnetic field) in the EUV waveband where the photospheric contribution is nil.
  - Develop techniques to measure the polarization information and in turn derive the plasma and magnetic field parameters
  - Development of the Polarimeter optics in the waveband of interest within the EUV region
  - Design a telescope-polarimeter system for future space application

Linkages to Space Programme:

- Solar coronal magnetic field is known as dark energy problem in Solar and heliophysics. As the coronal field drive all the solar atmospheric dynamics, measurements would greatly advance the solar physics research and also the space weather research – including the space weather alerts. The existing techniques, in the visible and IR bands have the issue of scattered components from the photosphere and hence utilizing the EUV waveband where photosphere emits no radiation would provide a great advantage. However, the Zeeman sensitivity would greatly reduce and limited to be observed in forbidden lines (also known as saturated Hanle lines). On the other hand, there are several allowed transition lines in this waveband which are sensitive to the coronal magnetic fields through Hanle effect. For both these magnetic diagnostic techniques sensitive polarimetry is required.
- Future solar physics research and space weather research will utilize these measurements if techniques are developed and flown in future space mission.

Expected Deliverables:

- A document/paper on the identified spectral band of interest in the EUV region which are sensitive to magnetic field.
- A document/paper on the methodology and techniques required to be developed in order to utilize the waveband identified in (1).
- Design and develop the hardware for polarization measurement (polarimeter) in the waveband of interest identified in (2).
- Laboratory testing of the hardware for its performance along with a detailed report including the process of development of the hardware and measurement techniques.
- Delivery of the hardware to URSC for further studies by coupling to an imaging system
- Design document of a telescope-polarimeter system (using the developed polarimeter) for a potential future mission.

RES-URSC-2025-005

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

GaN based high frequency programmable CC-CV dc-dc converter

Area of Research

Power Electronics

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

Dr. Pradeep. K. Peter
Shri. Lokaveer. A

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

pkp@ursc.gov.in
lokaveer@ursc.gov.in

Summary of the Proposed Research

To realize a dc-dc converter that can be configured to meet the diverse requirements of different spacecraft sub systems.

Scope of the work:

- Simulation
- Fabrication and testing of 2 dc-dc converters
- Demonstrate parallel operation

Linkages to Space Programme:

- On any Spacecraft Project.

Expected Deliverables:

- Hardware of 2 dc-dc converters
- Design notes
- Simulation files

RES-URSC-2025-006

Name of ISRO/DOS Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Design and Development of Intelligent Frequency Selective Surface (iFSS) for Satellite Application

Area of Research

Frequency Selective Surface (FSS)
Intelligent Frequency Selective Surface (iFSS)
Design optimization with Machin Learning (ML) Algorithm

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

Shri. Rahul Waghmare
Ms. Neha Agarwal
Shri. Balaji G

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

mnv@ursc.gov.in
rahulgw@ursc.gov.in
neha@ursc.gov.in
balajig@ursc.gov.in

Summary of the Proposed Research

An Intelligent Frequency Selective Surface (iFSS) is an advanced electromagnetic structure designed to control the transmission and reflection of electromagnetic waves in a smart and reconfigurable manner. The iFSS consists of an array of engineered resonant unit cells that can be dynamically tuned to adjust key wave properties such as frequency response, polarization, and phase characteristics. In satellite applications, especially within the Ku/Ka bands, this adaptability is essential to support high-throughput links, broadband internet, satellite TV, and mobile backhaul services. Tunable elements such as varactors, PIN diodes, or RF MEMS are integrated into the unit cells, enabling real-time reconfiguration of passbands and polarization states. Control circuits and embedded algorithms govern the tuning process, ensuring stable performance under varying incidence angles and environmental conditions. Furthermore, machine learning and optimization techniques can be employed to intelligently select tuning states, enhancing spectrum efficiency and minimizing interference. This intelligent and reconfigurable design makes iFSS a lightweight, compact, and future-ready solution for next-generation satellite communications and 6G space–terrestrial integrated networks.

Scope of the work:

- The scope of this research is centered on the design, development, and validation of an Intelligent Frequency Selective Surface (iFSS) for satellite communication systems operating in the Ku and Ka frequency bands. The work will cover the following aspects:
  - Design of Resonant Unit Cells – Development of FSS unit cell geometries capable of supporting dual-band operation Ku/Ka bands.
  - Integration of Reconfigurability – Incorporation of tunable elements (such as varactors, PIN diodes, or RF MEMS) to enable dynamic control of transmission and polarization states.
  - Control and Intelligence Layer – Implementation of control circuits and algorithms, potentially supported by machine learning in MATLAB, to achieve adaptive real-time reconfiguration for interference mitigation and efficient spectrum utilization.
  - Prototype Fabrication and Testing – Realization of the iFSS prototype and validation through experimental measurements in the Ku/Ka bands to confirm simulated performance.
- The proposed work aims to deliver a lightweight, compact, and reconfigurable electromagnetic surface that can be directly integrated into satellite payloads, enabling high link reliability, spectrum efficiency, and adaptive functionality for next-generation space communication systems.

Linkages to Space Programme:

- Ka/Ku-band iFSS linked into satellite payload data transmitters

Expected Deliverables:

- Novel iFSS Design – A compact and lightweight frequency selective surface structure optimized for Ku/Ka-band satellite communication with dual-band operation, dual polarization, and polarization rotation capability.
- Reconfigurable Unit Cells – Development of tunable FSS unit cells integrated with active elements (varactors/PIN diodes/RF MEMS) enabling dynamic control of frequency, phase, and polarization states.
- Intelligent Control Mechanism – FPGA-based or microcontroller-based control circuits along with adaptive algorithms (including machine learning support) for real-time reconfiguration of the iFSS.

NATIONAL REMOTE SENSING CENTRE

HYDERABAD

RES-NRSC-2025-001

Name of ISRO/DOS Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Data driven model for high-resolution root zone soil moisture profiling across India

Area of Research

RS & GIS, Earth Observation

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

Dr. Sampelli Anoop
Dr. Rabindra Kumar Nayak

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

anoop_s@nrsc.gov.in
rabindrakumar_nayak@nrsc.gov.in

Summary of the Proposed Research

This research aims to develop a high resolution estimation framework for root zone soil moisture (RZSM) across the Indian region by harnessing advances in generative artificial intelligence for geophysical prediction. A physics-informed diffusion model (e.g., DDIM) should be trained to fuse multi-sensor inputs—such as coarse-scale surface soil moisture (from satellite remote sensing), vegetation indices, meteorological drivers, and soil properties—to generate vertical soil moisture profiles extending to 100 cm depth.

To provide physically consistent training data, a fast soil—water column model should be implemented at 1 km spatial and daily temporal resolution, yielding "pseudo-ground truth" RZSM profiles that capture realistic hydrodynamic variability across diverse Indian landscapes. The framework should support uncertainty quantification by producing probabilistic soil moisture ensembles rather than single deterministic outcomes, enabling robust characterization of prediction confidence. Model evaluation should be carried out using in-situ soil moisture network data and independent satellite-based estimates.

The resulting 1 km daily RZSM dataset will offer a transformative data resource for drought assessment, and hydrological forecasting across India. Building upon this foundation, a pilot short-range (1—2day) probabilistic forecast system for root zone soil moisture should be developed, leveraging the generative model outputs to advance predictive capabilities in water resource under a changing climate.

Scope of the work:

- The proposed research should aim to develop a high-resolution root zone soil moisture (RZSM) estimation and forecasting framework for India by leveraging advances in generative artificial intelligence and physics-based modeling.

- Objective 1: To generate a physically consistent, high-quality daily RZSM dataset at 1 km resolution by training a physics-informed diffusion model (e.g., DDIM) using multi-sensor inputs such as satellite-derived surface soil moisture, vegetation indices, meteorological variables, and soil properties..
- Objective 2: To be validated using in-situ and satellite-based observations and develop a pilot probabilistic forecasting system for short-range (1—2 day) RZSM prediction using the generative model outputs.

Linkages to Space Programme:

- The proposed work directly supports India's space-based Earth observation programme by developing value-added climate and hydrological services fand NICES soil moisture products. It enhances the societal relevance of satellite missions through the generation of high-resolution root zone soil moisture datasets and probabilistic forecasts derived from multisensor data fusion and physics-informed generative Al modeling.

Expected Deliverables:

- High-resolution (1 km) daily root zone soil moisture dataset for the Indian region, derived through multi-sensor data fusion and physics-informed generative Al modeling.
- Pilot short-range (1—2 day) probabilistic root zone soil moisture forecast product, providing gridded ensemble-based probability maps With quantified uncertainly.

RES-NRSC-2025-002

Name of ISRO/DOS Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Development of Quantum Entanglement-Assisted Hybrid Model for Network Bandwidth Expansion

Area of Research

Optical Networking
Quantum Information Science
Network Protocol Engineering

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

Shri. Murali Krishna ANSV
Shri. Pradeep C

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

muralikrishna_ansv@nrsc.gov.in
pradeep_c@nrsc.gov.in

Summary of the Proposed Research

This research proposal aims to develop a Quantum Entanglement-Assisted Hybrid Communication Model (QEA-HCM) for enhancing the effective bandwidth of optical fiber networks without modifying their physical infrastructure. The approach utilizes Entanglement-Assisted Classical Communication (EACC) to transmit additional information using shared quantum correlations between entangled photons.

The proposed framework builds on foundational work in superdense coding [BW92] and entanglement-assisted classical capacity theory [BST99], where pre-shared entanglement enables two classical bits of information to be encoded per qubit. Recent advances in quantum network theory [PEW15, WEH18] and entanglement distribution over fiber links [ZLZ25] suggest that integrating quantum resources with classical channels can enhance data throughput and reliability in existing optical networks.

A comprehensive theoretical and simulation-based study will be conducted to evaluate bandwidth gain, noise tolerance, and information capacity under realistic fiber conditions such as loss, dispersion, and phase noise. The project will also investigate a Quantum-Enhanced Transport Protocol (Q-TCP or EA-OTP) for congestion control and feedback optimization using quantum correlations.

The expected outcome is a validated hybrid communication framework demonstrating bandwidth scalability beyond Shannon limits, aligned with ISRO's roadmap for quantum-assisted optical communication and Space Vision 2047.

Scope of the work:

The project is theoretical and simulation-driven, aiming to model the coexistence of classical and entanglement-assisted communication over the same optical infrastructure.

The main objectives include:

- Developing a mathematical framework for entanglement-assisted hybrid channels capable of supporting both classical and quantum states [BW92, BST99].
- Analyzing entanglement distribution and channel capacity under practical impairments such as attenuation, dispersion, and dephasing noise [YYL22, WXH25].
- Simulating superdense coding-based transmission and quantifying achievable bandwidth improvement relative to classical Shannon limits [PEW15].
- Designing a Quantum-Enhanced Transport Protocol (Q-TCP) incorporating quantum feedback for adaptive flow control.
- Integrating the theoretical model with Software-Defined Networking (SDN) frameworks for dynamic hybrid channel allocation [WEH18].

The scope builds upon current literature in quantum network architectures [WEH18], quantum error mitigation [Got10], and quantum-assisted communication protocols [Pre13]. Deliverables will include analytical models, simulation results, and theoretical performance limits for entanglement-assisted optical communication, guiding NRSC in designing future wide-area quantum-enabled networks for remote-sensing data transfer.

Linkages to Space Programme:

- This project supports ISRO's Space Vision 2047 objectives by enhancing the backbone network infrastructure for secure and efficient satellite data transfer. Quantum entanglement-assisted networking can substantially improve the throughput and reliability of WAN links used for remote-sensing data dissemination. The theoretical and simulation outcomes will inform the design of quantum-ready ground segment communication systems, enabling integration of quantum

feedback and bandwidth optimization mechanisms into ISRO's existing optical fiber and inter-center communication infrastructure. The research will strengthen India's readiness for quantum-assisted space communication and contribute to the broader goal of developing indigenous quantum network technologies.

Expected Deliverables:

- Analytical and simulation model for entanglement-assisted hybrid channel performance under realistic fiber conditions.
- Demonstration of bandwidth enhancement using superdense coding-based simulation.
- Design of Quantum-Enhanced Transport Protocol (Q-TCP / EA-OTP) incorporating quantum feedback.

Final technical report, simulation documentation, and peer-reviewed publications supporting ISRO's Quantum Communication Roadmap.

LIQUID PROPULSION SYSTEMS CENTRE

VALIAMALA

RES-LPSC-2025-001

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Investigation of the Influence of Isogrid/Waffle Rib Geometry on Pressurant Gas Requirement and Thermal Behaviour in Cryogenic Propellant Tanks

Area of Research

Propulsion

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

Shri. Rijin K V

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

kv_rijin@lpsc.gov.in

Summary of the Proposed Research

In cryogenic propulsion systems(using LH_2 or LCH_4 as fuel and LOX as oxidiser), efficient tank pressurization is vital to ensure uninterrupted propellant feed, structural safety, and optimal engine performance. Conventionally, analytical and numerical models for pressurant gas requirement assume smooth internal tank surfaces. However, cryogenic propellant tanks are typically fabricated with isogrid or waffle-type stiffening ribs on their inner walls to provide structural rigidity and weight reduction. These ribs significantly alter the local flow and thermal fields inside the tank.

The rib structures modify the boundary-layer development, enhance natural convection, and affect the overall wall heat transfer characteristics. Consequently, the interaction between the pressurant gas, tank wall, and liquid propellant deviates from the idealized case, resulting in a higher collapse factor or cooling factor—defined as the ratio of the actual to the ideal pressurant gas mass required. The rib geometry (height, pitch, orientation, and cross-section) and its ratio to the tank diameter, as well as the insulation condition (insulated vs. uninsulated), are expected to strongly influence these effects.

A systematic study is therefore essential to quantify the impact of rib geometry on the thermodynamic behavior of pressurant gases and to establish reliable prediction models and correlations. The findings are expected to contribute to improved pressurization system design with accurate estimation of pressurant gas requirements and will be crucial for the design and optimization of lightweight, structurally efficient cryogenic stages

Typical diameter of propellant tanwwks 4-7 m diameter, volume ranging from 100 to 600 cu.m, storage temperature variation of 75-90K for LOX, 19-21 K for LH_2 and 110-120K for LCH_4 with 3 to 6 bar pressure in tank ullage maintained by autogenous pressurant temperature varying from 250 to 400K, stage operating duration from150 to 200s and maximum acceleration upto 4g.

Scope of the work:

The proposed research shall cover theoretical, numerical, and experimental study of the influence of internal rib geometry on pressurant gas dynamics and heat transfer in cryogenic propellant tanks. The scope shall include the following tasks:

- **Comprehensive Literature Review:** Detailed review of existing studies on tank pressurization, heat and mass transfer in cryogenic systems, ribbed-surface convection enhancement, and collapse factor determination.
- **Numerical Modeling:** Develop three-dimensional CFD models of cryogenic tanks incorporating conjugate heat transfer, real fluid properties and transient thermodynamic effects. The models shall account for rib geometry (height, pitch, shape, and orientation) and variable wall boundary conditions (insulated/uninsulated).
- **Experimental Validation:** The numerical model shall be validated using sufficient experimental data. Either suitably scaled experiment shall be designed and conducted or reliable data from published literature, if available, shall be used. In either case, details of the proposed method (experimental plan or details of the published literature) and assessment on how it can adequately validate the numerical model shall be brought out in the research proposal.
- **Parametric Study:** Systematic analysis to determine the effect of rib height-to-tank-diameter ratio, pitch, rib orientation, and insulation configuration on local and global heat transfer coefficients, pressure evolution, and pressurant gas requirement.
- **Correlation and Model Development:** Formulation of generalized, non-dimensional correlations for convective heat transfer and collapse factor as functions of rib geometry and thermal boundary conditions. Also, develop a validated computational and empirical framework to predict pressurant gas requirement in ribbed cryogenic tanks.

The research outcome shall provide validated models and design correlations to predict and optimize pressurant gas requirements for ribbed cryogenic tanks used in advanced launch vehicle stages.

Linkages to Space Programme:

- Future Indian launch vehicles, including the next-generation LOX–methane propulsion stages, demand enhanced performance margins through optimized structural design and propellant management. Accurate prediction of pressurant gas requirements and thermal behavior in cryogenic propellant tanks is essential for achieving these goals. Investigation of isogrid and waffle-rib effects on internal tank heat transfer and pressurant dynamics will contribute to mass optimization, improved tank safety margins, and higher stage performance efficiency. The resulting correlations and validated models will be directly applicable to future heavy-lift and reusable vehicle concepts thus aligning with ISRO's strategic roadmap toward self-reliant, high-efficiency propulsion technologies and sustainable space transportation systems and is thus aligned with ISRO's long-term objectives toward realization of advanced, cost-effective, and reusable launch vehicle systems envisioned under Space Vision 2047.

Expected Deliverables:

- Validated Numerical Model: A 3-D CFD model capable of predicting pressurant gas behavior in ribbed cryogenic tanks with variable geometrical and boundary conditions.
- Heat Transfer Correlations: Empirical/numerical correlations for effective heat transfer coefficients on ribbed internal surfaces as functions of rib height, spacing, and orientation.

- Collapse Factor Correlations: Generalized expressions for the collapse (cooling) factor incorporating tank geometry, rib configuration, and insulation characteristics.
- Experimental Database: Sub-scale test data for cryogenic and surrogate fluid systems under representative pressurization conditions or data collected from literature (for validating the numerical model).

RES-LPSC-2025-002

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Development of suitable catalyst for Ammonium Di-nitramide (ADN) green mono propellant, to sustain very high decomposition temperature (Around 1800-2000^{0}C) in thruster environment without sintering

Area of Research

Satellite Mono propulsion system

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

Smt. Vidhya Karthikeyan
Shri. Yashwanthram G
Shri. Nagaraj K
Shri. Narender Kumar

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

vidhyakarthi@lpscb.gov.in

Summary of the Proposed Research

The Propellant Hydrazine & its derivatives are used for Mono and Bi-Propellant engines have been dominating the space industry for more than six decades owing to its high performance characteristics. Hydrazine used in spacecraft propulsion system is highly toxic and carcinogenic. Hydrazine has high vapour pressure due to which its fumes significantly pose a high risk of respiratory hazard at room temperature. It requires elaborate storage conditions and ground handling procedures. The high cost and hazardous situation associated with the handling of Hydrazine has led way to the development of substitutes. With the increasing level of spacecraft missions in the future, the need for green propulsion system has gained significance in the recent times. ADN have emerged as most promising substitute for hydrazine as monopropellant for spacecraft application. This proposal is aimed to develop catalyst for ADN green mono propellant.

Development of suitable catalyst for ADN:

The long-term success of any mono-propulsion system depends on the efficiency of the catalytic decomposition of propellant. The very high combustion temperature of ionic based green propellant leads to catalyst sintering, void formation, increase in pressure drop and loss of activity in case of conventional catalyst (SHELL 405). A high temperature resistant, suitable catalyst to be developed for high performing green mono propellant (ADN)

Development of suitable catalyst (selection of catalyst support material, active metal & coating

method) for ADN green mono propellant to sustain high temperature oxidizing thruster environment. Demonstration of dissociation of ADN propellant with developed catalyst at crucible level & at thrusters level tests.

Scope of the work:

Scope of Development of catalyst

- Development of suitable catalyst for ADN .
- Selection of catalyst support material with high surface area to withstand very high decomposition temperature (Around 1800 -2000°C) without sintering.
- Selection of active metal to withstand very high decomposition temperature (Around 1800-2000°C) without sintering.
- Selection and finalization of suitable coating method to coat active metal on carrier material.
- Characterization of Carrier material, Active metal and developed catalyst.
  - The reactivity of the developed catalysts with ADN shall be studied in a thermal analyzer. Catalyst shall be characterized for active metal loading using XRD and EDAX. Surface area of carrier material and catalyst, the mechanical strength of catalyst to be demonstrated.
- Supply of Catalyst along with characterization report.
- Demonstration of dissociation of ADN propellant with catalyst at Crucible level.
- Demonstration of dissociation of ADN propellant with catalyst at Thruster level.

Linkages to Space Programme:

- Satellite Mono propulsion system.

Expected Deliverables:

- Selection & finalization of suitable Catalyst, (selection of Carrier material and Active metal).
- The carrier material shall have high surface area and should withstand high ADN decomposition temperature.
- Catalyst carrier material shall be refractory, ceramic or suitable sintering resistance materials.
- The carrier surface shall be provided with suitable catalytically active metals such as Ir, Pt, Pd, Ru, Pt/Rh, Ir/Rh etc..
- Development of suitable Catalyst for ADN propellant.
- The active metal required on the carrier material shall be minimum 30% by weight.
- Supply of catalyst along with characterization report.
  - Pellet size: 25/30 USS mesh (710-600µ), Shape: Irregular shape. Qty: 30 grams (Supply in 2 batches),
  - Pellet size: 14/18- USS mesh (1.4-1.0mm), Shape: Irregular shape, Qty: 70 grams (Supply in 2 batches).
- Demonstration of disassociation of ADN propellant with catalyst at Crucible level.

- Demonstration of Dissociation of ADN propellant at Thruster level. (Propellant feed pressure: 24 bar, Flow rate: 5 g/s).
- Thruster level testing will be under LPSC scope. Feedback will be provided to them based on the Test results & improvement upon the catalyst shall be carried out if required.
- The detailed report on the whole process followed for realization of catalyst shall be provided.

RES-LPSC-2025-003

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Indigenization of Plasma Diagnostics tools for Magnetic nozzle plume analysis of Electrodeless Electric Propulsion Thrusters

Area of Research

Plasma diagnostics, Electric propulsion

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

Dr. Varaprasad Kella
Shri. Asish James

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

k_varaprasad@lpscv.dos.gov.in

Summary of the Proposed Research

The proposed research aims to design, develop, and validate a suite of custom-built plasma diagnostic probes—including RF-compensated Langmuir probes, double/triple Langmuir probes, emissive probes, Mach probes, momentum flux sensors, and B-dot probes for RF/Microwave plasma thrusters. These diagnostics, along with their associated electronic circuits, will be developed and tested.

Further, data analysis algorithms for extracting plasma parameters—such as electron/ion density, temperature, energy distribution, and plasma potential—shall be developed and validated. The algorithms will preferably be implemented using open-source programming languages such as Python.

Finally, the developed probes, electronics, and analysis algorithms will be deployed and demonstrated at the LPSC test facility to analyse magnetic nozzle plume.

Scope of the work:

- Design and fabrication of custom plasma diagnostic probes (RF-compensated Langmuir, emissive, Mach, momentum flux, and B-dot probes) tailored for electrodeless electric propulsion systems. 2 quantity of each probe is planned.
- Development of associated electronic circuits for signal conditioning, data acquisition, and probe control.

- Experimental validation of the probes and electronics under controlled plasma conditions.
- Formulation and implementation of post-processing algorithms for probe data analysis to estimate plasma parameters such as density, temperature, potential, and energy distribution.
- Deployment and demonstration of the developed probes and analysis algorithms at the LPSC test facility for characterization of magnetic nozzle plume of RF and microwave electric propulsion thrusters.
- Preparation of validation reports and user documentation.

Linkages to Space Programme:

- The proposed research directly supports the development and characterization of electrodeless electric propulsion systems, such as RF plasma thruster (10kW, 13.56MHz nominal operation) and microwave electron cyclotron resonance thruster (30W, 2.45GHz nominal operation), which are of relevance to spacecraft propulsion.
- Accurate plasma characterization enables performance optimization, plume modeling, and validation of theoretical and numerical predictions, thereby contributing to the indigenous development of high-efficiency electric propulsion technologies for future space missions.

Expected Deliverables:

Hardware:

- Delivery of experimentally validated plasma diagnostic probes, including associated electronic systems and documentation for integration and operation.
- CAD models and design drawings of the probes.

Software:

- Delivery of data analysis algorithms and source code for post-processing probe measurement data to extract plasma parameters, implemented preferably in an open-source language such as Python.
- Documentation and validation reports demonstrating algorithm performance with experimental datasets.

RES-LPSC-2025-004

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Fiber optic based continuous level sensing for ISROSENE

Area of Research

Sensors

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

Smt. Subramaniam R Geetha
Shri. Ch. Harish
Shri. N Sagar Babu

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

gsen@lpscb.gov.in

Summary of the Proposed Research

While conventional capacitance based level sensing has limitation of length of measurement beyond 1m due to fabrication limitation and high non linearity. Fiber optic based continuous level sensing is using Rayleigh backscattering principle seems to be the ideal choice with advantages that it can be extended upto 100 meter measurement length. Rayleigh scattering is the dispersal of light caused by inhomogenities that manifest as microscopic refractive index variations. The light pumped into is fiber is back scattered from different locations of inhomogenities. The external perturbation like temperature, strain etc which affect the refractive index causing variation in Intensity of Rayleigh scatter. Based on the interference signal on which FFT is performed, the frequency of signal is extracted. This maps to the location of backscatter along the fiber. This principle is used for Continuous level sensing.

Scope of the work:

- It is proposed that continuous level sensor with 1-2 mm level accuracy and be built with suitable C-OFDR signal conditioner to give a digital output. The light source shall be suitable laser like Tuneable laser/ swept laser etc. PI has to demonstrate the concept upto 2 meters in water and it has to be extended up to 10 meters.
- The level sensor has to be calibrated and accuracy and Non-linearity to be assessed.
- The input voltage shall be limited to 42 V (Max). The sensor should be appropriately packaged to suitable mounting inside metallic tank.
- Suitable Hermetic connectors to be used to terminate the sensor inside the tank.
- Further signal conditioner shall be outside the tank. The temperature of operation is 10 to 40°C.
- The Laser source shall be monitored for temperature variation to ensure frequency of the laser.

Linkages to Space Programme:

- Continuous level sensing of propellant level in Propellant tank. This is light weight, no electric signals, Immunity to RF and EMI. It can be monitored in remote location with minimum cabling. The project is proposed for ISROSENE. Once the sensor is realised and qualified, it applications can be extended to any propellant gauging requirement.

Expected Deliverables:

- 2 sets of Continuous Level sensors 2 m length, packaged sensors with signals conditioner.
- Documents for the design details (fabrication drawings, design documents etc).
- Design documents of test rigs.
- Sensor assembly and testing reports.
- Interrogator design details.

RES-LPSC-2025-005

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Realisation of Iridium coated Rhenium Combustion Chamber (cylindrical specimen) of the below mentioned size through Electroforming Technology
Diameter (Φ): 13mm
Height (h): 20 mm
Coating Thickness: Iridium-50 µm & Rhenium-1000 µm

Area of Research

Materials & Fabrication techniques.
Demonstration of Electroforming techniques for realisation of combustion chamber (cylindrical specimen), which will be useful in high performance engines

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

Smt. S. Mahalakshmi
Smt. Vidhya Karthikeyan

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

mahalakshmi@lpscb.gov.in
vidhyakarthi@lpscb.gov.in

Summary of the Proposed Research

Advantage of proposed Iridium coated Rhenium Combustion chamber:

The proposed Iridium coated Rhenium specimen is the proto model of combustion chamber of high performance engine which operates at temperatures up to 2200 °C and provide increased specific impulse over conventional chamber materials. Rhenium thrusters are prone to oxidation which limits the chamber life. Iridium coating on Rhenium thruster is reasonably re-sistant to oxidation up to its melting point.

Limitations in conventional Fabrication Techniques:

Fabricating a refractory metal into the thin-shell configuration of a thrust chamber is a real challenge. The refractory metals are typically very brittle and very difficult to machine. They also tend to be expensive, so that hogging a shape out of a billet is not cost-effective.

Proposed Alternatives for realization of Iridium/Rhenium Combustion chamber by Electroforming route/technique:

Electroforming is one of the promising methods of fabricating near-net shapes of complex geometry products. The basis of the technology is the electro deposition of compact metal layers onto a mandrel of the required form with the future mandrel removal. A number of less common metals cannot be deposited into thick, stress-free layers from electroplating aqueous solutions, but can be successfully obtained from high temperature molten salt electrolytes. These types of molten electrolyte have good thermal stability and allow electro deposition of dense, coherent, pore free layers of refractory metals used for manufacturing of high-temperature combustion chambers.

The manufacturing of high temperature proto model begins with mandrel fabrication then mandrel is coated with oxidation protection layer of Iridium. After deposition of Iridium protection layer, the Rhenium (refractory metal) is electroformed as the structure material.

Scope of the work:

- To demonstrate Electroforming technology as an alternative to conventional fabrication of Iridium coated Rhenium Combustion Chamber of size: Φ13 X 20 in mm, which will be useful in high performance engines.

Linkages to Space Programme:

- Electroformed Iridium coated Rhenium proto model shall be useful for realisation of High Temperature Thruster technology for Satellite Propulsion application.

Expected Deliverables:

Realisation of Iridium coated Rhenium Combustion Chamber (cylindrical specimen-1 no.) of the below mentioned size through Electroforming Technology.

- Size: Φ 13mm (Diameter) X 20 mm (Height)
- Coating Thickness: Iridium-50 µm & Rhenium-1000 µm

Evaluation criteria:

Electroformed Iridium coated Rhenium Combustion Chamber shall meet the following:-

- Coating thickness and the report shall be provided.
- Shall pass the adhesion tests.
- Shall withstand the Temperature of 2200°C.

RES-LPSC-2025-006

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Numerical and experimental slosh analysis of propellant tanks with elastomeric diaphragm as free surface interface

Area of Research

Fluid dynamics (CFD & FSI)

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

Shri. Sarath Chandran Nair S

Shri. V. Viswanath

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

s_sarath@lpsc.gov.in

Summary of the Proposed Research

Slosh disturbances are major concern in launch vehicles, satellites and interplanetary mission for its control stability where liquid propellants are used for its propulsion. These propellants are stored in separate tanks. Slosh phenomenon in those propellant tanks is represented mathematically as pendulum mass model in control stability studies. Various slosh parameters evaluated numerically and experimentally are used for design of a robust control system. In these cases free surface is free to oscillate and exposed to ullage gas. In one of the propellant tanks, an elastomeric diaphragm is introduced for propulsion requirement. Slosh parameters such as slosh frequency, slosh mass and damping for such propellant tank through theoretical and numerical methods are to be evaluated. Numerical analysis involves fluid structure interaction studies by modelling tank, fluid and elastomeric diaphragm and extracting slosh parameters under sinusoidal disturbance. Validation of numerical results with experiments are also to be done with elastomeric diaphragm at ullage. Based on the studies, a methodology to be developed to evaluate slosh parameters in presence of elastomeric diaphragm as free surface.

Scope of the work:

- To do theoretical, numerical and experimental studies to represent slosh phenomenon in a propellant tank in which an elastomeric diaphragm is provided as free surface.
- Material modelling of elastomers (diaphragm materials).
- To perform numerical analysis for evaluation of various slosh parameters in presence of such diaphragm.
- Validation of results through experimental studies in model tanks with different diaphragm materials and fill fractions.
- To generate a generalised empirical relation for evaluation slosh parameters for diaphragm tanks based on the studies for different fill fractions and diaphragm materials.

Linkages to Space Programme:

- Reusable Launch vehicle.
- Test vehicle project.
- Human space programs.
- Interplanetary landing missions.

Expected Deliverables:

- Transfer the methodology to LPSC for slosh analysis of propellant tanks with elastomeric diaphragm.
- Supply of various slosh parameters (frequency, mass, mass location and damping) based on numerical studies and validation through experiments done for different fill fraction for the tank used for case studies.
- Supply of empirical relation to evaluate slosh parameters (frequency, mass, mass location and damping) for tanks with diaphragm for any size, different diaphragm materials and fill fractions.

RES-LPSC-2025-007

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Plasma Impedance and RF Power Transfer Studies in RF/Microwave Electric Propulsion

Area of Research

Plasma diagnostics, Electric propulsion

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

Shri. Asish James

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

a_james@lpscv.gov.in

Summary of the Proposed Research

The proposed research aims to develop and validate computational models for estimating the real and imaginary components of plasma impedance and the corresponding power absorption characteristics under different experimental conditions, including variations in antenna geometry, applied magnetic field, and RF frequency. Estimation secondary plasma parameters such as electron density, electron temperature, and ion velocity can also be attempted.

Furthermore, the project will focus on the development of RF diagnostic tools (preferably non-intrusive methodology) capable of experimentally determining plasma impedance (both real and imaginary) in real time during thruster operation. The combined computational and experimental approach will provide a comprehensive understanding of plasma–wave interactions in electrodeless thrusters like RF plasma engine and ECR thruster.

Scope of the work:

- Develop computational models to estimate the real and imaginary components of plasma impedance and quantify RF power absorption under varying plasma and magnetic field conditions.
- Simulate the influence of key parameters—including antenna geometry, magnetic field strength, and RF frequency—on plasma impedance, power coupling efficiency and plasma production.
- Estimate additional plasma parameters such as electron density, electron temperature, and ion velocity from the developed computational framework.
- Develop RF diagnostic tools capable of experimentally measuring plasma impedance and power absorption during operation of thrusters.
- Validate computational predictions through controlled RF plasma experiments and correlate simulation results with experimental observations.
- Document and standardize the developed models, diagnostic techniques, and experimental procedures.

Linkages to Space Programme:

- The proposed research directly supports the advancement of electrodeless electric propulsion technologies such as RF plasma thrusters and microwave electron cyclotron resonance (ECR) thrusters, which are key to future deep-space and interplanetary missions.
- Accurate estimation of plasma impedance and power absorption enables improved RF power coupling efficiency, higher plasma production, and enhanced thruster performance. These outcomes contribute to the optimization of indigenous electric propulsion systems being developed for long-duration, high-efficiency spacecraft operations.
- The developed computational tools and experimental diagnostics will be directly applicable to LPSC's ongoing and future electric propulsion development programmes, supporting performance characterization, system validation, and design refinement efforts.

Expected Deliverables:

Software and Computational Models:

- Validated computational models for estimating the real and imaginary components of plasma impedance and RF power absorption under various operating conditions.
- Simulation framework capable of predicting plasma parameters such as electron density, electron temperature, and ion velocity.
- Source code and user documentation, preferably developed using open-source programming environments (e.g., Python, C++).

Experimental and Diagnostic Tools:

- Development and testing of RF diagnostic tools for experimental determination of plasma impedance and power absorption during thruster operation.

Documentation and Reports:

- Comprehensive technical documentation covering computational models, diagnostic techniques, experimental validation results, and usage procedures.
- Final report summarizing methodologies, validation results, and recommendations for implementation RF and microwave electric propulsion programmes.

RES-LPSC-2025-008

Name of ISRO/DOS Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Development and Validation of a Microwave Interferometry based Contactless Plasma Diagnostic System for High-Power Electric Propulsion Thruster

Area of Research

Plasma diagnostics, Electric propulsion

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

Dr. Varaprasad Kella
Shri. Asish James

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

k_varaprasad@lpsc.gov.in

Summary of the Proposed Research

In highpower thrusters, such as RF plasma thrusters operating up to 10 kW with particle densities near 10^{20} m^{-3}, conventional probes are impractical due to thermal stress, sheath distortion, and possible plasma perturbation.

The proposed research focuses on the development of a microwave interferometry– based contactless diagnostic system for high-power electric propulsion thrusters. Characterization of plasma parameters in the ionization region enhances understanding of the ionization process and helps estimate plasma density which is essential for assessing thruster performance and identifying anomalies during testing.

A complete interferometry setup will be designed, realized, and validated along with data-analysis algorithms developed in open-source platforms such as Python. The system and software has to be demonstrated at the LPSC test facility.

Scope of the work:

- Design and development of a complete microwave interferometry setup for contactless plasma diagnostics applicable to high-power electric propulsion thrusters.
- Fabrication and laboratory validation of the interferometry hardware, including microwave source, detector, waveguide/antenna system, and optical alignment components.
- Development of data-analysis algorithms to extract plasma parameters such as line-integrated electron density from interferometric phase-shift data.
- Implementation of software tools using open-source platforms (preferably Python) for signal processing, calibration, and real-time visualization.
- Experimental validation of the developed diagnostic system with controlled plasma sources
- Deployment and demonstration of the complete system and algorithms at the LPSC test facility for characterization of high-power RF plasma thrusters.
- Documentation and performance evaluation of the diagnostic setup, highlighting accuracy and repeatability.

Linkages to Space Programme:

- The proposed research directly supports the advancement of electrodeless electric propulsion technologies being developed for future space missions. By enabling non-intrusive plasma diagnostics through microwave interferometry, the project contributes to accurate characterization of high-power RF and microwave plasma thrusters, which are key candidates for next-generation spacecraft propulsion.

- The outcomes will enhance the capability to measure and monitor plasma density in high-energy regimes where conventional probes are not feasible, thereby improving thruster design validation, performance assessment, and model correlation. The developed system can be integrated into LPSC's electric propulsion test facilities, supporting ongoing efforts in indigenous development of high-power, long-life propulsion systems for deep-space missions.

Expected Deliverables:

Hardware:

- A fully functional and experimentally validated microwave interferometry setup for contactless plasma diagnostics in highpower electric propulsion thrusters.
- Associated microwave components, detector circuitry, and alignment hardware, along with integration and operating documentation.

Software:

- Data analysis and visualization algorithms for processing interferometric signals to determine plasma parameters such as electron density.
- Source code developed in an open-source language (preferably Python)
- with user documentation and validation reports.
- Demonstration and Documentation:
- Deployment and demonstration of the developed system at the LPSC test facility with RF plasma thruster.
- Technical report and performance summary detailing system accuracy and repeatability.

ISRO PROPULSION COMPLEX

MAHENDRAGIRI

RES-IPRC-2025-001

Name of ISRO/DOS Centre/Unit

ISRO PROPULSION COMPLEX, Mahendragiri

Title of the research proposal

AI based Predictive analysis to forecast abort pattern from vibration data during engine hot test

Area of Research

Propulsion

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

Smt. S. Sweet Annie Grace

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

annie@iprc.gov.in

Summary of the Proposed Research

This work focuses on the AI based analysis of vibration measurement data and finalization of suitable model and performances metrics for extraction of abort triggering patters from the data. AI-driven pattern recognition approach uses machine learning algorithms for identification of hidden structures in data, which can be then used for predictive analysis of abnormalities in the system. This process involves analyzing historical data to detect relationships and anomalies so that predictions and automated decisions are further possible in real time.

Scope of the work:

- This scope work is to carry out AI based analysis of vibration measurement data and finalize suitable model and performances metrics for extraction of abnormal abort triggering patters from the data. Initial steps involve data collection which is a set of normal and abnormal vibration data collected from previous engine tests. The time and frequency domain data extra dataset can be used for pattern identification. In this work, the different machine learning models and evaluation metrics will be compared and the model which will effectively reproduces the abnormal signature can be finalized for usage.

Linkages to Space Programme:

- CE20 cryogenic engine testing and can be used in further development engines also.

Expected Deliverables:

- AI based machine learning model with optimized computing power and efficiency for detection of abnormal vibration signature.

RES-IPRC-2025-002

Name of ISRO/DOS Centre/Unit

ISRO PROPULSION COMPLEX, Mahendragiri

Title of the research proposal

To demonstrate appropriate Technology for high speed datalogging in Fieldbus System

Area of Research

Industrial Network Architecture

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

Smt. Poofa Gopalan

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

poofa.gopalan@iprc.dos.gov.in

Summary of the Proposed Research

Industrial Fieldbus Pressure transmitters are installed in the test facility for digital pressure measurement. In the existing system configuration, the datalogging is possible only at 250ms periodicity.

Presently, there is a need for logging this data at 100ms interval. The existing system configuration reads the data from the controller CPU via an Ethernet Interface Card. Instead, direct data access from the Fieldbus H1 protocol can meet the requirement of high speed datalogging. A novel configuration shall be designed to read the data from the fieldbus transmitters circumventing the CPU. State-of-the-art technology, architecture shall be explored to arrive at the configuration. The data shall be read and logged every 100ms.

Scope of the work:

Cryogenic process demands high speed datalogging of critical measurement parameters. In the existing facility where measurement is realized with fieldbus transmitters, the demonstrated technology will provide digital data at 100ms enabling accurate monitoring of system.

Linkages to Space Programme:

The system is useful for ICET facility, where CE20 Engines and C25 stages will be qualified

Expected Deliverables:

Transmitters, Interface hardware and software.

RES-IPRC-2025-003

Name of ISRO/DOS Centre/Unit

ISRO PROPULSION COMPLEX, Mahendragiri

Title of the research proposal

Development of software for carbon footprint monitoring and measurement for IPRC activities.

Area of Research

Environment Protection

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

Shri. B. Gouri Shankar
Shri. M. Selvakumar

Shri. M. Selvakumar

gourishankar.b@iprc.gov.in

Summary of the Proposed Research

Towards achieving sustainable way of propellant production, assembly, integration and testing of rocket engines, stages and other activities by way of monitoring, measurement and recording of carbon emissions through development of software for carbon footprint monitoring and measurement for IPRC activities.

Scope of the work:

- 100% Renewable Energy for the Facilities
  - On green production – using renewable electricity for the electrolysis of water to produce hydrogen, and renewable energy for the cryogenic air separation process for oxygen. This is crucial for net zero.
- Water Circularity
  - Closed-Loop Cooling Systems: Implement sophisticated closed-loop systems for flame deflector pits and other cooling processes to minimize fresh water intake and eliminate wastewater discharge.
  - Rainwater Harvesting and Treatment: Maximize collection and reuse of rainwater for non-potable uses.
  - Advanced Wastewater Treatment: Treat all wastewater to a high standard for reuse or safe discharge, ensuring no harmful effluents.
- Sustainable Materials and Circular Economy Principles
  - Additive Manufacturing (3D Printing): Maximize 3D printing of engine components to reduce material waste ("buy-to-fly" ratio), enable optimized designs for efficiency, and potentially use recycled metal powders.
  - Lightweight and Recyclable Materials: Prioritize the use of lightweight, high-performance composites and alloys that are either durable for reuse or easily recyclable at their end of life.
  - Responsible Sourcing: Work with suppliers who have strong sustainability credentials and are actively working towards their own net-zero goals.
  - Waste Valorisation: Convert non-recyclable waste generated at the IPRC facilities into energy or useful by products where possible.
- Green Logistics and Supply Chain
  - Sustainable Transportation: Utilize electric or hydrogen-powered heavy-duty vehicles for internal logistics and transport of propellants where feasible. Optimize transport routes to reduce fuel consumption.

- Local Sourcing: Prioritize sourcing of materials and services from local suppliers to reduce transportation emissions.

Linkages to Space Programme:

- To achieve Net Zero emission in IPRC activities

Expected Deliverables:

- Software, License or Certificates obtained from Govt. Agencies (Ministry of Environment, Forest and Climate Change, CPCB and BEE), Reference Manual and Test Reports.

PHYSICAL RESEARCH LABORATORY

AHMEDABAD

RES-PRL-2025-001

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Radio Flux Monitor (RFM)

Area of Research

Radio instrumentation, Solar physics

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

Dr. Anshu Kumari

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

anshu@prl.res.in

Summary of the Proposed Research

Continuous monitoring of the solar radio flux at microwave frequencies (~2.8 GHz) is one of the most reliable long-term indicators of solar activity. The 10.7 cm (2.8 GHz) solar flux index, also known as the F10.7 flux, which is routinely measured at the Dominion Radio Astrophysical Observatory (Canada), and the 2.7 GHz observations at the Learmonth Solar Observatory (Australia), have served as standard references for more than seven decades. In continuation of this legacy, a new initiative for S-band Radio Flux Monitoring is being developed at USO-PRL. For this, we plan to develop a fully calibrated Fx-based digital correlator for data accumulation.

Scope of the work:

The scope of the proposal, as mentioned above, mostly consist of the following two activities:

- Design, develop and characterize a digital FX-based correlator firmware for regular monitoring of the Sun at 10.7 cm.
- Calibration technique of raw counts in SFU units using sky source/noise source.

Linkages to Space Programme:

- Over the past three decades, with the launch of dedicated solar missions such as SOHO, STEREO, SDO, PSP, and SolO, our understanding of the magnetic connection between the solar interior and the Sun-Earth connection has improved significantly. With the launch of new solar missions such as ADITYA-L1 (India's maiden space-based solar observatory), PUNCH, Proba-3, SunRISE, the next few years will be an exciting period for heliospheric research. Recent advancements in radio observations, utilising both ground-based and space-based instruments, have also significantly enhanced our understanding of the solar atmosphere in unprecedented detail.

- Prediction of solar cycle strength and its variation has been a challenging research problem. Radio observations at 10.7 cm (F10.7 flux), an excellent indicator of solar activity, are one of the running records of solar activity, expected to originate from the upper chromosphere/lower corona, and correlate very well with sunspot numbers, another indicator of solar activity. With the lack of any F10.7 flux monitoring instruments in the Asian time zone, RFM will serve as one of its kind in solar radio flux monitoring.

Expected Deliverables:

- A digital Fx correlator firmware for F10.7 cm solar radio monitoring with a moderate bandwidth and high temporal resolution.
- A calibration technique for converting raw voltages into solar flux units (SFU).

RES-PRL-2025-002

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Exploring rivers & paleo-channels using Remote sensing: For understanding Martian rivers

Area of Research

Remote Sensing

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

Dr. Vijayan S

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

vijayan@prl.res.in

Summary of the Proposed Research

Rivers are major sources of fresh water, and they transport/erode large amounts of sediments. On Earth, the rivers are dynamic, and their water discharge varies from location to location. Due to climatic variations and/or tectonics, the river changes its direction, leading to the formation of paleo channels. Such migrations are clues to past activities of rivers.

On Mars, all the water-fed rivers are currently paleo channels. To understand the river dynamics, sediment transportation/erosion, and migration, it is indeed important to understand the terrestrial river systems.

This research aims to envisage the major river system within the country and how the river floodplains vary over time. The variation within the floodplains will reveal the sediment transported/eroded in a river channel. Also the paleo channel associated with the major river channel will be explored for the possible delineation of the river system using high-resolution optical, DEM and microwave images.

Scope of the work:

The scope of this proposal is to explore the Indian rivers across diverse environments to understand their dynamics.

- A detailed floodplains evolution for major river systems (eg., Brahmaputra, Mahanadi, Penna, Vaigai, Thamiraparani, etc)

- Temporal and multi wavelength exploration for the river dynamics through migration, sediment deposition/transportation/erosion processes.
- Paleo channels associated with the river system and their characteristics.

A set of tools and procedures from these river systems to be developed and can be applied to nationwide river systems.

Linkages to Space Programme:

- ISRO's future lander/rover mission to Mars will be exploring the role of past water history on Mars. For such mission, understanding the terrestrial rivers and paleo channel networks and paleo lakes will facilitate insightful information. Most of the Martian lander/rover mission landed adjacent to river channels.

Expected Deliverables:

- Temporal evolution of major river floodplains with estimation of sediments quantity
- Tools to apply the river evolution and sediment estimation model to rivers across India
- Quantification of sediment transport within rivers

RES-PRL-2025-003

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Developing VNIR Spectral Library of Planetary Analogues

Area of Research

Planetary Remote Sensing – Experimental

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

Dr. Neeraj Srivastava

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

sneeraj@prl.res.in

Summary of the Proposed Research

Planetary analogues from selected terrestrial locations provide the much-needed clues for unravelling the geology of distant and largely inaccessible planetary bodies. Reflectance spectroscopy in the VNIR is a key remote sensing tool for determining surface composition and physical properties of planetary surfaces from a distance. However, extracting this information from remotely acquired data is a challenging task since the spectral reflectance of particulate surfaces is dependent on several parameters such as viewing geometry, mineral mixture, grain size, space weathering, temperature, and pressure. Thus, it is imperative to carry out reflectance spectroscopy of a variety of planetary analogue targets in laboratory under simulated conditions and develop a comprehensive understanding of the their scattering behaviour. The research work proposed here aims to build a spectral library by studying the scattering behaviour of a suite of key Moon and Mars analogues from India and abroad in the spectral range 350–2500 nm under varying simulated conditions. Suitable modelling will be used to derive

their optical constants, which is a pre-requisite for quantitative mineralogy in case of mineral mixtures. The ASD Fieldspec 4 HiRise along with custom built Goniometer and Planetary Environmental chamber at Planetary Remote Sensing Laboratory, PHYSICAL RESERACH LABORATORY will be used to carry out these studies. The lithologies with unique compositions, textures, formation conditions, and geological significance will be initially characterized for petrology and mineralogy using the standard instruments available at PHYSICAL RESERACH LABORATORY. Thereafter, detailed spectral reflectance characteristics will be studied to decipher their formation processes and correlate them with the surfaces of Moon and Mars. Such an approach will improve our understanding of the geological character and evolutionary history of these planetary bodies.

Scope of the work:

- Spectral libraries are an important component of remote sensing and spectroscopy. In the international scenario, there are a few standard libraries such as RELAB (Brown Universities, USA) and C-TAPE (University of Winnipeg), which have played a key role in our understanding of the geology of Moon Mars, and asteroids. India, also has a rich geological heritage of planetary analogs (for e.g. Matanomadh, Sitampundi Anorthosite, Dhala impact crater, Lonar impact Crater, and Puga Valley in Ladakh etc. We wish to build an indigenous and detailed spectral library of rocks and minerals from these and many more location from within the country and abroad. For this purpose, we will be using ASD Fieldspec 4 Hirise, and our customized facilities (Goniometer and Environmental Chamber) at the Planetary remote Sensing Laboratory, PHYSICAL RESERACH LABORATORY.

Linkages to Space Programme:

- India aspires for detailed Moon and Mars exploration during the next two decades or so, culminating to human landing on the Moon. The spectral library planned to be prepared in this project by carrying out experiments under various simulated conditions (varying geometry, grain size, environmental conditions) will help us identify and quantify the composition and physical properties of planetary surfaces using reflectance/imaging spectroscopy. A portable reflectance spectrometer is expected to fly in most of the future missions (both orbital and in-situ) because of its potential as a non-destructive tool enabling quick real time detection of suface composition and properties. We plan to develop a well-characterized, diversified and comprehensive spectral library to precisely interpret the real time remotely sensed data.

Expected Deliverables:

- Spectral library of well-characterized planetary analogues (rocks and minerals) as a function of varying viewing geometry, grain size variations and environmental conditions.
- The library will also comprise of the derived optical constants and a detailed information regarding the scattering behaviour of various target materials.

The spectral library will be published in peer reviewed journal and hosted in a repository for broader use by the community.

RES-PRL-2025-004

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Development of a high-performance workstation based real-time control system (RTCS) for adaptive optics

Area of Research

Astronomical Instrumentation, Adaptive Optics Imaging System Development

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

Dr. Mudit Kumar Srivastava

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

mudit@prl.res.in

Summary of the Proposed Research

Adaptive optics (AO) is a technology to correct the wavefront error caused by earth turbulent atmosphere thereby improving the image quality of ground-based telescopes. An AO based camera is proposed to be designed and developed for the PRL 2.5m Mt Abu telescope. The AO corrections are done through the measurement of the phase of incoming wavefront with a wavefront sensor (WFS) and then applying the compensating correction to it through a lower order tip-tilt mirror (TTM) a higher order deformable mirror (DM). This operation is done continuously throughout the course of the astronomical observations in real time, as the atmospheric turbulence varies with a typical temporal time scale of tens of milliseconds. Thus, a real-time control system (RTCS) forms the backbone of adaptive optics operation. In this project we propose to develop an RTCS for the closed loop operation of the AO components WFS, TTM and DM. The RTCS is planned to be based on a high-speed workstation with a compatible Linux based operating system for the AO components interface. The project involves development of the control software, algorithms, communication interface etc for wavefront measurements and corrections. As this software need to be integrated within the larger software envelop of AO instrument being developed at PRL a close coordination with PRL team is required.

Scope of the work:

- The project needs to be executed in close coordination with PRL team. Adaptive Optics (AO) components have already been selected and are being tested in a laboratory test bench. Therefore, the architecture of real-time control system (RTCS), suitable make and specifications of the workstation and underlying operating system need to be compatible with what is being used in PRL test bench set-up. Hardware components and experimental set-up are ready is PRL so several close collaborative visits may be needed to PRL to test the developed algorithms and software. The software would include several utilities for the test and characterization of individual AO components, open and close loop operations of the AO systems, test utilities for the debugging and troubleshooting etc. It is envisaged that the computational resources (such as workstations) are to be replicated at PRL and with the project team however if needed, another set of identical AO component could also be procured for parallel developments. The project could utilize the full-time services of a research fellow, typically from the background of computer science, electronics, computational physics, engineering physics etc. (bachelor or master degree) for a period of three years.

Linkages to Space Programme:

- Adaptive Optics (AO) is a critical technology for ground-based astronomical observations in optical

and near-infrared domains. By correcting atmospheric distortions in real time, AO enables telescopes to achieve near-diffraction-limited image resolution. It has accelerated research in high-resolution imaging of exoplanets, satellites, and distant celestial objects. The PRL Mt Abu Observatory, with its 2.5m telescope, provides an ideal platform to develop and employ AO technology, enhancing capabilities for the Indian research community. Beyond astronomy, AO has emerging applications in free-space optical communications, improving the quality and reliability of laser links between ground stations and satellites. It is also key for quantum communication, where phase stability and minimal signal loss are crucial for secure quantum key distribution (QKD). Developing AO systems in India strengthens indigenous capabilities in precision optics, control systems, and space communication technologies, supporting ISRO's scientific and strategic missions.

Expected Deliverables:

- A complete software package for the detection and correction of wavefront for adaptive optics (AO) applications. The software would include several utilities for the test and characterization of individual AO components, open and close loop operations of the AO systems, test utilities for the debugging and troubleshooting etc.

RES-PRL-2025-005

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Design of Application Specific Integrated Circuits (ASICs) for X-ray radiation detectors for the future planetary missions

Area of Research

Miniaturized Electronics - Application Specific Integrated Circuits (ASICs) for X-ray radiation detectors

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

Dr. M. Shanmugam

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

shansm@prl.res.in

Summary of the Proposed Research

Silicon drift detectors are widely used in planetary studies, solar studies, X-ray imaging, and astronomy due to their excellent performances in terms of energy resolution in 1-30 keV energy range. PRL has developed single-channel X-ray spectrometers such as Solar X-ray Monitor and Alpha Particle X-ray Spectrometer flown on Ch-2 / Ch-3 Missions with discrete electronics readout. There are large number of scientific applications demanding large area detectors to detect faint signals from the scientific targets. The large detection area enhances sensitivity, making them suitable for applications in astrophysics, as well as in application where count rates are low. The linear detector configuration simplifies integration into arrays, enabling high spatial resolution and improved imaging capabilities further facilitating position sensitive spectrometers. These applications use multiple detectors and in some cases position sensitive readout within the detector itself. For the signal readout, using a discrete electronics will consume large Power, Mass and Volume. Hence, the ASICs are well suited for such applications which will enable us to develop a miniaturized space instrument suitable for the future planetary/space missions. Hence, the design and fabrication of ASICs are very important for such applications within the country.

Scope of the work:

- The research work in the first phase focusses primarily on Design of Application Specific Integrated Circuits (ASICs) for X-ray radiation detectors, specifically for Silicon based detectors. This ASIC will have chain of signal readout electronics such as Charge Sensitive Amplifier, Pulse shaper (including Pole-Zero compensation, Base line restoration etc.) and a peak hold circuit. Provision shall be made for ADC accommodation within the ASIC. Initially, the development can be for one channel ASIC with optimal design performance such as low energy threshold of few keV and energy resolution of ~ few hundreds of eV. Subsequently, the design shall be expanded to multi-channels (2,4 and 8 channels) ASICs. The desired inputs for the development of ASIC will be provided by PRL.

Linkages to Space Programme:

- As ISRO is gearing up for the series of Planetary/Space missions, many scientific applications require large area detector based X-ray Instruments Planetary/Astronomical observations. There are several ongoing and future planetary missions which are expected to use Silicon based detectors for the scientific measurements. Use of such detectors in larger number would require large volume, size and power if discrete components based electronics is used and hence it is essential to go with ASIC based readout for such applications.

Expected Deliverables:

- In the first phase of the project, the design of single channel ASIC silicon based X-ray radiation detectors. Once the performance is demonstrated at the design level, then subsequently, ASIC will be fabricated in the subsequent phases and then multi-channel ASIC development will be attempted. The design details and design files associated with the foundry (soft and hard copies) shall be provided to PRL.

RES-PRL-2025-006

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Properties of astrophysical dust

Area of Research

Galactic Astronomy and Astrophysics

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

Dr. Shashikiran Ganesh

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

shashi@prl.res.in

Summary of the Proposed Research

Dust grains are ubiquitous in the Galaxy. They can be found in a wide variety of environments ranging from Solar and Stellar systems to large scale molecular clouds and starforming regions. They are found in circumstellar environments and also in planet-forming disks. Inspite of this widespread distribution, we still don't fully understand these important constituents of the Galaxy. Some of the most important work in recent times has been on the study of dust in comets in the Solar system. PRL's 1.2m telescope

at Mount Abu has contributed a great deal of polarization measurements for comets over the last three decades. This research proposal covers two steps of the study of astrophysical dust. In one case we shall look at understanding dust grain properties using light scattering models and simulations. In the next step the vast amount of polarimetric data available at PRL will be used to constrain the models and give us an insight into the properties of the dust grains.

Scope of the work:

- This research work is aimed at the understanding of dust in various astronomical environments. Observations of dust in comets and molecular cloud cores are possible from the Mt Abu observatory and elsewhere. Light scattered by dust gets polarized and this phenomena can be used for deriving the quantitative and qualitative features of the dust grains through further simulations. In general, the degree of polarization seen depends on the characteristics of the dust grain (size, shape, composition). The proposed research will make use of existing data with the possibility of obtaining newer data as needed and work on their interpretation using simulations. Modeling will be carried out using Monte Carlo techniques. Light scattering algorithms as the t-matrix method, the discrete dipole approximation technique will also be used. These observations and simulations are expected to help gain insight into dust grain growth and evolution in the different environments. Observations of polarized sunlight from cometary dust provide information about the size, shape and composition of the dust grains. Models developed under this theme will allow for interpretation of the characteristics of astrophysical dust in the cometary and galactic environment.

Linkages to Space Programme:

- The models developed under this program will be invaluable in the interpretation of the polarization data collected at the Mt Abu Observatory. Observations carried out and models built under this theme are expected to provide feedback into the science goals for instruments to be built for future ISRO missions to the minor bodies in the Solar system.

Expected Deliverables:

- Astrophysical models of dust in comets and molecular cloud cores.
- Homogenous data base of observed cometary polarization compiling PRL's dataset with other data from the astronomical literature.
- Observational data set on dust in various astrophysical environments.
- Extended data set of organics from various classification of meteorites
- Protocols to be set for various SOM component separation.

RES-PRL-2025-007

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Unraveling Himalayan permafrost dynamics and water security through remote sensing, field investigations and isotopic ratio analysis

Area of Research

Earth, weather and climate sciences

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

Dr. Amzad Hussain Laskar

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

amzad@prl.res.in

Summary of the Proposed Research

This proposal will address the growing threat of climate-induced water scarcity in the semi-arid western Himalayas, where rapid glacier retreat and elevation-dependent warming are altering water availability for high-altitude communities dependent on glacial and snowmelt sources. Despite their potential hydrological significance, permafrost and rock glaciers remain among the least studied components of the Himalayan cryosphere. This project aims to fill this gap through an interdisciplinary framework integrating remote sensing, geophysical investigations, geomorphology, isotopic studies and socio-economic research.

The study has the following four main objectives: (i) Assessment of permafrost using geophysical techniques such as Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) at selected sites in Himachal Pradesh and Ladakh to map subsurface ice-rich permafrost and estimate water storage potential; (ii) Mapping and modeling for developing a standardized rock glacier inventory following international guidelines and analyzing their activity using SAR and high-resolution optical imagery; and (iii) Assess the hydrological and social impacts of permafrost thaw by quantifying thaw-water contributions to streamflow (using δD and δ18O) and evaluating community vulnerabilities through field measurements, traditional knowledge, and socio-economic surveys; (iv) Document indigenous adaptation practices and develop strategies for climate-resilient water and hazard management.

By combining high-resolution remote sensing with field validation, this project will generate critical datasets for modeling permafrost dynamics and hydrological potential. The outcomes will improve understanding of cryosphere-hydrology interactions, refine predictive models, and inform climate-resilient water management and policy planning. Ultimately, the project seeks to enhance water security and strengthen adaptation capacities of vulnerable high-mountain communities facing accelerating climate change.

Scope of the work:

- It is an integrated scientific investigation of permafrost and rock glacier systems in the semi-arid western Himalayas to evaluate their hydrological potential, spatial variability and response to climate change. It aims to generate robust baseline data on the distribution, ice content, and water storage capacity of frozen ground, an essential yet poorly understood component of the Himalayan cryosphere. Through the combined use of high-resolution remote sensing, geophysical surveys (ERT and GPR), and in-situ validation, the project will produce detailed maps and models of permafrost and rock glacier dynamics across selected sites in Himachal Pradesh and Ladakh. Extensive sampling and stable water isotope analyses form a key component of the project to understand the hydrological processes and quantify the role of permafrost in sustaining local water supply.

- In addition to scientific measurements, the project will assess local perceptions of climate and water-related changes through participatory socio-economic surveys. This will facilitate the integration of indigenous knowledge and traditional practices into climate adaptation and hazard mitigation strategies. The scope also includes establishing standardized protocols for mapping and monitoring permafrost in line with international guidelines. Overall, the study will strengthen the scientific basis for understanding high-mountain hydrology, improve predictive capability of cryosphere-linked water resources, and support evidence-based decision-making to enhance the resilience and water security of vulnerable Himalayan communities.

Linkages to Space Programme:

- The proposed study is closely aligned with India's Space Programme, particularly ISRO's initiatives on cryosphere and hydrology monitoring through Earth observation. By utilizing ISRO's satellite datasets such as CartoSAT, Resourcesat, RISAT and the newly launched NISAR mission, the project will map and monitor permafrost and rock glaciers, assess their spatial and temporal dynamics, and estimate stored water volume. Integration of satellite-based observations with field-validated geophysical data will enhance the accuracy of cryosphere models and improve understanding of permafrost degradation under climate change.

- The study directly supports ISRO's National Cryosphere Programme and its broader objectives of using space technology for water resource management, climate resilience, and sustainable mountain development. The project outcomes will contribute to developing improved geospatial tools and methodologies for monitoring the Himalayan cryosphere, reinforcing ISRO's role in advancing space-based applications for environmental assessment and policy planning in data-scarce, high-altitude regions.

Expected Deliverables:

Year 1. Baseline data generation, field campaign and methodology development:

- Site selection using CartoSAT, Resourcesat, and RISAT data, development of standardized protocols for permafrost mapping, preliminary permafrost and rock glacier inventory maps, stable isotope ratio measurements, first year report preparation.

Year 2. Field campaign and data integration:

- Second field campaign, processing and analysis of multi-temporal datasets for permafrost mapping, high-resolution permafrost and rock glacier distribution maps preparation with field validation, laboratory analysis of stable isotope ratios, interim report with integrated satellite and field-based model outputs.

Year 3. Modelling, applications and dissemination

- Estimation of water volume equivalent, development of GIS-based decision-support layers for water resource and hazard management, integration of findings with ISRO's National Cryosphere Program, suggest sustainable management strategies for the vulnerable communities, final technical report, peer-reviewed publications and submission of all geospatial outputs to data repository.

RES-PRL-2025-008

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Atmospheric Clouds and their association with precipitation patterns over the North-Eastern Indian Region: Insights from Lidars and Satellite observations

Area of Research

Atmospheric Remote Sensing (RS & GIS)

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

Prof. Som Kumar Sharma

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

somkumar@prl.res.in

Summary of the Proposed Research

Atmospheric clouds are one of the vital components of the hydrological cycle. Cloud characteristics and precipitation patterns are highly variable over the orographically complex regions, such as the Indian North-Eastern regions. The weather and climate of the Earth-atmosphere system over the Indian North-Eastern region are highly sensitive. This NE region hosts the place of the highest rainfall in the world. Atmospheric processes and cloud dynamics are highly sensitive and highly varying along with the atmospheric processes. Understanding the cloud physics, their properties, and temporal evolution is essential for understanding the origin and impact of clouds and their feedback in the system over the Indian North-Eastern region. Their parameterisation will play a crucial role in the weather and climate models for improving the forecast. Furthermore, High-altitude icy cirrus clouds are very important, and investigation of their characteristics is essential for the understanding of the Earth's radiation budget in the orographically challenging region, such as the Indian North-Eastern regions. This study will be focused on the investigation of the Atmospheric Clouds and their association with precipitation patterns over the North Eastern Indian Region using ground-based Lidars and Satellite observations. Presently, three Lidar systems under the Physical Research Laboratory's Lidar Network Program are in regular operation over the North-Eastern Indian region.

Scope of the work:

- Dynamics of the atmospheric clouds, and different layers of clouds play an important role in the precipitation pattern in orographically complex regions.
- The Lidar provides observations with high temporal and vertical resolutions of clouds and boundary layer characteristics. These observations will provide an estimation of strong downdrafts and updraft and their association with precipitation, layers of cloud bases in the hilly and plain regions over the Indian NE-region.

- The Indian North-Eastern region orography and densely forested region are playing a role in the discrepancies/differences with satellite-based estimation of Cloud Top Height/ Cloud Base Height from the Lidars, and Cloud Top height from the satellite will also be investigated. These will further help in calibrating satellite sensors and in the tuning of the cloud detection algorithms for the Indian North-Eastern region; further, these will be used for weather modelling purposes, which need accurate cloud information to initialize numerical models.

Linkages to Space Programme:

- These investigations will provide a deep insight of the clouds over the Indian North-Eastern region and boundary layers (using Lidar-based observations with high temporal and vertical resolution) will be valuable for the calibration of satellite-based sensors and also for future satellite missions for Earth observations in the orographically complex regions. Furthermore, these observations will also be used for the ground truth input for the improvement of regional weather and climate models for improving predictions over the Indian North-Eastern region.

Expected Deliverables:

- The atmospheric cloud dynamics, their vertical structures, and their association with the precipitation over the Indian North-Eastern region.
- Investigation on the cloud water carrying capability of the clouds below and above the Cloud Lifting Condensation Level (LCL)
- Quantification of the satellite-based observation of Cloud heights and cloud layers along with ground-based Lidar observations and to investigate cause and consequences of the anomalies over the Indian North-Eastern region.

Investigations will be utilized for calibrating satellite sensors and tuning of the cloud detection algorithms; and will be used for weather modeling purposes, which need accurate cloud information to initialize numerical models over the orographically complex the Indian North-Eastern region.

RES-PRL-2025-009

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Development of tools for the robotization of telescopes at Mt Abu Observatory to enhance the capability of the EM follow-up of neutrino-based triggers

Area of Research

Astronomy and Astrophysics

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

Shri. Sunil Chandra

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

schandra@prl.res.in

Summary of the Proposed Research

With the first detection of an astrophysical neutrino from the direction of the flaring blazar TXS 0506+056 in 2017 plus several studies further, a new important messenger has been added to the list of information carriers. These findings strongly support the idea that hadronic cascades—particularly proton–photon (p-γ) interactions—play a significant role in the energy-loss mechanisms operating within astrophysical jets, a huge step forward in the field of particle acceleration. Added, the fact is that these triggers come with a huge positional uncertainty attached to these triggers, an efficient follow-up mechanism hence demand autonomous observations, at least up to certain levels if not completely.

Mt Abu observatory hosts four telescopes equipped with various instruments to avail photometry, polarimetry, spectroscopy and spectro-polarimetry, a fantastic suite of observational capabilities. Most of these telescopes are operated in a semi-automated manner. The proposed project offers a) the development of a number of software modules to frame a generic architecture which shall be used to connect most of the telescopes at PRL Observatory and avail the autonomous operability, and b) to develop and optimize the control units to achieve the robotic telescope operations.

This implementation shall also be very useful for followup of optical transients and near-earth objects like comets and asteroids.

Scope of the work:

- The development of software modules required for the observatory control system, pipelines, autonomous data archiving, alert handling, observation planning, internal communications, task scheduling, etc needs some level of understanding of the telescope operations, nature of monitoring programs, and functionalities of various inhoused instruments. This is why this project actually caters the interests of many techno-savvy astronomy enthusiasts from the interdisciplinary domains.
- The proposed project is not limited to the robotization of Mt Abu Observatory telescopes but also to avail experiences and technology for the infrastructure useful for any robotic telescopes in future. Learnings and resources from this project shall be extended to attach other observing facilities to our grid and hence to effectively build a shared, scalable, multi-functional transient follow-up machine in our country.
- The idea is to generate a suite of packages which after production shall be available as public open resources.

Linkages to Space Programme:

- Electromagnetic follow-up of high-energy neutrino triggers demands wide-field sky coverage with real-time data analysis and autonomous decisions for deep monitoring using spectroscopy, polarimetry, and photometry. With KM3NeT and IceCube-Gen2 soon reaching full capacity, the number of triggers will rise dramatically, making manual classification and follow-up impractical. This project aims to build scalable capabilities for rapid multi-messenger response using optical/IR facilities in India and through international collaborations, while also developing preparatory technologies for future autonomous operations at Mt Abu Observatory.
- Looking ahead, India's expanding space ambitions and demonstrated capability position it to establish scientific infrastructure on the Moon. A robotic, large-field-of-view UV/optical/IR transient-

survey telescope on the lunar surface could revolutionize early detection and characterization of energetic cosmic phenomena. This respond project will generate several generic tools, resources, and technology as an essential step toward such long-term goals by strengthening technical readiness and fostering collaborative multi-messenger astrophysics. Although such an endeavor appears challenging at present, recent achievements—such as China's technological demonstration of a 7-inch telescope on moon and its scientific benefits—provide strong motivation and a viable proof of concept for pursuing similar ambitions.

Expected Deliverables:

- Software modules and controllers for autonomous operations of the optical telescopes at Mt Abu Observatory Suits of generic modules for the autonomous data handling and analysis.

RES-PRL-2025-010

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Miniaturized sensor development and signal processing hardware for space instrument to measure transient electric field/charged dust

Area of Research

Sensor for electric field/charged dust

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

Prof. Jayesh Pabari

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

jayesh@prl.res.in

Summary of the Proposed Research

During a dust devil on Mars, charged dust is produced and lifted in the atmosphere. Also, dust devils may lead to electrical discharges, producing the transient electric fields. The project work involves development of miniaturized sensor and associated signal processing hardware in the mentioned area.

Scope of the work:

- The scope of research covers development of miniaturized sensor and its sensor specific electronics/ hardware for the detection of transient electric field/charged dust. It also involves new technique of detection and related aspects, conceivably.

Linkages to Space Programme:

- The research project is directly linked to the ISRO Mars mission, Venus mission and other planetary missions. The work is in line with the present activities of PRL in respective fields.

Expected Deliverables:

- The expected deliverables are miniaturized sensor and its signal processing hardware, along with the processing algorithm.

RES-PRL-2025-011

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Planetary analogue to Venus: Implication for future Venus Exploration

Area of Research

Earth and Planetary materials

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

Dr. Dwijesh Ray

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

dwijesh@prl.res.in

Summary of the Proposed Research

A near perfect terrestrial analogue to Venus is still elusive on Earth and no single terrestrial analogue can account for all science attributes. However, continued research on new and a variety of analogue sites are always important and useful to understand the geologic evolution and planetary processes on Earth and beyond. Venus is known for its hostile environment (with ~460°C temperature and ~92 bar pressure). Geomorphology of young volcanoes (both subaerial and underwater) from Earth can be useful to understand style of volcanism, rate of occurrences of pyroclastic and tephra events. Findings from experiments conducted on terrestrial basalts and their weathering processes can limit the type and quality of data required for upcoming missions aimed at uncovering the petrologic history of surface igneous rocks. Nevertheless, the analogue sites provide opportunities for involvement of young researchers in future planetary missions to Venus and elsewhere, which will depend on training, testing of payloads and skill development of scientists.

Scope of the work:

To contribute to future ISRO's Venus Orbiter mission by bringing scientist and engineers from different domains with an emphasis on future planetary missions.

- To study the morphometry of terrestrial volcanoes and its landforms and weathering in the context of Venus.

To generate mineralogical and geochemical data and understand the planetary surfaces, interiors, and processes via laboratory analysis.

- Development of protocols for terrestrial and extra-terrestrial samples.
- Study planetary analogues via field trips and sample collection from new terrestrial analogue sites.
- Development of human resources.

Finally, all the resources generated from the project will be made available to the public and prepared for use.

Linkages to Space Programme:

- The proposed initiative is fully in accordance with ISRO's upcoming Venus Orbiter mission. The

laboratory readiness and analytical procedures will be thoroughly implemented through mineralogical and geochemical analyses of Earth-based (terrestrial) materials and available relevant planetary analogue materials to prepare and mineral database for volcanic suite of rock in the Venusian context.

Expected Deliverables:

- Morphometric analyses and lava morphology of volcanoes from Indian subcontinent.
- Geochemical analyses of terrestrial rocks, minerals for comparative planetology.
- Terrestrial impact crater modelling.

The deliverable will additionally encompass human resources, capacity development, and preparedness for Venus Orbiter Mission (VOM).

RES-PRL-2025-012

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Quantifying the effect of convective turbulence on distribution of key trace species in Venusian clouds and Haze

Area of Research

Planetary Atmospheres

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

Prof. Varun Sheel

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

Shri. Dipak Kumar Panda

Summary of the Proposed Research

Despite long term observations from past missions like Venus Express and Akatsuki, we still do not completely understand the spatio-temporal variability of the cloud layer, especially the detached haze layer above the cloud top. The composition of these regions is tightly controlled by the multiscale atmospheric dynamics, which regulate the distribution of sulfuric acid aerosols and key trace gases such as SO , H O, CO, and OCS. It is therefore important to model the relative contributions of short scale convective motion and large-scale dynamics, on the composition of the Venusian cloud layer and upper haze.

Scope of the work:

- At PRL, we are working with a Venus GCM coupled with photochemistry and microphysics of the cloud layer. This model should be constrained by the huge amount of archival data available from Venus Express and Akatsuki missions, to study the role of the dynamical and physical processes shaping the composition of the cloud layer. Such a study is important to prepare us for ISRO's Venus mission which will observe various properties of the upper haze. It will provide a comprehensive understanding of what we should look for with our instruments being developed for the Indian Venus mission.

Linkages to Space Programme:

- This work has direct link to ISRO's upcoming Venus mission to be launched in 2028. For the mission to be successful, Indian scientists need to develop a deeper understanding of the processes in the Venusian cloud layer and haze. This will directly help in the development of many of the instruments on the Indian Venus mission, that will observe this region.

Expected Deliverables:

- This work will result in the development of a 1D transport model with a convective scheme coupled to photochemistry of the cloud layer. Results will be compared with an existing Venus GCM (being used at PRL), to compare contributions of convection with that with that of large-scale dynamics, on the composition of the cloud layer and haze. The model will be useful for future observations by the Indian Venus mission. This is crucial for the success of ISRO's Venus mission. Flux calculation of cosmic dust reaching to Earth.

RES-PRL-2025-013

Name of ISRO/DOS Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Lunar dust analogues: A laboratory mimic for Chandrayaan-4 sample return mission

Area of Research

Laboratory Astrochemistry

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

Prof. Bhalamurugan Sivaraman

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

bhala@prl.res.in

Summary of the Proposed Research

The lunar regions where Sun light does not fall for millions of years, known as the permanently shadowed craters, are quite cold. So they could act as cryogenic traps where molecules can form an icy mantle on the top of lunar fine dust. Therefore, the chemical composition in such colder places could be quite different from those areas of the Moon which are exposed to the Sun light. There have been more interests to explore these areas on the Moon, especially the regions in the lunar south pole, this includes the upcoming Chandrayaan-4 mission to return sample from the lunar south pole.

The condition of lunar south pole fine dust which is quite cold can be recreated in the laboratory and the chemistry on top these fine dust covered by molecular ices (especially biomolecules) can be studied. These laboratory studies will help in understanding the nature of the biomolecules in the sample from the Chandrayaan-4 sample return mission.

Scope of the work:

- The chemical changes on the lunar dust are due to the energetic particle irradiation and impact events. Whilst energetic particle irradiation initiates chemical reactions it is the impact events that

delivers a variety of ingredients that play a major role in the chemistry. Especially, when the impactor happens to be a carbonaceous meteorite then the smaller and complex carbon containing molecules are delivered.

- The carbonaceous meteorites are known to contain a rich variety of molecules such as the polycyclic aromatic hydrocarbons (PAH's) and the molecules of life, such as amino acid and nucleobases. After the impact even, these molecules in their original form or after chemical alteration become a component of the lunar regolith. Our understanding on their stability are limited, to-date.
- In this project, we aim to recreate the condition of varying mixtures of lunar regolith containing biomolecules, such as amino acids, nucleobases and sugars, and subject it to energetic processing and impact events - impact induced shocks. Post-processing, the analogues will be examined *ex-situ* to know the extent of stability and polymerization.

Linkages to Space Programme:

- The project is quite important to understand the biomolecular content in the samples to be obtained by the Chandrayaan-4 sample return mission.

Expected Deliverables:

The project will enrich our understanding on

- The stability of molecules (especially biomolecules) in the lunar environment.
- The extent of polymerization of biomolecules in the lunar environment and this work will be a laboratory support to understand the extent to which we can expect the molecules of life on real lunar samples which will be returned by the Chandrayaan-4 mission.

ISRO INERTIAL SYSTEMS UNIT

THIRUVANANTHAPURAM

RES-IISU-2025-001

Name of ISRO/DOS Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

Title of the research proposal

Development of mathematical models and algorithms for Image Navigation, Registration and Tracking for Geostationary Imager

Area of Research

Geostationary Satellites, Orbital Dynamics, Image and Signal Processing

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

Shri. Nishank Kumar

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

nishank_kumar@vssc.gov.in

Summary of the Proposed Research

Geostationary Imagers are used in meteorological satellites. It consists of two axis gimbal Scan Mirror Mechanisms, which scans the earth, clouds and its environments and generates two dimensional and three dimensional images in multiple spectral bands. These images are used for weather forecasting and disaster warning on a daily basis. The major problems faced in weather forecasting are inaccuracies in weather predictions due to following reasons.

- Disturbances in the spacecraft due to station keeping errors (orbital and attitude errors) resulting in pixel location error. These errors are known as Image Motion & Mirror Motion Compensation (IMC/MMC) Errors.
- Systematic errors in the system caused by sensor, actuator, drive electronics, thermal and mechanical distortions, which results in non-linearity in imaging.

All these errors cause inconsistency in image navigation and registration with respect to the geographical locations on the earth and affect prediction accuracies. Understanding and modelling these dynamic errors caused by various orbital perturbations, in terms of orbital parameters and earth-satellite geometry and applying these models to compensate these errors in real time is the aim of the project. Numerical simulations and experiments to be carried out on real time INSAT images as well as on engineering model of scan mirror mechanism to evaluate the performance.

Scope of the work:

- Study and modelling of orbital dynamics and various disturbances in the spacecraft due to orbital inclination, eccentricity and asymmetric distribution of the Earth's gravity, the gravitational interaction of the moon and the sun, solar radiation pressure etc.
- Analysing the impact of '8' shaped motion of sub-satellite point due to non-zero orbit inclination on image navigation.

- Development of mathematical models and algorithms for improving Image Navigation, Registration and Tracking accuracies.

Linkages to Space Programme:

- INSAT-4th Generation Geostationary Satellite, Advanced Imager.

Expected Deliverables:

- A mathematical model and source code for orbital dynamics and Image Motion & Mirror Motion Compensation (IMC/MMC) Errors.
- A mathematical model and source code for Image Navigation error compensation [Image navigation refers to absolute and relative spatial correspondence between the image and ground target i.e. in registering the image pixels on fixed lat-long grid).
- A mathematical model and source code for Image Registration [i.e. aligning multiple images of a same scene taken at different time].
- A mathematical model and source code for Geometric error correction of Geo Images (i.e. accurate mapping of coastline boundaries with Geo Images).
- A mathematical model and source code for accurate tracking of various atmospheric events (cyclones, forest fires, clouds, heavy rainfall, flash floods etc.)
- GUI with source code having following options
  - ✓ Accept orbital parameters and generate IMC/MMC error model and data in both azimuth and elevation.
  - ✓ Read real time INSAT images and apply error models to performradiometric correction, geometric correction, image navigation and registration and generate corrected image and various data products.
  - ✓ Disaster warning, tracking and forecasting of various atmospheric events viz cyclones, forest fires, clouds, heavy rainfall, flash floods etc.

RES-IISU-2025-002

Name of ISRO/DOS Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

Title of the research proposal

High Precision Linear Actuator for Hyperspectral Infrared Sounder

Area of Research

Sensor and Actuator

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

Shri. Sandip Das
Shri. Nishank Kumar

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

sandip_das@vssc.gov.in,
nishank_kumar@vssc.gov.in

Summary of the Proposed Research

Design, development and realization of high precision linear actuator and drive as per following specifications:

- Travel Range : 0-50 mm
- Maximum Velocity :10mm/sec (programmable 0 to 10 mm/sec)
- Minimum Incremental Motion:100 nm
- Repeatability : 10 nm
- Linearity : +/-50 nm
- Absolute Position Sensor Resolution : 5 nm
- Drive Load Capability : 10 N
- Operating Temperature : 0 to 75 degC
- Compact Design : 65x50x25 mm (approximate)

Scope of the work:

- Design and development of high precision linear actuator (piezo/mechanical) and its drive electronics with closed loop control system.
- Absolute position information with resolution of 5 nm.
- Self locking feature when switched off to save energy.

Linkages to Space Programme:

- INSAT-4th Generation Geostationary Satellite, Hyperspectral Infrared Sounder

Expected Deliverables:

- Prototype hardware for linear actuator with associated drive electronics, all hardware and software design details, applications, source code, schematics, mechanical drawings etc.
- Mathematical model and source code for control loop design.
- GUI interface with source code for
  - ✓ Commanding the actuator to move in incremental steps or continuous motion at different selectable rates.
  - ✓ Monitoring of various health parameters including absolute position, current, voltage etc.

RES-IISU-2025-003

Name of ISRO/DOS Centre/Unit

ISRO Inertial Systems Unit, Thiruvananthapuram

Title of the research proposal

Formal Analysis of Synchronization Logic for quadruple redundancy used in INS Processor Module

Area of Research

Theoretical Computer Science, Computer Logic, Computer Algorithms, Verification

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

Ms. Deepa Sara Jhon

Ms. Dhanalakshmi P. P

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

deepa_john@vssc.gov.in

Summary of the Proposed Research

The inertial navigation system (INS) for launch vehicle missions is a real time embedded system that acquires the data from motion sensors and rotation sensors and calculates the position, velocity and orientation of the launch vehicle without using external references. The Navigation Processor Module(NP) is a mission critical system that processes the sensor data and transforms the sensor data to a given reference frame and integrate, to generate the navigation states of the launch vehicle for the On –board Computer(OBC).

The quadruple redundant processor systems (NP and OBC) use independent crystal oscillators to maintain their real time .A logical clock derived from the oscillator frequency will generate an interrupt that shall be used to schedule the data acquisitions and navigation computations .The navigation data shall be used by OBC to generate control and sequencing commands for the actuators.

The NGC chain is hard real-time distributed system. The sensor data acquisition,error compensation and navigation is handled by NP. The guidance and control algorithm and control command actuation is handled by the OBC. The sense to post transport delay is defined as the time taken from sensing of the data from inertial sensors to the posting of the actuator control command for the sensed vehicle states. This is to be maintained within a specified deviation to meet the mission requirements.

It is necessary to ensure that all the four NPs use the sensor data latched with minimum skew for navigation computations to ensure that the navigation solution from the same time sample of sensor data are available for voting at OBC Hence it is necessary that the NPs are closely synchronized to each other.

Traditionally, a detailed test bed validation is done for the synchronization scheme to detect and establish the functionalities of the system under possible failure modes. In order to ensure the system design will cater to its safety critical requirements under all conditions, there is a need to impose formal methods for software design The proposal is to apply formal methods for software safety analysis of the synchronization logic of the Navigation System for man-rated missions

Scope of the work:

- Formal analysis of synchronization logic for Naviagtion systems.
- A formal model shall be developed using open source tools.
- The normal language requirement specifications of the algorithms are to be translated to formal specifications and verified for functional requirements and safety critical properties.

Linkages to Space Programme:

- Formal methods for Safety critical Software in Gaganyaan.

Expected Deliverables:

- Formal model of synchronization logic used for quadruple redundancy (source code of model developed in open source tool).
- Identification of safety properties of item 1 from requirements specifications in normal language and translation to formal language.
- Establishment of the completeness and soundness of the requirements.
- Identification of non-compliance situations for the properties.

INDIAN INSTITUTE OF REMOTE SENSING

DEHRADUN

RES-IIRS-2025-001

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Permafrost induced hazard susceptibility in Western Himalaya

Area of Research

Cryosphere/Mountain Hazard/RS&GIS

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

Dr. Pratima Pandey

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

pratima@iirs.gov.in

Summary of the Proposed Research

The reported elevation dependent warming and increased temperature variability at high altitudes has impending impact on thawing of permafrost and altering the seasonal freeze-thaw which can further induce ground deformation, slope instability consequentially causing mountain hazards, livelihood impacts, infrastructure damage and alternations of landscapes.

Permafrost thawing is assumed to be a serious threat to infrastructure as it has potential to trigger mass movement in mountain. The increasing high altitudes hazards such as Chamoli event in the year 2021 and South Lhonak Lake outburst Flood event in the year 2023 have permafrost thawing implications. Permafrost thawing can also induce ground subsidence which can affect the livelihood of local mountain community. The permafrost thawing induced deformation will be studied at vulnerable locations.

The data available from newly launch NISAR and other existing microwave and optical datasets has tremendous prospective for the assessment of horizontal and vertical deformation in the periglacial regions of western Himalaya from permafrost degradation perspective.

Despite having a significant impact and contribution of permafrost on Himalayan Hazards such as ice/rock avalanche, moraine/debris flow and slope destabilization very limited study has been carried out in the assessment of susceptibility of permafrost induced mountain hazards.

Scope of the work:

- The proposed research will utilize recently available remote sensing datasets to model and map permafrost distribution using AI/ML techniques validated with the field-based investigation. Further, the potential high altitude hazards areas in the western Himalaya will be identified under the permafrost zone. The vertical and horizontal surface deformation will be assessed and the hazards susceptibility will be investigated. The remote sensing-based studies will be supported and also validated with the rigorous field-based observation using geophysical instrument.

Linkages to Space Programme:

- The Cryospheric Programme under ISRO.

Expected Deliverables:

- This research seeks to derive novel outcome such as the permafrost distribution, thawing, and association with slope destabilizations and mountain hazards. The project will shed light on the characteristics of mountain permafrost specific to Himalaya. The findings from this study will help policy makers for planning and management of implication of thawing of permafrost for slope destabilization and related high mountain hazards. The use of advanced remote sensing techniques along with detailed geophysical investigation will improve the knowledge of characteristics of Himalayan permafrost and its association with high altitude hazards.

RES-IIRS-2025-002

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Geological characterization of lunar and Martian surface features using recent National and International Missions.

Area of Research

Planetary Geology

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

Dr. Mamta Chauhan

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

mamtachauhan@iirs.gov.in

Summary of the Proposed Research

Availability of High-resolution optical, multispectral, hyperspectral sensors and elevation data from various lunar and Martian missions can be utilized to characterize geological features like impact basins, craters and volcanoes and related landforms by analysing them for mineralogy, lithology, morphological, topographical and structural interpretation.

Scope of the work:

- These data with utility for identification, spectral-compositional analysis, geomorphic evolution and chronological study can be integrated with ground based Spectral-compositional study of various igneous exposures in conjunction with geochemical study to understand and correlate their mineralogy, composition, formation conditions, and environment in similar setup at the Moon and Mars.

Linkages to Space Programme:

- Future Planetary missions of ISRO.

Expected Deliverables:

- Detailed geological analysis of landforms (Volcanic and Impact) and lithology (mafic and silicic)

on Moon and Mars by generating comprehensive geological map, mineral map and quantification of morphological features using multi-sensor planetary datasets to understand their nature of occurrence, associated mineralogy, morphological characteristic and geological evolution.

RES-IIRS-2025-003

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Quantifying Methane Emissions from Indian Wetlands using Satellite Datasets

Area of Research

RS & GIS

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

Dr. Vaibhav Garg

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

vaibhav@iirs.gov.in

Summary of the Proposed Research

Wetlands are one of the major natural sources of methane (CH), a potent greenhouse gas with high radiative forcing. Quantifying methane emissions from wetlands is important for understanding India's greenhouse gas balance, informing climate policy, and improving models of methane flux under changing land use and climate.

There have been several studies estimating wetland methane emissions in India through field measurements (flux chambers, eddy covariance, etc.) and through broader-scale modelling using coarse satellite data. For example:

- A hierarchical empirical model using MODIS (Moderate Resolution Imaging Spectroradiometer) data and ARIMA modeling for wetland extent, temperature etc.
- Case studies in Odisha (Orissa) for Chilka, Anshupa, and Gahirmatha estimating seasonal and annual CH fluxes.
- Recent inventories of methane emissions from various sources in India indicating wetlands account for ~8.6% of national CH emissions.
- However, these approaches typically suffer from limitations such as:
- Spatial resolution: Many sensors (MODIS, Sentinel-5, etc.) are coarse, making it hard to resolve emissions at fine scales (e.g. patches of wetland, small water channels).
- Spectral resolution: Detecting methane with confidence often requires narrow-band SWIR near methane absorption features (e.g., ~1.65 µm, ~2.3 µm).
- Temporal revisits: Wetlands being dynamic (hydrology, inundation, vegetation) require frequent observations.
- Cloud cover, atmospheric interference: Wet season, monsoons, etc., complicate remote sensing.

Recent advances:

- Hyperspectral satellites like EnMAP, PRISMA, EMIT and the commercial constellation (GHGSAT, PIXXEL Firefly constellation, Planet's Tanager series) have been demonstrated for methane detection and quantification.
- The high spatial and fine spectral resolution (narrow SWIR absorption bands), is capable of detecting point sources with emission rates on the order of ~100 kg CH per hour under good conditions.

Given this, there is a strong opportunity to apply satellite datasets to Indian wetlands, both to improve emission estimates locally, and to compare with other hyperspectral (and multispectral) systems to understand trade offs (e.g., detection limit vs coverage vs revisit rate).

Scope of the work:

- Quantify methane emissions from representative Indian wetlands using remote sensing data, over a multi-year period.
- Compare the results (spatial, temporal, magnitude) with estimates using hyperspectral datasets and possibly multispectral sensors.
- Assess detection limits, uncertainties, and spatial/temporal dynamics of wetland CH fluxes as observed through hyperspectral remote sensing.
- Evaluate scaling: how local emissions inferred via hyperspectral and other sensors aggregate to regional and national scales; comparison with bottom up/field measurement inventories.
- Develop methodological protocols for remote sensing of methane emissions in wetlands: best practices for data acquisition, atmospheric correction, cloud masking, plume detection, etc.

Linkages to Space Programme:

- NICES

Expected Deliverables:

- High resolution quantification of methane emissions from multiple Indian wetlands across seasons.
- Comparative assessment of hyperspectral and other datasets: strengths, weaknesses, detection thresholds, etc.
- Improved national / regional methane emission estimates from wetlands with lower uncertainty.
- Methodological protocols for wetland CH remote sensing (useful for researchers, government, satellite mission planners).
- Publications in peer reviewed journals; datasets made available (subject to licensing) for the community.
- Potential policy relevance: better information for India's climate reporting, potential mitigation strategies for high emission wetlands or hotspots.

RES-IIRS-2025-004

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Use of L & S dual-band NISAR data for Crop growth monitoring, crop yield estimation, crop biophysical parameters retrieval and soil moisture estimation.

Area of Research

Radar Remote Sensing applications in agriculture and soil moisture, L & S dual-band NISAR, AI/ML techniques, Advance Microwave Remote Sensing techniques e.g. InSAR, PolSAR, PolInSAR etc., & multi-parametric SAR and multi-sensor data.

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

Dr. Hari Shanker Srivastava

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

harishanker_srivastava@iirs.gov.in

Summary of the Proposed Research

AGRICULTURE: 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 different penetration capabilities of L & S dual-band NISAR, make NISAR a right choice for crop growth monitoring, crop yield estimation and crop biophysical parameters retrieval for various crops.

Availability of L & S dual-band data from NISAR has provided new opportunities to resolve many issues in the field of Radar Remote Sensing applications in agriculture, which were difficult to resolve earlier. Use of multi-parametric L&S band NISAR along with advance SAR techniques like InSAR, PolSAR and PolInSAR allow to monitor crop growth, crop yield estimation and to retrieve various crop biophysical parameters like LAI, Crop height, Crop volume, Crop water content, Crop fresh biomass, crop density etc. with high accuracy.

Moreover, the integration of other sensor data with SAR data may further enhance the accuracy of developed methods and/or models to achieve the above mentioned objectives. Furthermore, the use of various Machine Learning Techniques can further improve the retrieval accuracy.

SOIL MOISTURE: 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 covers 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 L & S dual-band NISAR along with advance SAR techniques like Interferometric coherence, Hybrid polarimetry, fully polarimetry, PolInSAR can successfully retrieve soil moisture under variety of agricultural heterogeneities with high accuracy. 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 course 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.

Scope of the work:

- AGRICULTURE: Use of SAR remote sensing in agriculture in India is mostly dedicated to Kharif crops due to it's all weather capability and many other Rabi crops including few kharif crops are either unexplored or under-explored. Therefore, there is huge potential to exploit unique sensitivity of L & S band NISAR towards shape, size, orientation, structure and moisture content of various components of crop plant along with varying penetration capability of L & S band signals to develop full-fledged methodologies and/or models for many more crops, which are either unexplored or under-explored.
- In addition, large number of studies conducted over Indian sub-continent are typically focused on either SAR or optical/hyperspectral data. As the complimentary information available in these datasets, the combined use of SAR and optical/hyperspectral may further improve the model performance.
- SOIL MOISTURE: Although lot of research work has already been done in the field of soil moisture retrieval using active and/or passive microwave remote sensing data. However, there is still ample Scope of research to address various challenges involved in soil moisture retrieval using microwave remote sensing. Availability of L & S dual-band SAR data from NISAR, techniques like PolSAR, InSAR, PolInSAR along with advance AI/ML algorithms are expected to significantly improve the soil moisture retrieval accuracy under variety of agricultural heterogeneities and will lead to operational monitoring of soil moisture.

Linkages to Space Programme:

- Development of operational methods / models for utilisation of L & S band NISAR data

Expected Deliverables:

- AGRICULTURE: Detailed methodology and/or methods / operational models to exploit potential of L & S band NISAR data for various applications in the field of agriculture like crop growth monitoring, crop yield estimation, crop biophysical parameters retrieval etc.
- SOIL MOISTURE: Development & validation of Methods / Methodology/ operational models for soil moisture estimation using multi-frequency L & S band NISAR and/or passive microwave remote sensing data under variety of agricultural heterogeneities. Methodology/model should be applicable to large area soil moisture estimation.

RES-IIRS-2025-005

Name of ISRO/DOS Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

AI/ML based Integrated Multi-Sensor Multi-Temporal Remote Sensing Framework for Dynamic Geo-Ecosystem Assessment and Management

Area of Research

Remote Sensing Technology and AI/ML

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

Dr. Anil Kumar

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

anil@iirs.gov.in

Summary of the Proposed Research

Geo-ecosystems — comprising forests, croplands, wetlands, grasslands, and urban green systems — are dynamic entities influenced by climate variability, anthropogenic activities, and natural disturbances. Traditional single-sensor or single-date remote sensing approaches provide only static snapshots, limiting our ability to capture ecosystem dynamics such as phenological transitions, disturbance–recovery cycles, and spatial heterogeneity.

Recent advances in multi-sensor Earth Observation (EO) (Sentinel-1/2, NISAR, GEDI, EnMAP, PRISMA, Planet, ECOSTRESS, SMAP, etc.) and multi-temporal AI/ML analytics have opened new possibilities for generating continuous, high-resolution, and multi-dimensional insights into geo-ecosystem processes.

This respond theme aims to develop an integrated framework that fuses optical, SAR, LiDAR, hyperspectral, and thermal data over multiple time periods to quantify, model, and monitor structural, biophysical, and biochemical changes in ecosystems.

Scope of the work:

- To develop and validate a multi-sensor, multi-temporal remote sensing technology framework for holistic assessment, monitoring, and modeling of geo-ecosystem dynamics at regional to national scales.

Linkages to Space Programme:

- To test and develop algorithms for ISRO EO data for Geo-Ecosystem Assessment and Management.

Expected Deliverables:

- Develop Algorithms as well as Methodology through a software.

NORTH EASTERN SPACE APPLICATIONS CENTRE

SHILLONG

RES-NESAC-2025-001

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

Deep Learning approach for tree species identification and structural parameter extraction in selected sites of Meghalaya using Unmanned Arieal Vehicle hyperspectral and LiDAR image

Area of Research

Foresty and Ecology

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

Dr. Kasturi Chakraborty

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

kasturi.c@nesac.gov.in

Summary of the Proposed Research

The proposed research focuses on developing a Deep-learning-based framework with UAV hyperspectral & LiDAR images based on tonal variations and structural components for tree species, biodiversity mapping, forest type classifications etc. in Meghalaya. Traditional monitoring methods, largely rely on optical or field-based surveys. This study aims to leverage hyperspectral imagery (HSI) and LiDAR from UAV-based sensors and/or satellite sources to enhance the ongoing classification methods. By exploiting the detailed spectral signatures of vegetation, the project aims to accurately classify forest species and assess canopy health. A hybrid deep learning architecture may be developed to model both spectral, spatial and the forest structural parameters for better monitoring and assessment.

The expected outcomes should include fine-grained forest species classification maping templates and an operational GIS-based Decision Support System (DSS) for integrating with optical information. The data fusion techniques also may be explored to improve the information extraction.

Scope of the work:

- The scope of the proposed research encompasses the development and implementation of an advanced hyperspectral and LiDAR based forest species classification system in Meghalaya using Advanced Deep-learning models. The study should cover UAV based data handling and information extraction, explore the data fusion techniques to help identify multiple species in the forest ecosystem of Meghalaya. The study should aim to improve the classification accuracy of the forest species classification. Thorough ground-based data should be collected during the study to validate the results. Its methodologies and outcomes should serve as a replicable framework for forest health monitoring, species identification and extraction of other important forest structural parameters.

Linkages to Space Programme:

- The proposed research is closely aligned with ISRO's Space Vision 2047, which emphasizes the use of Earth Observation (EO) technologies for sustainable natural resource management, climate resilience, and environmental monitoring. The project can leverages hyperspectral data from ISRO's HySIS, and AVIRIS-NG missions, directly supporting ISRO's on-going efforts in biodiversity assessment, forest resource mapping, and ecological monitoring.
- By developing an advanced Deep-Learning framework for forest classification and health assessment, the research can contribute to ISRO's objectives of advancing AI-driven-UAV geospatial analytics and next-generation remote sensing applications. The integration of hyperspectral data and LiDAR complements ISRO's upcoming missions for future hyperspectral/LiDAR satellites, enhancing vegetation analysis.

Expected Deliverables:

- Deep Learning Framework integrating for spectral–spatial forest analysis.
- Forest species identification key for species distribution mapping, canopy structure analysis for improved identification of tree species and forest type mapping across Meghalaya.
- Decision Support System (DSS) integrating- UAV data acquisition, processing and output generation
- Framework for Future Integration with ISRO's upcoming Earth Observation missions

RES-NESAC-2025-002

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

Develop a Fast/Flat Plate Antenna Sensor to understand the cloud to ground and intra cloud lightning characteristics over hills

Area of Research

Planetary Science

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

Dr. Abhay Srivastava

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

dr.abhaysrivastava@nesac.gov.in

Summary of the Proposed Research

The mechanisms and propagation processes of lightning remain only partially understood, particularly in hilly regions. Key parameters such as propagation speed, preliminary breakdown, cloud-to-ground and intra-cloud classification, polarity, and continuing current may exhibit region-specific variations. Achieving sub-microsecond measurement precision is essential to recognize these variances. To better characterize lightning behavior in mountainous and plans, analyzing lightning waveforms using a flat-plate or fast antenna sensor offers a powerful approach for identifying distinct electrical signatures and propagation features. The present work will consider to develop a fast antenna sensor and study the characteristics at of lightning at 4-5 locations in complex terrain.

Scope of the work:

- This research will advance the scientific understanding of lightning behavior in complex topographies by integrating electric field sensing at sub microsecond level, waveform analysis. The outcomes will contribute to both fundamental atmospheric physics and applied lightning propagation mechanism in plan/mountainous regions over the country.

Linkages to Space Programme:

- Understanding the lightning signature on various locations will help to future planetary missions of ISRO as lightning is key signature of active atmosphere. The work will make a self-reliance of three-dimensional lightning mapping on earth in future.

Expected Deliverables:

- Fast/Flat Plat Antenna Sensor, Signature of lightning like preliminary breakdown, cloud to ground and intra cloud classification method in different locations on complex terrain.

RES-NESAC-2025-003

Name of ISRO/DOS Centre/Unit

North Eastern Space Applications Centre, Shillong

Title of the research proposal

Development of GNSS Receiver with NaVIC multi- frequency support for ground-based GNSS Reflectometry applications Development of GNSS Receiver with NaVIC multi- frequency support for ground-based GNSS Reflectometry applications

Area of Research

Satellite Navigation

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

Shri. Anjan Debnath

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

anjan.debnath@nesac.gov.in

Summary of the Proposed Research

GNSS Reflectometry is a sgnal-of-opportunity application of available GNSS signals which are reflected from various surfaces(sea, Land, waterbody) to derive various remote sensing products(Soil Moisture, Vegetation Biomass, Sea Wind Direction etc.). It is generally used by intercepting reflected GNSS signals through a low-earth orbiting platform having a GNSS-R receiver(two polarization-diversity antennas with DSP blocks). Though such systems are widely used in Europe or America(GEROS, CyGNSS), only a technology demonstration experiment has been conducted through a test receiver on board EOS-8 Satellite by ISRO. The NaVIC signals give a rare opportunity for use of the signals for various applications. A novel RF Front end design will be attempted in the research work.

Scope of the work:

- The work will encompass design & development of a GNSS-R receiver with a custom RF Front-End for NaVIC signal reception and following standard DSP to generate actionable RS products for Soil Moisture analysis or Water Body Detection etc.

Linkages to Space Programme:

- It is linked to high resolution earth observation & microwave remote sensing application(Soil Moisture estimation, Watrerbody detection etc.) through Signal of opportunity & use of NaVIC signals for SATNAV spinoff applications.

Expected Deliverables:

- Actionable products like near surface soil moisture, Water body detection, volume extraction, Sea monitoring, Glacier Monitoring etc. for DMS applications etc through a GNSS-R receiver customized for NaVIC signals.

ISRO TELEMETRY TRACKING AND COMMAND NETWORK

BENGALURU

RES-ISTRAC-2025-001

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Geolocator based on TDoA for Interference detection in the following signal frequencies:
NavIC downlink signal in L and S bands LEO TTC frequencies in S bands

Area of Research

Satellite Navigation Technology, GNSS interference, Signal processing

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

Shri. Abhishek Gupta

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

abhishekg@istrac.gov.in

Summary of the Proposed Research

NavIC services and TTC services are critical infrastructure which are prone to intentional and nonintentional interferences. In order to mitigate the interference, it is necessary to first detect the interference, identify the type and then localize using suitable signal processing algorithms. One such localisation technique is the Time Difference of Arrival (TDoA) which can be used to geolocate the interference transmitter.

Scope of the work:

The proposed research include:

- Design and implementation of a Geolocator system comprising of multiple sensing nodes (to confirm the interference).
- Design and implementation of Interference Detection algorithms.
- Design and implementation of Interference Source direction estimation algorithms.
- Design and implementation of Interference Source localization: Geolocator.

Linkages to Space Programme:

- Design will be used to improve the interference mitigation performance of NavIC receivers deployed at critical infrastructures.

Expected Deliverables:

- Functionality tested hardware platform design with the complete setup comprising of the GNSS jammer, sensing units, time synchronisation module, antennas etc.

- Functionality tested Software modules for above mentioned algorithms, HDL design files, simulation model including test benches and netlist for the complete design if any.
- Design Documents, Algorithms in the soft copy (CD/DVD) and hard copy (print) format and intellectual property.
- Simulation results of the implemented methods.
- Test results.
- Project report.

RES-ISTRAC-2025-002

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design and development of multipath mitigation techniques and algorithm using advanced Correlators in baseband signal processing

Area of Research

Satellite Navigation Technology, Multipath effect, Signal processing

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

Ms. Neelu Kasat

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

neelurathi@istrac.gov.in

Summary of the Proposed Research

The proposal is to mitigate the impact of multipath phenomenon due to high rise buildings, vegetation, etc. on the reception of real time NavIC signals.

Multipath effect can be dealt at antenna level, signal design level, baseband signal processing and at navigation data processing. The proposal is to design and develop advanced correlator technologies in order to detect multipath signals and mitigate the impact so that the measurement accuracy does not degrade.

Scope of the work:

- The scope of this proposed research is to deal with the multipath effect at baseband signal processing.
- There are basically two approaches, namely, parametric estimation and non-parametric estimation.
- Methods like vision correlator, CADLL (coupled amplitude delay locking loop) based on signal parameter estimation can be explored for this proposal. A better or improved version of correlator technology can be proposed as a solution.
- The prime objective is the required algorithm and hardware development for the NavIC receivers so that loss of lock and errors in pseudo range measurements for NavIC L1, L5 and S band signals is minimized.

Linkages to Space Programme:

- Design will be used to improve the multipath mitigation performance of NavIC receivers deployed at critical infrastructures.

Expected Deliverables:

- Functionality test of the new algorithm deployed in the NavIC receiver hardware.
- Design Documents, Algorithms in the soft copy (CD/DVD) and hard copy (print) format and intellectual property.
- Simulation results of the implemented methods.
- Test results.
- Project report.

RES-ISTRAC-2025-003

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of Metal Lens Antenna for Wind Profiler Radar at K Band

Area of Research

GRIN Lens, Feed antennas, antennas for wind profiler radar

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

Dr. Manas Sarkar

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

manas_sarkar@istrac.gov.in

Summary of the Proposed Research

Gradient index (GRIN) lens antenna is one of the most suitable structures for multibeam application. In the GRIN lens, refractive index varies along the radial distance of lens. When the feed moves along the focal plane of the lens, a collimated beam forms by converting spherical waves into plane waves on the other side of the lens. Thus, beam steering can be achieved by moving only feed at the focal plane without moving the entire large antenna system.

Since, the dielectric materials at higher frequency has more loss, here it is proposed a metal GRIN lens with graded refractive index profile along the radius. This will have advantage of over dielectric material for manufacturing as well as uncertainty of dielectric material properties.

To use the lens as multibeam operation 5 horn antennas are planned in north, east, south, west and zenith direction with feasibility of elevation variation. This configuration will ensure the uniform gain of all five beams without any scan loss as a good candidate for wind profiler radar application.

Scope of the work:

- Study of various metal lens antennas and its configurations.
- Unit cell design and simulation for the intended frequency band.
- Design of lens to meet the overall specifications.
- Realization of prototype lens and horn antennas and integration.
- Measurement and characterization ensuring the required performance.
- Report generation.
- Specifications:
  - Freq: 24 GHz
  - Bandwidth: 200 MHz (min)
  - Gain: 34 dB (min)
  - Sidelobe Level: 15 dB (typical)
  - No. of simultaneous beams: 5 beams (NESWZ)
  - Elevation: should be controllable

Linkages to Space Programme:

- Wind Profiler radar.
- In future, technology will be useful for Ground Station for multi-satellite TTC application.

Expected Deliverables:

- Complete design and simulation files.
- All the simulation results fulfilling the requirements.
- Design Report.

RES-ISTRAC-2025-004

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Quad-band anti jamming antenna for NavIC CDMA signals

Area of Research

Satellite Navigation Technology, GNSS interference, Signal processing

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

Ms. Neelu Kasat
Shri. Abhishek Gupta

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

neelurathi@istrac.gov.in

Summary of the Proposed Research

NavIC services are critical infrastructure which are prone to intentional and non-intentional interferences. In order to mitigate the interference, one way is the use of controlled beam forming antennas. Firstly, the direction of the interference is found using the signal received from an array of multiple antenna elements placed in all directions. Secondly, the phase and amplitude of signal transmitted from the individual elements are carefully controlled and combined constructively in the desired direction to form a strong, focused beam and destructively in the other direction to minimize interference.

Scope of the work:

The proposed research include:

- Design of an 8-element quad band anti jamming antenna catering to the following bands: NavIC L1, NavIC L2, NavIC L5 and NavIC S band.
- Design and implementation of detection algorithm for direction of interference.
- Passive elements gain: >5dB.
- Active element gain: >30dB.
- Noise figure: <2.5dB.
- Interference suppression: >50dB.
- Design and implementation of interreference mitigation through real time beam forming and beam steering.

Linkages to Space Programme:

- Design will be used to improve the interference mitigation performance of NavIC receivers deployed at critical infrastructures.

Expected Deliverables:

- Complete antenna system consisting of 8-elements along with integrated RF sub-system.
- Functionality tested Software modules for above mentioned algorithms, simulation model including test benches for the complete design if any.
- Design Documents, Algorithms in the soft copy (CD/DVD) and hard copy (print) format along with the intellectual property.
- Simulation results of the implemented methods.
- Test results.
- Project report.

RES-ISTRAC-2025-005

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Artificial Intelligence (AI) enabled Data Association and Intelligent Radar Scheduling for Short-Arc Space object Tracking in distributed multi-sensor networks with sparse measurement sets

Area of Research

Radar Systems

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

Venepally Sravan Kumar

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

sravanvenepally@istrac.gov.in

Summary of the Proposed Research

Tracking resident space objects (RSOs) using ground-based radar systems is a critical component of Space Situational Awareness (SSA). However, the task becomes particularly challenging under short-arc observations and sparse measurement regimes—typically limited to range, azimuth, and Doppler—where traditional tracking and data association algorithms struggle with ambiguity and uncertainty. This work intend to use artificial intelligence (AI)-enabled framework for joint data association and adaptive radar scheduling within a distributed multi-sensor radar network.

The proposed approach integrates machine learning techniques—including probabilistic data association networks, deep neural estimators, and reinforcement learning-based radar tasking—to enhance both measurement-to-object association accuracy and real-time radar resource allocation. The system intelligently prioritizes sensor tasks and schedules radar observations to maximize information gain under tight time and observability constraints. Furthermore, a hybrid uncertainty-aware orbit determination module is incorporated to estimate trajectories with quantified confidence, even from fragmented and low-information data.

Scope of the work:

- This project aims to design, develop, and validate an AI-driven framework for data association and adaptive radar scheduling to track space objects using limited observables (range, azimuth, Doppler) from short-arc measurements collected via distributed multi-sensor radar systems. The system will address challenges such as fragmented tracking, measurement uncertainty, and sensor resource constraints, by integrating machine learning, probabilistic inference, and radar resource management techniques.

The scope includes:

- Algorithm development for robust data association under sparse observability.
- AI/ML integration for adaptive sensor scheduling
- Uncertainty-aware orbit determination to estimate object trajectories from incomplete and noisy data.
- Simulation environment creation for realistic scenario testing (space objects, radar models, tracking arcs).
- Performance benchmarking against baseline methods (e.g., MHT, JPDA, greedy scheduling).

Linkages to Space Programme:

- It will be linked to ISRO space object tracking program using multiple radar sensors.

Expected Deliverables:

- Literature Review Report.
- System Architecture Document.
- AI/ML-based Data Association Module.
- Adaptive Radar Scheduling Module.
- Orbit Determination Engine.
- Simulation Environment.
- Evaluation and Benchmarking Report.
- Final Technical Report.

RES-ISTRAC-2025-006

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design and development of Photonic Transmitter

Area of Research

Photonics

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

Shri. Shahul Hameed V

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

sahul@istrac.gov.in

Summary of the Proposed Research

The design of photonic transmitters for radar systems represents a critical frontier in radar technology, offering transformative advantages in terms of bandwidth, power efficiency, and signal integrity.

Scope of the work:

The objective of this proposal is to study and design Photonic Transmitter for Radar applications. The following are the problem statements:

- Study of different Photonic techniques for RF Signal generation.
- Study of different modulation techniques like Optical Heterodyning/photomixing, direct modulated laser technique, mode-locking technique.
- Design of basic RF generating equipment like Electro-optic Mach-Zehnder Modulator, Multiplexer, Optical Amplifier and high-speed photodiode.
- Configuration of the Basic Lineup of a Photonic Transmitter with above modules.
- Develop a low-cost, bench-top, lab based proof of concept of a Photonic transmitter.

Linkages to Space Programme:

Radar Systems.

Expected Deliverables:

- Literature Review.
- Design Document.
- Transmitter architecture and bill of materials.
- Lab based POC of Photonic transmitter.

RES-ISTRAC-2025-007

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design, simulate and create high-performance antenna arrays with fewer elements than a dense array by using optimization algorithms

Area of Research

Signal Processing

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

Ms. Chandini K C

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

chandinidevi@istrac.gov.in

Summary of the Proposed Research

Sparse array design is to minimize the number of antenna elements and the physical aperture size without sacrificing performance. Sparse array designs use optimization techniques to distribute antenna elements in a way that reduces side lobes, keeping them below a certain threshold while ensuring that the main beam remains focused.

Scope of the work:

- Sparse array design algorithms aim to maximize directivity by optimizing the antenna positions so that energy is concentrated in the desired directions. Sparse arrays, when designed properly, can minimize scan loss by optimizing element spacing and distribution across the aperture, ensuring that the array maintains a consistent radiation pattern over a wide scanning range. The spacing between antenna elements is too large relative to the wavelength, leading to false beams. The sparse array design by simulating the radiation pattern, side lobes, directivity, and other performance metrics. The number of elements with the need for low side lobes and minimal grating lobes. Sparse array designs are particularly useful in real-world applications where space, weight, and cost constraints are significant, such as in satellite communication systems or radar networks. Using optimization techniques and EM simulations ensures that these sparse arrays provide robust performance, even in challenging environments, while minimizing the impact of side lobes, scan loss, and grating lobes.

Linkages to Space Programme:

- Digital Array Radars.

Expected Deliverables:

- Literature Review.
- Algorithms Report, Flowchart.
- Array Optimisation Algorithms.
- Simulations and analysis reports.
- Constraint files.
- Software Codes.

RES-ISTRAC-2025-008

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Digital Twin–Based Robotic Cell for Ground Equipment Fabrication

Area of Research

Signal processing

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

Shri. Rishabh Agrawal

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

rishabh_ag@istrac.gov.in

Summary of the Proposed Research

The objective of this project is to develop a digital twin–integrated robotic cell capable of fabricating and repairing components used in radar systems. The system will merge robotics and digital twin technologies to create a smart, adaptive, and efficient fabrication setup.

Scope of the work:

- By building a real-time virtual replica of the manufacturing environment, the project aims to optimize tool paths, simulate thermal and structural behaviours, and enable real-time process monitoring and feedback control. The robotic cell will be designed for modularity, integrating sensors for temperature, current, and deposition rate tracking. The outcome will be a functional prototype capable of on-demand manufacturing and repair, reducing lead time, vendor dependency, and downtime of the systems.

Linkages to Space Programme:

- Radars

Expected Deliverables:

- Literature Review
- Design report

- Algorithms design, flowchart and documentation
- Simulations
- DT model architecture, robot–cell modeling

RES-ISTRAC-2025-009

Name of ISRO/DOS Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

ISAR RADAR signal processing for space objects imaging

Area of Research

Signal Processing

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

Shri. Chinni Prabhunath G

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

chinni_george@istrac.gov.in

Summary of the Proposed Research

By utilizing the relative motion of the space objects and the radar platform, ISAR exploits the Doppler shifts in the received signal to create detailed two-dimensional images of objects in space. ISAR signal processing techniques need to handle these challenges by resolving fast-moving targets and differentiating space objects from other potential sources of interference.

Scope of the work:

- In ISAR systems, the Doppler shift caused by the relative motion of the radar and the target is used to generate an aperture in the range direction. By processing the received signal over multiple radar pulses, Doppler frequency variations allow for fine resolution of space objects in the image. ISAR processing provides both range resolution (distinguishing objects based on distance) and azimuth resolution (distinguishing objects based on their relative angle). ISAR uses advanced signal processing techniques like motion compensation and Doppler filtering to enhance the resolution of the resulting radar images. ISAR imaging can be achieved by processing multiple radar returns over time, from different angles of observation. Advanced clutter rejection algorithms, such as adaptive filtering and time-frequency analysis, are used in ISAR systems to suppress noise and clutter, ensuring that the focus remains on the space objects. By combining ISAR imaging with track-before-detect algorithms, the radar system can provide near-instantaneous updates on the location, trajectory, and potential collision risks of objects in space.

Linkages to Space Programme:

- Radar.

Expected Deliverables:

- Literature Review.
- Algorithms Report, Flowchart.
- ISAR Image processing Simulations and Analysis.
- Clutter rejection.
- Software Codes.

HUMAN SPACE FLIGHT CENTRE

BENGALURU

RES-HSFC-2025-001

Name of ISRO/DOS Centre/Unit

Human Space Flight Centre, Bengaluru

Title of the research proposal

Development of a Digital Twin for Astronaut Health Monitoring and Performance Optimization during Space Missions

Area of Research

Human Physiology and Behavior modelling using Digital Twin

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

Ms. Pragya Shah

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

pragya-hsfc@isro.gov.in

Summary of the Proposed Research

This research aims to develop a digital twin (DT) model of astronauts to monitor, simulate, and optimize their physiological, psychological, and performance metrics throughout the duration of space missions. By integrating real-time data from wearable sensors, biometric measurements, and behavioral tracking tools, the digital twin will serve as a comprehensive and personalized representation of each astronaut's health and physical state in space. The goal is to predict health risks, enhance astronaut training, provide early detection of performance declines, and assist in post-mission recovery.

Scope of the work:

- The research will involve the creation of a framework to build, update, and utilize these digital twins for long-duration space missions, with a special focus on spaceflight-induced changes such as the effects of microgravity, radiation exposure, sleep disruption, and psychological stress. The digital twin will be capable of real-time feedback and predictive modelling to support mission control in managing astronaut health and performance effectively.

Linkages to Space Programme:

- Behavioural modelling of astronauts for human space programme
- Personalized performance and health prediction for long duration space flight

Expected Deliverables:

- Digital Twin Architecture: A comprehensive digital twin model that simulates astronaut physiology, psychology, and behaviour in space. This model should include a flexible and adaptable framework that can update in real time using incoming health data.
- API for Sensor Integration: A set of APIs that allow seamless integration with various wearable sensors and other data sources, ensuring that the astronaut's real-time health data can be continually updated in the digital twin model.

- Predictive Health Analytics System: A suite of predictive health analytics tools that can forecast potential health issues or performance degradation based on an astronaut's data
- Behavioral Performance Modelling: Tools to simulate and track cognitive performance during space missions, including how astronauts handle stress and fatigue, and how this affects their decision-making and task execution.
- Feedback System for Astronauts: A real-time feedback system for astronauts to receive updates about their health and performance, such as recommendations for adjusting physical activity, sleep, nutrition, or mental health support.

RES-HSFC-2025-002

Name of ISRO/DOS Centre/Unit

Human Space Flight Centre, Bengaluru

Title of the research proposal

An FBG based Wearable body joint motion monitoring System

Area of Research

Biomechanical Monitoring/Exercise Counter measures

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

Shri. K Nikhil Yadav

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

Nikhilk-hsfc@isro.gov.in

Summary of the Proposed Research

In the microgravity environment (or confined space environments) of spaceflight, maintenance of musculoskeletal health is critical, and proper exercise form (especially for lower limb joints such as the knee) is key for effective countermeasures against bone and muscle loss. Current monitoring of astronaut exercise form is limited by equipment bulk, telemetry constraints, and human supervision requirements. We propose to develop a wearable sensing system based on Fibre Bragg Grating Sensors integrated into a knee sleeve or thigh calf garment or Hand Glove, capable of measuring knee flexion/extension angle, dynamic knee motion, and joint loading posture in real time. The system will be optimized for confined space use (e.g., in a spacecraft cabin), low power, compact, and robust to electromagnetic interference (which is relevant in spacecraft). The system will provide feedback on exercise form (e.g., correct squats, lunges, leg presses, etc) and monitor knee angle trajectories and rates to ensure maximal efficiency of exercise routines and minimise injury risk.

The research will involve: design of the fibre optic sensor array (e.g., plastic optical fibre (POF) or fibre Bragg grating (FBG) sensors) embedded into wearable textile/sub garment, calibration of sensor output to knee joint angle (and possibly angular velocity), integration of small onboard electronics for signal conditioning and telemetry, algorithm development (possibly ML based) for real time correction/feedback, user trials (ground analogue astronaut exercise environment) and validation. The deliverable will be a prototype wearable system ready for space environment testing.

Scope of the work:

- Optical sensor design: embedding optical fibres in a stretchable textile, designing the layout to capture knee flexion/extension reliably (and perhaps also thigh calf relative motion) during various exercise postures relevant for astronauts (squats, lunges, leg press, resisted extensions).
- Signal conditioning hardware: miniaturised optical source(s) + photodetector(s), electronics, interface with wearable garment, low power and radiation hardened considerations for space environment.
- Calibration methodology: mapping optical signal (e.g., transmitted light loss, wavelength shift, bending curvature) to knee joint angle, using biomechanical reference (motion capture, goniometer). Testing on subjects performing relevant exercise sequences.
- Algorithm development: estimation of knee angle, angular velocity, detection of incorrect form or deviations (e.g., knee valgus, insufficient extension), possibly using machine learning models trained on sensor + reference data.
- Integration and ergonomics: the wearable garment must fit astronaut, operate comfortably in microgravity (or analog), withstand repeated use, cleaning, and interface with onboard telemetry/ logging.

Linkages to Space Programme:

- The proposed system directly supports the musculoskeletal health maintenance of astronauts by providing real time monitoring of knee joint motion during exercise on board spacecraft (e.g., aboard the Indian Space Research Organisation (ISRO) crew modules or other microgravity platforms).
- Efficient exercise form reduces wasted effort, improves muscle/bone loading and thus mission health outcomes and reduces risk of injury.
- Wearable, compact, low power sensor systems fit well into constrained spacecraft interiors and reduce reliance on ground based motion capture or bulky instrumentation.
- The fibre optic technology is beneficial in spacecraft due to its immunity to electromagnetic interference, light weight, and potential for multiplexing (multiple sensor points) which is advantageous in space instrumentation. (See recent review on wearable optical fiber sensors
- This research opens up industry academia collaboration (textile/optical sensor firms, biomechanics labs, space health research institutes) and will strengthen ISRO's capabilities in advanced crew health monitoring technologies.

Expected Deliverables:

- A fully documented design of the wearable sensor garment (knee sleeve or thigh calf band) incorporating fibre optic sensors, with textile integration drawings.
- Hardware modules: optical source + photodetector + signal conditioning electronics (compact, low power) packaged for wearable use.
- Firmware/software: real time sensor data acquisition, calibration routines, knee angle estimation algorithm, feedback logic for exercise form.
- Calibration and validation report: mapping between optical signal and joint angle, error statistics (RMSE, mean absolute error) from human subject trials.

- Prototype wearable system demonstrating knee angle monitoring during representative exercise sequences.
- User manual and integration guidelines for crew use, including considerations for microgravity/ confined space environment.
- Final technical report to ISRO including test data, performance metrics, limitations, and recommendations for future deployment in space flight or analog environments.

SATISH DAWAN SPACE CENTRE

SRIHARIKOTA

RES-SDSC-2025-001

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Experimental Study on Acoustics for a Supersonic Jet with Single and Multiple Nozzles

Area of Research

Jet Acoustics, Acoustic Suppression System

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

Shri. G Venkatesh
Shri. K Kali Prasad

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

venkatesh.grandhi@shar.gov.in
kvkprasad@shar.gov.in

Summary of the Proposed Research

Supersonic jets produce high-intensity noise due to shock waves, turbulent mixing, and complex interactions between exhaust flows and the surrounding environment. This noise presents significant challenges for aerospace applications, particularly for rocket engines. Understanding the acoustic behavior of supersonic jets is critical for developing noise mitigation strategies.

While much research has been conducted on single-nozzle jets, the acoustic characteristics of jets with multiple nozzles remain less explored. Multiple-nozzle configurations are increasingly relevant in modern propulsion systems, particularly for distributed propulsion. The interactions between the flows from multiple nozzles introduce additional complexities, such as interference patterns, enhanced mixing, and potential noise amplification or attenuation.

This research aims to generate a cold flow test set-up with various supersonic single / clustered nozzles and experimentally investigate the acoustic characteristics of supersonic jets with both single and multiple nozzles. Clustering of nozzles with multiple configurations of inter-nozzle spacing shall be experimentally evaluated to understand the effect of clustered jet collation. Parameters like effect on jet mach number, spacing of clustered nozzles, effect of transients on jet acoustics can be experimentally evaluated in the cold flow simulation study.

Scope of the work:

- To characterize the acoustic behavior of supersonic jets with single and multiple nozzles.
- To study the effects of nozzle geometry, spacing, and operating conditions on noise generation and directivity.

- To develop insights into noise amplification or attenuation mechanisms in multiple-nozzle configurations.
- To provide experimental data for the selected acoustic models.

Linkages to Space Programme:

- It will be helpful in understanding acoustics for single vs multiple nozzle for ISRO's future launch vehicles.

Expected Deliverables:

- Comprehensive acoustic and flow data for single and multiple-nozzle configurations.
- Angular noise distribution through directivity maps for various configurations and operating conditions.
- Insights into the relationship between flow structures and acoustic characteristics.
- Provide validation framework for acoustic prediction models.
- A detailed report and academic paper summarizing findings, methodologies, and recommendations for future research.

RES-SDSC-2025-002

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

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

Area of Research

Radar System, Radar Cross Section, Debris Orbit estimation, Numerical Analysis

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

Shri. A. Vaidhyanathan
Shri. Sriranganath Annam
Shri. Praneeth Varma

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

vaidhynathan.a@shar.gov.in
sriranganath_a@shar.gov.in
praneeth.varma@shar.gov.in

Summary of the Proposed Research

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 rangeof 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.

Scope of the work:

- To study on the Dynamic characteristics and RCS estimation of Space debris from MOTR tracked data.

Linkages to Space Programme:

- The deliverables from this project may be helpful in RCS Estimation and dynamics Characterisation of Space Debris from MOTR tracked data.

Expected Deliverables:

- 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.

RES-SDSC-2025-003

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Developing a Jet Noise Source Localization Technique using a Microphone Array with Appropriate Beam Forming Algorithms

Area of Research

Supersonic jet acoustics

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

Shri. G Venkatesh
Shri. V Venkata Ramakrishna
Shri. K Kali Prasad

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

venkatesh.grandhi@shar.gov.in
vvrk@shar.gov.in
kvkprasad@shar.gov.in

Summary of the Proposed Research

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.

Scope of the work:

- To formulate a software tool for supersonic jet noise source localization for free jet, impinging jet, near and far field acoustics.
- Validation of the source localization tool using standard/ appropriate test case at a sub-scale level and scaling up to the actual case.
- Realization of required hardware viz. microphone array, processing hardware, camera, etc.

Linkages to Space Programme:

- Identifying the supersonic jet noise sources will help in better configuration of launch pad geometry viz. Jet Deflector duct & water injection scheme to reduce the lift-off noise.

Expected Deliverables:

- Development of supersonic jet noise source localization tool applicable to free and impinging jets.

RES-SDSC-2025-004

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Analyze aerosol optical properties at East Coast of India

Area of Research

Machine Learning, Meteorology,Atmospheric science

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

Shri. Pinaki Ranjan Sarkar
Shri. Diptangshu Sekhar Raj

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

pinaki.rs@shar.gov.in

Summary of the Proposed Research

The proposed research explores the use of machine learning to analyze and integrate data from Aethalometer, Nephelometer, and Robotic Sun Photometer to advance our understanding of atmospheric aerosols and their effects on air quality, climate, and radiative forcing. Each instrument available at East Coast of India provides unique insights into aerosol characteristics: Aethalometers measure black carbon concentrations, Nephelometers assess light scattering properties, and Sun Photometers track aerosol optical depth in Solar & Lunar condition. By combining these datasets, machine learning models can uncover complex patterns in aerosol composition, behavior, and dispersion under varying environmental conditions. Analysis of aerosol optical properties, like absorption and scattering, and assess their climatic impact. Machine learning models, particularly deep learning, will be applied to integrate this

high-resolution ground-based data with satellite observations, improving aerosol transport models and aiding the calibration of remote-sensing.

Scope of the work:

- Analyze aerosol optical properties, like absorption and scattering, and classification of the aerosols & asses their radiative effects on Climate.
- Generate Synthetic data for Aerosol distribution using realistic Black Carbons and explore the use of Physics Informed Neural Network like methods for solving the aerosol distribution models covering realistic geographical area.

Linkages to Space Programme:

- Insights gained will benefit satellite-based air quality monitoring, disaster management, and climate prediction.

Expected Deliverables:

- Detailed analyses of aerosols' role in radiative forcing and their climate impacts.
- Estimation of seasonal variation on optical properties of aerosols. Correlation analysis with radiation data variation, heat and other data which may be found relevant.

RES-SDSC-2025-005

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Numerical simulation of propellant slurry casting

Area of Research

Simulation of non-Newtonian slurry flow

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

Shri. Srinivas Yara
Shri. Chandra Prakash Kotwal

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

srinivas.yara@shar.gov.in
chandraprakash.kotwal@shar.gov.in

Summary of the Proposed Research

Solid motors are being used of boosters for launch vehicles. Solid motor processing involves raw material preparation, mixing, casting, curing and finishing operations. After propellant mixing, propellant slurry will be cast into the rocket case by maintaining vacuum and slurry feed rate. Slurry flows from the mixer bowl/hopper to rocket case through the feedline and falls into the rocket case. Propellant slurry is consisting of 68% oxidiser, 18% fuel, 10% binder and 0.8% curator. Slurry viscosity increases from 600 Pa-s (end of mix) to 1600 Pa-s in 4 hours on account of curing reaction. This propellant slurry is considered as non-Newtonian fluid.

For processing the large rocket case, casting is being carried out with vertical feed line and for small rocket cases, multi feed (inclined feedline) is being used. Any bubble formed/present during propellant casting, rises through propellant slurry with varying viscosity regions.

Now, it is proposed to carryout numerical simulation of propellant casting using ANSYS Fluent and bubble rise phenomenon in slurry.

Scope of the work:

- Develop a methodology for steady state numerical analysis of propellant slurry casting for a given vertical feedline and multi feed.
- Unsteady bubbles rise phenomenon in propellant slurry with varying viscosity regions.

Linkages to Space Programme:

- Solid propellant slurry casting is related to processing of S200, HS200, S139 and SS1 segments and HPS3 motors for LVM3, GSPV and PSLV.
- This simulation will provide the insight of propellant casting and flow distribution during casting.

Expected Deliverables:

- Finalise parameters like mesh size, time step, residuals, algorithm selected, boundary conditions parameters for numerical simulation.
- Submission of ANSYS Fluent files in DVD format.
- A presentation of methodology evolved for numerical simulation and results at SMPC, SDSC SHAR.

RES-SDSC-2025-006

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Comparative Analysis of Thermal, Spectroscopic, and Morphological Properties of Ceramic Thermal Protection Systems Pre and Post Rocket Launch

Area of Research

Material Science; Thermal Protection Systems; Rocket Launch; Thermal Analysis; Ceramic TPS Materials

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

Shri. Veerabhadram G.
Shri. S.S Chaitanya

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

veera557@shar.gov.in
sschaitanya@shar.gov.in

Summary of the Proposed Research

This research aims to present a comprehensive comparative investigation between ceramic-based

(thermal cement) thermal protection systems (TPS) applied over structural steel or RCC substrates, which are widely used in launch pad and vehicle support structures. The study focuses on evaluating the thermal, spectroscopic and morphological characteristics of these materials both before and after exposure to extreme thermal and pressure conditions simulating rocket launch environments. Experimental investigation will be done availing thermogravimetric and differential thermal analysis, Differential scanning calorimetry, Fourier-transform infrared spectroscopy, Raman spectroscopy, XRD, Field-emission scanning electron microscopy, Energy dispersive X-ray spectroscopy and atomic force microscopy testing to assess compositional stability, surface degradation, and mechanical integrity.

In parallel, AI-ML techniques are to be integrated to understand and correlate the degradation phenomenon to understand and predict the coupled thermo-mechanical response of the TPS under high-temperature and pressure gradients. The integration of experimental and machine learning data will enable a detailed understanding of the degradation mechanisms, delamination behaviour, and overall thermal shielding efficiency of each coating system. Comparative assessment will help identify material-specific advantages, such as heat resistance, structural resilience under cyclic loading. The outcome of this integrated experimental-mathematical framework will provide critical insights for selecting and optimizing protective coatings for reusable and long-duration launch infrastructure, ensuring enhanced safety, durability, and performance of steel-based support structures in aerospace and space applications.

Scope of the work:

- The scope of this research encompasses a comprehensive evaluation of ceramic-based thermal protection systems (TPS) applied on structural steel or RCC substrates, which form the primary material base for rocket launch pad and vehicle support systems. The study extends beyond conventional thermal characterization to include detailed spectroscopic, morphological, and thermal analyses under simulated rocket-launch thermal fluxes and high-pressure combustion conditions. Experimental methods will be coupled with machine learning and artificial intelligence tools to model degradation mechanisms, predict thermal shielding performance, and correlate microstructural changes with thermo-mechanical response. This hybrid framework aims to generate predictive insights into material endurance, delamination thresholds, and coating efficiency across multiple heat cycles. Outcomes from this investigation will provide quantifiable metrics for coating optimization, durability improvement, and reusability assessment, directly contributing to indigenous material qualification protocols for launch infrastructure and high-temperature aerospace systems.

Linkages to Space Programme:

- This research directly aligns with ISRO's Vision 2047, which emphasizes technological self-reliance, sustainable infrastructure, and collaborative innovation in the Indian space ecosystem. The proposed study supports SHAR-SDSC, ISRO's objectives of enhancing launch pad durability, reusability of ground systems, and thermal resilience of critical components for next-generation missions such as Gaganyaan, Chandrayaan-4 (LUPEX-Lunar Polar Exploration), and the Bharatiya Antariksha Station. By developing AI-integrated, experimentally validated models for predicting TPS degradation under extreme launch conditions. The outcomes are expected to feed into ISRO's material qualification frameworks, promoting synergistic advances in thermal management, predictive maintenance, and structural integrity across reusable space infrastructure platforms.

Expected Deliverables:

- **Comprehensive Thermal Protection Dataset:** A complete database of pre- and post-launch thermal, spectroscopic, morphological, and mechanical characteristics of ceramic-based TPS coatings over steel or RCC substrates benchmarked under simulated launch pad conditions.
- **Validated Experimental Protocols:** Standardized experimental methodologies (TGA-DTA, FTIR, Raman, FESEM-EDS etc.,) for evaluating TPS integrity and degradation under transient thermal shocks representative of rocket exhaust exposure. (*Carrying out minimum of ten tests, to ensure accuracy and repeatability)
- **AI/ML-Integrated Predictive Framework:** Development of machine-learning models for prediction and correlation of degradation, delamination, and thermo-mechanical stress behaviour in TPS-steel assemblies. The trained models will enable real-time prediction of coating failure thresholds and thermal endurance.
- **Comparative Performance Report:** A detailed analytical report comparing ceramic TPS materials in terms of heat resistance, microstructural stability, and reusability, providing quantitative/qualitative metrics for material qualification and launch pad maintenance frameworks.
- **Technical Documentation and Knowledge Transfer:** Delivery of a final consolidated report on "TPS Degradation w.r.to launch environment" (including data tables, figures, results, and AI-based predictive codes) to SDSC SHAR.

RES-SDSC-2025-007

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Development of process unit for homogeneous gas phase oxidation of NO to NO_2 in industrial scale for production of Di Nitrogen Tetra Oxide (N_2O_4)

Area of Research

Propulsion (Production of earth storable oxidizer)

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

Shri. Sanjay Gulabchand Jain

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

sanjay.jain@shar.gov.in

Summary of the Proposed Research

In the existing production process of N2O4, NO radical is obtained through NH3 - Air oxidation process. Subsequent to this the NO radical undergoes homogeneous gas phase oxidation in presence of secondary air at ~ 1.69bar pressure in a process unit termed as oxidation tower. This process unit plays vital role for conversion of NO to NO_2.

- To design this oxidation tower through understanding of chemical kinetics, thermodynamic data of homogenous gas phase oxidation of NO to NO2 is highly essential. Towards this development of laboratory model of this process unit is envisaged.
- To scale up to pilot plant level.

Scope of the work:

The scope of this proposal is to design a suitable process unit to facilitate the homogenous gas phase oxidation of NO to NO2.Upscaling followed by induction of the proposed process unit from lab scale to the pilot level at the existing plant at Propellant Complex Rasayani, Mumbai.

Major Specifications of existing industrial level unit:

- Flow Rate of gas stream (NOx) to the unit :7200 kg/hr
- Flow Rate of Air to the unit: 1965 kg/hr
- Temperature at Inlet gas stream: 40-48 °C
- Temperature at Outlet gas stream: 30-36 °C
- Inlet flow rate of coolant (cooling water): 200m3/hr

Linkages to Space Programme:

- The Propellant Complex Rasayani plant is the only source in India to supply the required quantities of earth storable oxidizer to ISRO operational launch vehicles (PSLV, GSLV, LVM3). The existing plant is almost 40 years old and needs replacement of the Oxidation process unit.

Expected Deliverables:

- Chemical kinetics and thermodynamic data of homogeneous gas phase oxidation of NO to NO_2.
- Laboratory model of the process unit capable of accomplishing the above said reaction.
- Upscaling of lab scale model to the pilot level at our existing plant at Propellant Complex Rasayani, Mumbai.
- Design inputs for developing industrial scale Oxidation process unit.

RES-SDSC-2025-008

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Development of a Stewart-Gough Platform for Six-Component Load Measurements

Area of Research

Propulsion Testing, Sensors, Data Processing

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

Shri. K Kali Prasad
Shri. G. L. Rao
Shri. R Ashok Kumar

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

kvkprasad@shar.gov.in
glrao@shar.gov.in
ashokkumar.r@shar.gov.in

Summary of the Proposed Research

The accurate measurement of multi-component loads is essential in many engineering fields, including aerospace, robotics, automotive testing, and structural health monitoring. Traditional load cells are often limited to measuring forces and moments along one or two axes, which constrains their applicability in advanced systems requiring six-degree-of-freedom (6-DOF) load data. The Stewart-Gough platform, a parallel mechanism featuring six actuators connecting a base to a moving platform, presents a promising solution for such complex measurement needs. Its compact design, stiffness, and precision make it an ideal candidate for capturing forces and moments in six axes simultaneously.

However, significant challenges remain in its practical implementation, including precise calibration, minimizing cross-sensitivity, and adapting the platform to diverse testing environments. This research aims to overcome these challenges by designing, fabricating, calibrating, and validating a Stewart-Gough platform optimized for six-component load measurements. The study will not only enhance the theoretical understanding of parallel mechanisms but also provide a robust tool for real-world engineering applications.

Scope of the work:

This research has four main objectives.

- Design a Stewart-Gough platform specifically for six-component load measurement applications is to be carried out.
- Calibration methodology to ensure accuracy and minimize cross-sensitivity between components.
- Fabricate a sub-scale experimental rig to validate the design and calibration methods.
- Demonstration of the platform's performance through experiments, showcasing its ability to measure multi-component loads effectively.

Linkages to Space Programme:

- Six component Thrust measurement system for solid/hybrid rocket motors for performance evaluation.

Expected Deliverables:

- The research will produce several key deliverables, including detailed design documentation with CAD models, technical drawings, and FEA results. A functional sub-scale experimental rig will be fabricated and tested, accompanied by calibration software capable of accurately processing sensor data. The project will also deliver experimental results demonstrating the platform's performance in real-world load measurement scenario. Finally, a comprehensive report will detail the methodology, outcomes, and further potential applications of the platform.

RES-SDSC-2025-009

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

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

Area of Research

Radar System, Tracking Filters, Target Association Algorithm. Optimal Tracking filter

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

Shri. A. Vaidhyanathan
Shri. Sriranganath Annam
Shri. Praneeth Varma

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

vaidhynathan.a@shar.gov.in
sriranganath_a@shar.gov.in
praneeth.varma@shar.gov.in

Summary of the Proposed Research

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

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 aremostly used in offline analysis.

Scope of the work:

- To study various optimal tracking filter with various data association like PDA, JPDA and MHT in real time application of MOTR for tracking multiple targets in different tracking scenarios.

Linkages to Space Programme:

- This proposal has linkages to the Near real time application of MOTR for tracking multiple targets.

Expected Deliverables:

- 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.

RES-SDSC-2025-010

Name of ISRO/DOS Centre/Unit

Satish Dawan Space Centre, Sriharikota

Title of the research proposal

Machine learning model development to analyze historical and real-time sensor data to predict component wear, forecast failures, and schedule preventive maintenance for Launch pad system

Area of Research

Structural Engineering coupled with Machine learning

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

Shri. Jitendra Kumar Kumawat
Shri. Parth Gaikwad
Shri. Balamurugan K

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

jitendra_kumawat@shar.gov.in
parthgaikwad@shar.gov.in
bkannan3@shar.gov.in

Summary of the Proposed Research

Umbilical tower at Second launch pad is currently being used for launch of various launch vehicles LVM3, GSLV and PSLV. The launch pad consists of many mechanical systems which comprise of various structural elements, mechanical system and hydraulic systems and are subjected to launch induced environment & saline environment of sea. These structures are undergoing maintenance before every launch and evaluated periodically. The structures also face different failures and wear & tear. Towards this, it is planned to develop a machine learning model in python by using the historic & real time sensors data for predictive maintenance and diagnostics. With development of such model, downtime for the maintenance of these structures can be reduced and the unexpected launch delays can be avoided in case of failure of the system. The research proposal will include development of the model, training the model with real time and historic data of previous launches and subsequently, using the model for predicting the maintenance of the system.

Scope of the work:

- The development of this type of model can be stretched to any other systems maintenance of which can be subjected to the prediction of the model. The regular maintenance before every launch can be avoided. Also, the breakdown maintenance can be predicted in advance using the system. In current second launch pad, the model can be effectively utilized for all mechanical systems i.e. Cryo arms, SCVRPs, Tower Crane etc. and same can be extended to Third launch pad (TLP). This also can be a step in the designing of smart launch pads based on the AI.

Linkages to Space Programme:

- It will be helpful to predict component wear, forecast failures, and schedule preventive maintenance for Launch pad system.

Expected Deliverables:

- Development of Machine learning model: ~ 12 months.
- Training of the model and implementation ~ 6 months.
- Total duration ~ 18 months.

ISRO HEADQUARTERS
BENGALURU

RES-ISRO HQ-2025-001

Name of ISRO/DOS Centre/Unit
ISRO Headquarters, Bengaluru

Title of the research proposal
Potential Economic Impact Assessment for Indian Human Space Programme

Area of Research
Human Space Exploration, Econometrics and Management sciences

Name of Co-PI (Focal Point) from ISRO Centre/Unit
Shri. Abhishek Jha
Shri. Nishant Kumar

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

Summary of the Proposed Research
Indian Human Space programme (HSP) is a national programme with the participation of various industries, national R&D laboratories, academia and start-ups. Indian HSP programme aims to catalyse science and technology innovation through wider partnership between ISRO, Industry & Academia resulting in development of the essential technology & infrastructure elements to enable assured Indian access to Low Earth Orbit (LEO) and beyond for advancing national scientific and technological capabilities.

These efforts are leading to a gamut of upstream and downstream economic activity in the country. Further, access to LEO and beyond will also lead to utilisation of microgravity / space environment for economic activities such as in-space manufacturing and advanced technology demonstrations as well as promote activities such as space tourism. The proposed research aims to carry out potential Economic Impact Assessment for the Indian Human Space Programme including direct/ indirect employment generation.

Scope of the work:
- The study will explore the various contributing factors for the assessment of potential economic impact of Indian human space programme as well as the employment generation predictions, considering end to end economic activities associated with human space programme in short and long run (Operational Indian Space Station; Indian Human Exploration Missions to Moon & Beyond).

Linkages to Space Programme:
- The proposed study is highly relevant for Indian Human Space Programme. It will help in carrying out overall economic impact assessment of Human Space Programme and will be vital inputs for decision/policy makers for assessing programme performance.

Expected Deliverables:

- Predictions of potential economic impact of Indian Human Space Program considering associated wide spectrum of upstream and downstream economic activities and factoring multiplier effects.
- Model for employment generation potential predication of Human Space Programme.
- Assessment of yearly employment generation potential of human space programmes till 2040.

Annexure-1
Declaration Form

Terms and Conditions of ISRO Research Grants

1. The approved funds should be utilized solely for the purpose for which they have been granted unless ISRO agrees otherwise. A Certification that the funds have been so used should be produced by the grantee Institution after the end of each year of the support.
2. Due acknowledgement to ISRO should be made in all reports and publications arising out of the part of the work supported by ISRO. The grantee will take prior permission of ISRO before publishing any work based on the ISRO supported project.
3. Two copies of all the publications resulting from the research conducted with the aid of the grant should be submitted to ISRO.
4. Any intellectual property rights or such information/knowledge being able to sustain or create or any such right arising out of the projects sponsored by ISRO will be held jointly by the Academic Institution/R & D institution and ISRO as per RESPOND norms. Academic Institute/R & D institution and ISRO shall inform each other before filing for any protection of any Intellectual Property Rights resulting from any of the project sponsored by ISRO. Academic institute/ R & D institution and ISRO will ensure appropriate protection of Intellectual Property Rights generated from cooperation, consistent with laws, rules and regulations of India. The expenses for filling the Patent protection in India and abroad shall be borne equally between Institute and ISRO. Any/all financial accruals due to any commercial exploitation, of this patent shall be shared equally between them, on 50:50 basis. However any of the parties is free to utilize the IPR for their own use on non commercial basis.
5. The principal Investigator is required to submit two copies of yearly reports indicating the progress of the work accomplished. He is also required to submit two copies of a detailed technical report on the results of the research/development after the completion of the project. The reports will become the property of ISRO.
6. In addition, ISRO may designate Scientists/specialists to visit the Institution periodically for reviewing the progress of the work.
7. An inventory of items purchased from ISRO funds should be sent to ISRO, giving the description of equipment, cost in rupees, date of purchase and name of the supplier along with a purchase certificate from the Administration of the Institution. All items of equipments and unconsumable items costing more than Rs. 5,000/- shall remain the property of ISRO and ISRO reserves the right to transfer them or dispose of them on the termination of the project as ISRO may deem fit.
8. The accounts of the expenses incurred out of ISRO funds should be properly maintained and should be authenticated by an approved auditor. The final accounts statement in duplicate duly audit should be sent to the pay & Accounts Officer, DOS/Senior Accounts Officer, ISRO Headquarters, as the case may be, at the end of each financial year of support.

9. If the total amount sanctioned is not spent during the period of support, the remainder amount should be surrendered to the Pay & Accounts Officer, ISRO Headquarters, as the case may be, within one month after the completion of the project.
10. The assets acquired wholly or substantially out of the ISRO grant should not, without its prior sanction, be disposed off, encumbered or utilized for purposes other than that for which the grant is sanctioned.
11. A register of assets permanent and semi-permanent should be maintained by the grantee Institution, which should be available for scrutiny by Audit.
12. The grantee institution should not divert the grants-in-aid for utilization of the same for similar objects of another institution if it is not in a position to execute or complete the assignment. The entire amount of the grant should then be immediately refunded to ISRO by the institution.
13. The terms and condition of ISRO research grants are subject to change from time to time, but the funding of any project will be governed by the terms and conditions existing on the date of starting of the project with ISRO funds.

Declaration

I / We have clearly read the above terms and conditions and hereby agree to abide by the rules and regulations of ISRO research grants and accept to be governed by all the terms and conditions laid down for this purpose.

I / We certify that I / We have not received any grant-in-aid for the same purpose from any other Department of the Central Government / State Government / Public Sector Enterprise during the period to which the grant relates.

	Signature & Name	**Designation**
Principal Investigator		
Head of the Department / Area		
Head of the Institution (Seal of the Institution is required)		

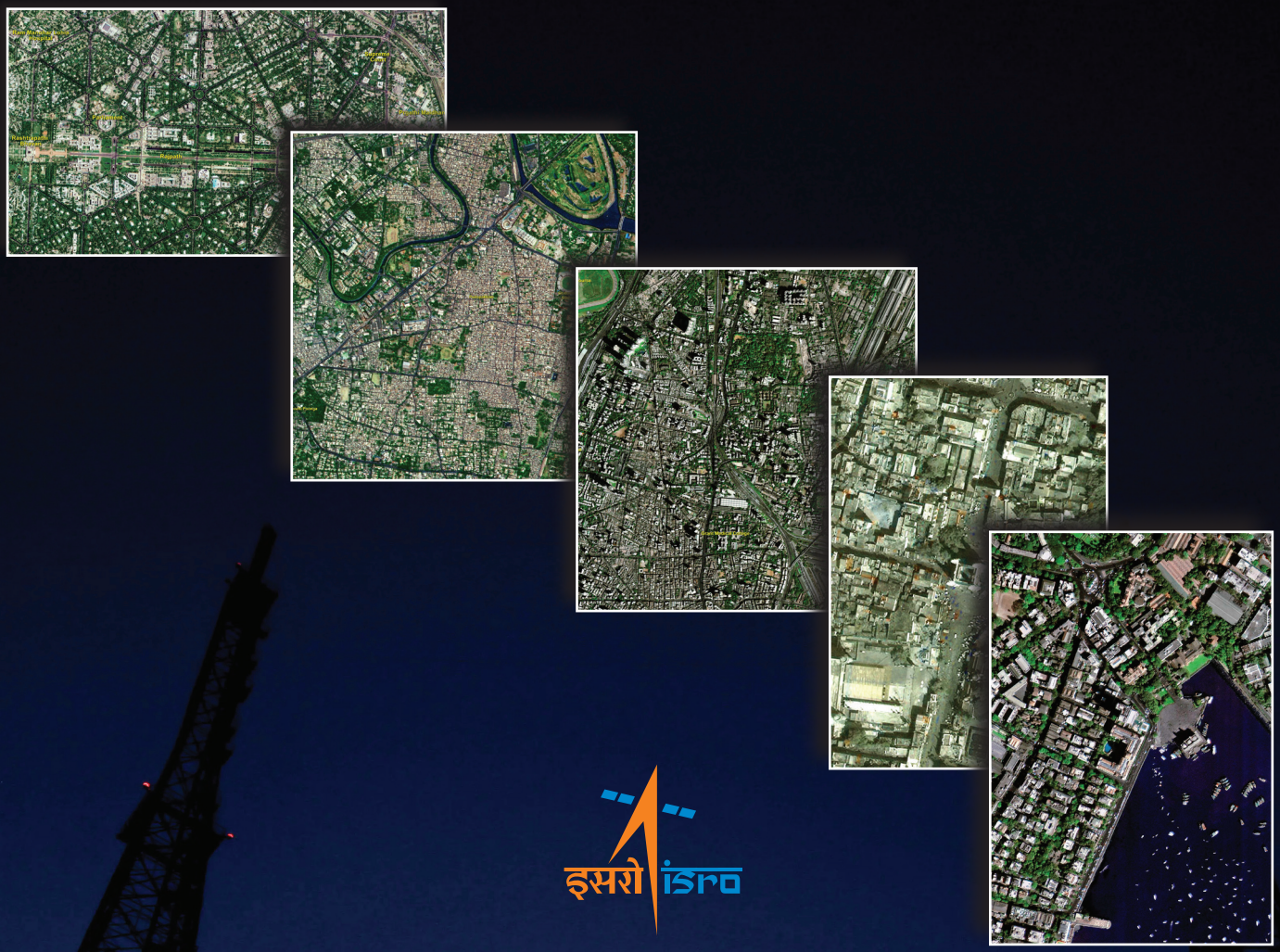
Annexure-2

RESPOND COORDINATORS OF ISRO/DOS CENTRES

Sl. No	ISRO/ DOS Centre	Name & Designation	Contact details
1	VSSC	Shri. Santhosh Kumar S Deputy Head, ASRD Programme Planning & Evaluation Group Vikram Sarabhai Space Centre (VSSC) ISRO PO Thiruvananthapuram-695 022, Kerala	Tel Phone No: 0471-2564620 Email: s_santhoshkumar@vssc.gov.in
2	SAC	Dr. Abha Chhabra Head, RESPOND and Research Management Division Research, Outreach and Training Management Group Management and Information Systems Area Space Applications Centre (SAC), ISRO Ahmedabad-380 015, Gujarat	Tel Phone No: 07926913306/3334 Email: research_sac@sac.isro.gov.in
3	URSC	Smt. V. Chinna Ponnu Group Director, ATDG U R Rao Satellite Centre HAL Airport Road Vimanapura PO Bengaluru-560 017, Karnataka	Tel Phone No: 080-25084480/81 080-25084391 Email: chinna@ursc.gov.in
4	NRSC	Dr. P Satyanarayana Head, PMD, PPEG/MSA National Remote Sensing Centre NRSC, Balanagar Hyderabad-500 037	Tel Phone No:040-23884017 040-23884012 Email: satyanarayana_p@nrsc.gov.in
5	LPSC	Shri. Sandeep Kumar Scientist/Engineer-SF PPEG, MSA Entity Liquid Propulsion Systems Centre (LPSC-V), Valiamala Thiruvananthapuram-695 547, Kerala	Tel Phone No:0471-2568277 Email: sandeepkumar@lpsc.gov.in respond@lpsc.gov.in
6	IPRC	Smt. A Cross Sapna Scientist/Engineer-SG DDH,PPED IPRC Mahendragiri-627 133, Tamil Nadu	Tel Phone No: 04637-281843 Email: cross.sapna@iprc.gov.in

7	PRL	Dr. Nandita Srivastava Professor and Deputy Head (Admin), Udaipur Solar Observatory Physical Research Laboratory (PRL) Badi Road, Dewali Udaipur-313001, Rajasthan	Tel Phone No: 0294-2457211 (office) Email: nandita@prl.res.in respond@prl.res.in
8	SDSC-SHAR	Shri. P.V.V.S. RAMA RAO Head MSA Satish Dhawan Space Centre SHAR - ISRO Sriharikota-524124 -Andhra Pradesh	Tel Phone No: 08623226104 Email: ramarao.pvvs@shar.gov.in
9	IISU	Shri. K S Nandhakumar Scientist/Engineer Head-PPEG, PPED ISRO Inertial Systems Unit (IISU) Vattiyoorkavu PO Thiruvananthapuram-695 013, Kerala	Tel Phone No: 0471 2569340 Email: ks_nandhakumar@vssc.gov.in
10	IIRS	Dr. Ashutosh Bhardwaj Scientist/Engineer Head, RPMD Programme Planning and Evaluation Group (PPEG) Indian Institute of Remote Sensing (IIRS), Indian Space Research Organization (ISRO) 4 Kalidas Road, Dehradun-248001 West Bengal	Tel Phone No: 0135-2524350, 4351 (Off.) Email: respond@iirs.gov.in ashutosh@iirs.gov.in
11	NARL	Dr. S. Sridharan Scientist/Engineer National Atmospheric Research Laboratory (NARL) Gadanki-517 112, Pakala Mandal Chittoor, Andhra Pradesh	Tel Phone No: +91-8585-272124 Email: susridharan@narl.gov.in
12	NESAC	Dr. K K Sharma RESPOND Committee Chairman Scientist/Engineer North Eastern Space Applications Centre (NESAC) ISRO, Umiam Meghalaya-793 103	Tel Phone No: 0364 2570138 Email: kk.sarma@nesac.gov.in sarmakk@gmail.com
13	ISTRAC	Shri. Pradeep Kumar C Scientist/Engineer Group Head, Signal Processing & Software Development Group Radar Development Area, ISTRAC/ISRO Plot No 12 & 13, 3rd Main, Phase II Peenya Industrial Area Bangalore-560058, Karnataka	Tel Phone No :+91-80-28094489 Email: pradeepkc@istrac.gov.in

14	MCF	Shri. S.N. Jagannath Scientist/Engineer Master Control Facility Hassan-573201, Karnataka	Tel Phone No: 08172-273112 Email: jagannath@mcf.gov.in
15	HSFC	Shri. Ravinthar S Sci/Engr-SG Group Head Programme Planning and Evaluation Group Management systems Area, Human Space Flight Centre (HSFC), ISRO HQ Bengaluru-560094, Karnataka Mr. Kathan Suthar Sci/Engr-SC Programme Planning and Evaluation Group Management systems Area, Human Space Flight Centre (HSFC), ISRO HQ, Bengaluru-560094, Karnataka	Tel Phone No: 080-2217 2620 Email: ravinthar-hsfc@isro.gov.in Tel Phone No: 080-2217 5604 Email: kathansuthar-hsfc@isro.gov.in
16	LEOS	Shri. Raja V L N Sridhar Scientist/Engineer Laboratory for Electro-Optics Systems (LEOS) Bengaluru, Karnataka	Tel Phone No: 080-22685166 Email: rvlnsridhar@leos.gov.in



RESPOND & Academic Interface

Capacity Building and Public Outreach
Indian Space Research Organisation
Bengaluru