RESPOND BASKET 2022

RESPOND & AI

Capacity Building Programme Office
ISRO HQ, Bengaluru

START

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Message

Indian Academia has an impressive role in supporting R&D activities of ISRO since inception of Indian space programme. Prof. Satish Dhawan having recognized the need of a robust interface with academia to carry out R & D projects relevance to ISRO, established the **Sponsored Research Programme** ("RESPOND"), in early 1970s'. Over the past five decades, RESPOND has supported more than 100 premier academic institutions across the country and contributed to executing more than 500 projects.

Academia possess a rich knowledge on current developments in the areas of science and technology, which can be leveraged to ISRO programmes. At present, ISRO is pursuing research in new areas of advanced space sciences, technologies and human space flight enabling projects. There was an overwhelming response from the academia and R&D institutions for joint research collaboration in these areas. To take it further, RESPOND Basket comprising of about 200 nos. of focused research topics, catering to the immediate R&D challenges of ISRO. This facilitates academia to enter into R&D projects with ISRO.

Capacity Building Programme Office (CBPO), ISRO Headquarters, Bengaluru has taken efforts to consolidate the R&D proposals from all ISRO centres for the year 2022 to put it into this "RESPOND Basket". It gives me immense pleasure to release this document for utilization by academia. I wish that the academic community will make use of this opportunity to contribute to the space research in the domains of Space Science, Space Technology and Space Applications for National Development and for Societal Benefits.

Date: March 08, 2022

(Somanath. S)

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N Sudheer Kumar
Director, CBPO

PREFACE

Indian Space Programme had a humble beginning from Physical Research Laboratory (PRL), Ahmedabad in early 60s' and grown to a full-fledged organization in the year 1969. All these decades, the space programmes were coined based on the societal needs. Many development programmes were driven by indigenous efforts and they were sustained, out of continuous research in various fields of space science and technology. Indian Academia joined hands in developing various space technologies throughout this journey and it has been a continuous endeavor to jointly collaborate on ISRO projects, to tap the research potential available with academia.

Subsequent to introduction of new space sector reforms, ISRO is venturing into many new technologically challenging missions. ISRO is looking for greater participation and contributions from academia in a focused manner. In order to enable the faculty of the academic Institutions and R&D laboratories across the country, to submit research proposal in line with ISRO's Programmatic requirements, "**RESPOND Basket**" is released every year during "Academia Day". Considering the overwhelming response received from academia during the previous years, "RESPOND Basket-2022" is generated with up to date research topics. The document comprises of around 200 most urgent and important research problems of ISRO as identified by ISRO/DOS centers. A brief write-up on each research topic and expected deliverables etc. are also provided in the document, to enable the faculty for generating proposals.

I enthusiastically invite academia to come forward and submit the proposals under RESPOND Basket -2022 and contribute to the ongoing research and development activities of ISRO.

(N Sudheer Kumar)

GENERAL INSTRUCTIONS

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

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

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

4. The age limit for the Principal Investigator is below 65 years (sixty-five) including the project period. Proposals from individuals not affiliated to any recognized institution/R & D institutions will not be considered.

5. "Declaration Form" shall be submitted in the prescribed format only. 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/capacity-building/sponsored-research).

7. The last date for submitting the proposals online under "RESPOND BASKET-2022' is **May 15, 2022.**

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.

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Research Topics from ISRO/DOS Centre — Page No.s

VIKRAM SARABHAI SPACE CENTRE
THIRUVANANTHAPURAM

RES-VSSC-2022-001

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

Title of the research proposal
Data assimilation for fluid dynamics using experimental and computational data.

Name of Co PI from ISRO Centre/Unit
Shri. Padmanabha Prasanna Simha

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Area of Research
Experimental fluid mechanics

Summary of the proposed research and expected deliverables
Configuration of a liquid jet injected into a subsonic or supersonic cross-flow of gas is well known as Jet-In-Cross-Flow (JICF) which is having the wide range of application from high-speed air breathing engines to cooling of exhaust plume generated during ground testing of rockets. Traditional JICF configuration for the application to air breathing engines is a very well-researched subject area. However, the behavior of a liquid jet injected into a free supersonic gas jet has been studied to a much smaller extent. A free supersonic gas jet refers to the unbounded, finite-area jet, where the gas flow is at supersonic speed and exhibits a shock train structure consisting of Mach diamonds. Free supersonic gas jets are commonly observed at the exit of exhaust nozzles used in rocket propulsion. During testing of a high thrust rocket engines, it is extremely important to accurately quantify and mitigate the thermal and acoustic loads on test stand infrastructure generated by engine firing. Liquid jet injected into a free-supersonic gas jet needs a thorough understanding on liquid penetration depth, break-up & surface density of water particles. This preliminary study using the small-scale experiments with GN2/Air as the gas jet will deliver the meaningful analytical co-relation on liquid jet in cross-flow. Available hot test data shall be used for the scale-down of the experiments and validation.

Scope of the Work:

- Scale-down configuration of liquid jet in a free-supersonic gas based on the inputs provided by IPRC.
- Identification of Non-intrusive diagnostic tools used to examine the behavior of the internal shockwave structure in the over-expanded gas jet with and without liquid injection.
- Mapping of primary break-up mechanism of a liquid jet using diffused backlit imaging with pulsed laser.
- Geometric & kinetic parametric study of liquid jet in a free supersonic gas.

Deliverables:

- Scale down methodology for Jet-In-Cross-Flow.
- Experimental results using non-intrusive diagnostic tools for studying the primary breakup.
- Surface density of water particles upon interaction with gas jet for the scale-down experiments.
- Mapping of penetration depth with reference to non-dimensional numbers.
- Analytical correlation using geometric & kinetic parameter of liquid and gas jet.
- Realized scale-down water and gas nozzle.

RES-VSSC-2022-002

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

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

Name of Co PI from ISRO Centre/Unit

Shri. M Prasath,
Shri. Padmanabha Prasanna Simha

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Area of Research

Experimental

Summary of the proposed research and expected deliverables

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

Scope of the Work:

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

Deliverables:

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

RES-VSSC-2022-003

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

Title of the research proposal
Medium Independent Scramjet Design and its characteristics.

Name of Co PI from ISRO Centre/Unit
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Area of Research
Experimental Fluid Mechanics

Summary of the proposed research and expected deliverables
For achieving supersonic or hypersonic speeds, ramjet and scramjet engines are used. In all the purposes, they use atmospheric air for combustion. However, due to small resident time of the air in the combustor (of the order of 1ms), mixing of fuel and air, flame holding and sustained combustion are the challenging tasks. Hence, to make the air breathing propulsion more effective, an engine called Medium Independent Jet Engine or MI-Jet is proposed. Unlike the conventional air breathing system, a separate pre-burner is used where premixed combustion takes place with the help of stored fuel and oxidizer. This high enthalpy combustion product is then allowed to mix with the primary air (through energy transfer) that subsequently expands through the nozzle for generating high thrust and high ISP.

Scope of the Work:

- The scope is to design the MI jet engine including intake, isolator, pre-burner, mixer and the nozzle. The intake characteristics and the mixing performance between the primary as well as the high enthalpy secondary jets need to be quantified. Also, the thrust and ISP generated by the nozzle to be studied. The entire flow physics from head to tail to be visualized suitable techniques.

Deliverables:

- Design details, complete data.

RES-VSSC-2022-004

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

Title of the research proposal
Insensitive high nitrogen binders for energetic applications

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Area of Research

Energetic Binders

Summary of the proposed research and expected deliverables

Binder systems are used in propellants for matrix generation, in pyrotechnics for granulation and pelleting as well as in explosives for polymer bonded explosive formulations. Conventional binders have drawbacks such as use of toxic & moisture sensitive isocyanates as curators coupled with their sensitivity and poor thermo-vacuum stability. High nitrogen-based binders can be an environmentally benign replacement for the existing systems owing to their good thermal stability, curing possibility with polyamines and they are stable. Moreover, these binders being energetic will add to the gross heat output and enhance the gas yield. Hence, research towards the development of novel high nitrogen binders needs be actively pursued.

Scope of the Work:

- Development of new insensitive (to mechanical) and ESD safe high nitrogen binder system.

Deliverables:

- Literature survey on high nitrogen energetic binder systems (E.g. Tetrazole/Tertrazine based systems).
- Selection of the potential candidates based on criterion such as Friction sensitivity < 120N, Impact sensitivity <5J, thermal stability >2000C etc.
- Synthesis of monomer, pre-polymer and polymer.
- Selection of suitable curator which is non-toxic, environmentally stable and with low vapour pressure.
- Establishing curing system and curing parameters.
- Complete characterization of neat polymer/blend, evaluation of parameters such as thermal stability, ballistic properties, impact and friction, cured resin properties etc.

RES-VSSC-2022-005

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Metastable Interstitial Composites (MICs) for low impact energy pyro applications.

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Area of Research

Nano Energetics

Summary of the proposed research and expected deliverables

Metastable Interstitial Composites refers to the emerging class of pyrotechnic materials wherein the constituents (metal & metal oxide) are in the nano state. These compositions are uniquely different from the conventional micron sized pyrotechnic compositions in ways like fast reaction rate (order of several m/s), high throughput (higher heat of reaction) and increased sensitivity to mechanical stimuli. MICs find application as high temperature pressure generators, low impact energy substitutes for lead based primary explosive systems etc. Research and development in this frontier field is imperative in exploiting the usage of these materials in aerospace ordinance systems.

Scope of the Work:

- Formulation, realization and characterization of novel MICs.

Deliverables:

- Theoretical thermochemical analysis to identify the right formulation.
- Standardizing the process parameters.
- Realization of the MIC composition with requisite properties like low impact sensitivity (0.1 to 0.2 J) and fast reaction/burn rate (<20ms/ >700m/s).
- Characterization of the composition for its ballistic and sensitivity parameters.

RES-VSSC-2022-006

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of Plasma Enhanced Chemical Vapor Infiltration Process (PE-CVI) for C/C composite

Name of Co PI from ISRO Centre/Unit

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Area of Research

Structures

Summary of the proposed research and expected deliverables

Carbon/Carbon (C/C) composites are considered the most promising materials for high-temperature structural applications due to their excellent properties at high temperature reaching up to 2500 ˚C in inert atmospheres and with appropriate coating/ oxidation inhibitors, these can survive in oxidizing environments too.

C/C Composites are realized by densification of carbon preform with carbon matrix, either derived from an organic liquid precursor like phenolic resin or pitch or by pyrolysis of hydrocarbon through CVI process. The CVI process is widely used for realization of C/C composite product, as it is known to give consistent properties. In this process, porous carbon fiber preform is densified with PyC obtained from pyrolysis of precursor gas (hydrocarbon).However, the conventional CVI process is highly time consuming as result of which processing timesare too long. Further to control the ameliorate quality of PyC as a matrix, especially in thick carbon fiber preforms, is difficult.

In the literature,it is reported that the effectiveness of CVI can be improved by plasma treatment of precursor gas which enhances the rate of deposition and quality of PyC matrix. In Plasma enhance chemical vapor infiltration process (PE-CVI) hydrocarbon gas is ionized before entering into the CVI reactor.

Scope of the Work:

- To have a detailed understanding on PE-CVI a study on densification of C/C composites by this process is required. It is required to fabricate a pilot PE-CVI reactor to demonstrate the process methodology as well as to simulate the experimental condition in order to find out optimum process parameter suitable for processing C/C composite product through this process.

Deliverables:

- Enhanced Rate of PyC deposition thus reducing turnover time of realizing C/C composites.
- More uniform densification of a carbon preform leading to more consistent properties of C/C composites.
- Quality of PyC is improved since the deposition is isotropic.
- C/C composites with improved strength can be realized in less time.

RES-VSSC-2022-007

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Modeling of Vacuum Arc Re-melting process for Maraging Steel ingots.

Name of Co PI from ISRO Centre/Unit

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Material Management Division (MMD), MMA/MME,
RFF Area, Vikram Sarabhai Space Centre, Thiruvananthapuram

Area of Research

Process Metallurgy

Summary of the proposed research and expected deliverables

M250 grade Maraging steel products are used in Indian Space Programme for critical application and are processed through Vacuum Induction Melting (VIM) followed by Vacuum Arc Re-melting (VAR). Process control for producing aerospace quality ingots is very important and requires thorough understanding of thermos-physical processes taking place during VIM/VAR. Aim is to model the process variables and relate these to ingot quality.

Present study is aimed at modelling the process of VIM/VAR and developing optimum parameters for VAR melting to control the extent of non-metallic inclusions in the ingot. Required input process parameters shall be provided by VSSC. VAR melting process shall be simulated to arrive at optimum melt conditions required to obtain clean melt.

Scope of the Work:

- Process modeling of VAR and delivery of the model to VSSC.
- Parameter optimization of VAR.

Deliverables:

- Process model and optimized parameters for implementation at work center to improve yield/ quality of the ingot.

RES-VSSC-2022-008

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Predicting magnetic properties of critical element free permanent magnets for space applications through multi-scale modeling approach.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Magnetic Materials

Summary of the proposed research and expected deliverables

Magnetic materials find applications in space program as permanent magnets and subsystems such as sensors and actuators. In order to process critical element free permanent magnets lots of compositional and experimental iterations are required. We look for a multi-scale modeling

approach based on micromagnetic simulations coupled with atomistic spin dynamics simulations (ASD) to probe the different magnetic phenomena such as magnetic anisotropy, spin dynamics, exchange bias, and microstructural effects to predict temperature dependant magnetic properties.

Scope of the Work:

- Prediction of (1) Energy product and (2) temperature dependant properties of critical element free permanent magnetic materials using ASD and micromagnetic simulations.

Deliverables:

- Work enables cost effective experimental process flow for permanent magnet realization for ISRO application.

RES-VSSC-2022-009

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Modeling and Simulation of Magnesio-thermic reduction pyrovacuum distillation processes in extraction of Titanium sponge from TiCl4.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Extractive Metallurgy

Summary of the proposed research and expected deliverables

VSSC established the first Titanium Sponge plant in the country using the technology developed by DMRL, Hyderabad. The plant uses Kroll's Process for manufacturing Titanium Sponge from TiCl4. The process involves magnesio-thermic reduction of TiCl4 followed by pyro-vacuum distillation of the reduced sponge for removing locked up magnesium and MgCl2. Specially made SS 304/430 cladded vessels (reactors) are used for the processing. The extreme operating conditions (temperature upto 975 °C, pressure down to 50 microns of Hg vacuum and corrosive vapours) for long duration (~250 Hrs) and the cyclic heating and cooling is causing severe distortion to the process reactors. Modeling and simulation of the process using FE analysis is proposed for understanding the temperature and stress distribution in the process rectors during the various stages of reduction and distillation operations. Constitutive heat and mass transfer equations involved in the reduction and vacuum distillation processes needs to be solved for optimizing the process parameters to maximize the productivity. The study shall recommend the optimum temperature, vacuum level and duration for achieving complete distillation of magnesium and MgCl2 vapours for a 3.5 MT batch. Simulation studies shall predict the stress strain distribution, residual stresses and distortion in the reactors. The study shall suggest suitable modifications in the process reactors to keep the distortion within

limits. The study shall look into the feasibility of employing a combined cycle process in which the operations from magnesium loading to vacuum distillations can be performed within single setup of the process reactors.

Scope of the Work:

- 3D modeling of process reactor and allied systems.
- Simulation of TiCl4 reduction process.
- Simulation of Vacuum distillation process.
- FE analysis of the process reactor during reduction and vacuum distillation process.
- Analyzing leakages in the system due to thermal distortion.
- Design analysis of process reactors.
- Feasibility study for employing combined cycle process.

Deliverables:

- Temperature, stress and strain distribution in the process reactor during reduction and vacuum distillation operations.
- Distortion prediction and suggestion for design modifications to resist the distortion
- Optimum process parameters for vacuum distillation for reducing processing time and achieving maximum purity.
- Development of combined cycle process.
- Reduction in energy consumption and improvement in quality and yield of aerospace grade Titanium sponge from TSP.

RES-VSSC-2022-010

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Spinel or Garnet ferrite thin films for satellite applications

Name of Co PI from ISRO Centre/Unit

Dr. K. Ashok

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Area of Research

Electro Magneto Ceramics

Summary of the proposed research and expected deliverables

Spinel (AB_2O_4) or Garnet ($A_3B_5O_{12}$) ferrites are inevitable in the present satellites in L to C band microwave components (circulators/isolator) as bulk material. For millimeter wave and high

frequency requirements, thin films can only meet desired electro-magneto properties. Synthesis and optimizing critical process parameters to cater satellite requirement is an interesting topic of research. Doping with suitable divalent/trivalent cation or anion substitute play pivotal role in tailoring functional properties. Crystallographic understandings and interface engineering on thin films with respect to suitable substrate are also to be studied. Line width, Spin line width and other physical properties specifications have very tight tolerance.

Scope of the Work:

- VSSC have microwave test facilities to measure electro ceramics. The Scope of the work is to develop Spinel or Garnet thin film by suitable deposition method. Optimization of thin film process conditions and study of magnetic properties.

Deliverables:

- The deliverable will be optimization of spinel or garnet ferrite thin film process, effect of dopant concentration, FMR testing and fundamental material characterization results.

RES-VSSC-2022-011

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Non destructive evaluation, coating thickness measurement and characterization of low density materials like Carbon-carbon specimens with Silicon carbide coatings and refractive index measurements of various thermal protection coatings using THz imaging technique.

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Area of Research

Feasibility study on NDE of various low density materials using Terahertz time domain spectroscopy (THz-TDS).

Summary of the proposed research and expected deliverables

At present, Eddy current testing, and Acousto ultrasonic testing methods are used for defect detection, coating thickness measurement of TPS over Aluminium, CFRP, Cork and MDA substrates. Currently no other complimentary techniques are available for validating the test results. Terahertz time domain spectroscopy is a non contact method which uses non-ionizing radiation. This method can be used as an alternative to these techniques which requires one side access of the component. CFRP sandwich structure bonded with cork which is used as payload fairing in SSLV heat shield. Debond detection in the specimen and measurement of the PC-10 coating thickness can be checked by THz NDT. Refractive index of the coating is required for accurate thickness measurement. Refractive index can be Measured by Time domain spectroscopy in through transmission mode.

Scope of the Work:

- Terahertz (THz) NDT is an emerging NDE technique for the NDT of variety of nonconductive materials. THz radiation can penetrate a wide variety of non-conducting materials (such as plastic, ceramics, composites, puffs etc). It can penetrate through low density materials and reflect by metallic interfaces. This allows non-destructive analysis of hidden features or substances, and detects their defects, inclusions, contaminations etc.
- The proposal is to develop a non contact method for thickness measurement of low density materials used as TPS over different substrate materials such as CFRP, Cork and MDA. This technique is useful for the thickness measurement of PCTFE coating over the semi cryo seal rings.
- To measure the optical properties of the coating like refractive index.
- Characterization of low density material like polymer, explosive etc.

Deliverables:

- Debond detection of CFRP sandwich structure bonded with cork specimen.
- Carbon-carbon specimens with Silicon carbide coating before and after hot test.
- Coating thickness measurement of PMC-30, PC-10 white over CFRP substarte (used in heat shield of GSLV-Mk-III).
- Gaganyan crew module TPS coating thickness measurement (Oposil NC and Oposil C coated over Medium density ablative(MDA) which is used as TPS).
- Terahertz spectroscopy measurement of low density materials.
- Refractive index measurement of TPS coatings.

RES-VSSC-2022-012

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Influence of inclusions, material in-homogeneities and voids in the macroscopic behavior of metals for aerospace applications.

Name of Co PI from ISRO Centre/Unit

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Mr. Karthikeyan M. K.,

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Area of Research

Computational mechanics/material science and experimental mechanics

Summary of the proposed research and expected deliverables

The raw materials used for the realization of launch vehicle components are mostly obtained through casting and forging processes. During these processes, there are chances of formation of flaws like material in-homogeneities, porosity and foreign inclusions inside the bulk of the material. These flaws may significantly affect the macroscopic behaviors such as yield strength and ductility of the materials. The influence of these flaws on the material behavior would mostly depend upon its size or precisely the volume fraction. Therefore, it is necessary to find out the length scales at which the said flaws start deteriorating the material behavior. Furthermore, since different materials have different microstructure, findings of one material cannot be generalized to all other materials. Hence, an extensive computational and experimental study for understanding the effect of flaw size on the material behavior considering the material microstructure embedded with the flaws is essential.

Scope of the Work:

- Theoretical formulation and computational modelling to study the size effect of in-homogeneities, inclusions and voids.
- Fabrication of specimens with engineered flaws simulating various length scales.
- Validation of the theoretical and computational models through experiments.
- Estimation of critical length scales and volume fraction of the flaws influencing the macroscopic properties in various aerospace materials.

Deliverables:

- Theoretical formulation in report form.
- Numerical formulation in report form.
- Computational code/UMAT for simulation of the said flaws.
- Procedure document for using the code/UMAT.
- Guidelines for material selection and rejection based on size of the flaws.

RES-VSSC-2022-013

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development and implementation of Robust Thin-walled open section beam finite element with the following features.

Name of Co PI from ISRO Centre/Unit

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Area of Research

FEAST software development (FEA software)

Summary of the proposed research and expected deliverables

Development of a beam element which can generate exact static solutions of shear flexible thin-walled laminated open section beam of any cross-section using a unified coupled field formulation even in the presence of arbitrary lamination sequence leading to the coupling of extension, bending, shear and torsion terms in constitutive matrix. The proposed element shall facilitate extracting accurate cross-sectional stiffness which can be used in FE modeling of 1D thin-walled composite (TWC) beams. The shape functions of the exact locking free element shall include both exponential and polynomial terms that help to capture the torsional response accurately particularly for thick sections.

Scope of the Work:

- FEA software development

Deliverables:

- Source code in Matlab / C++

RES-VSSC-2022-014

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Determination of poroelastic parameter (Biot's constant) of an ablative decomposing composites (anisotropic) material under high temperature for aerospace launch vehicle application.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Ablative structures, Porelasticity, Anisotropic

Summary of the proposed research and expected deliverables

Composite materials used as high temperature insulators. The ablative composites exposed to heat will degrade and outgas. This outgassing can cause internal pressurization of the composite, leading to blistering, delamination or failure of the part. Poroelasticity theory can be used to analyze these phenomena. Poroelasticity is the theory of the deformations and stresses in porous solids containing pressurized fluid within the pores.

The composite material is non-homogeneous, anisotropic and has non-constant properties both in space (different layup orientations, hybrid layups, temperature gradients) and time (rapid heating and chemical degradation).

The fluid of interest is hot gas which is being generated internally due to pyrolysis and flowing quickly to outgassing outer surface. Gradients in temperature, pressure and stress are often very severe. The aim is to use poroelasticity theory for above conditions to achieve an accurate and useful analysis to find the Biot's constant of degrading composite.

Scope of the Work:

Advanced micromechanical analytical model i.e. creating a model for effective elastic stress to be obtained mechanical stress and pressure formulation using equation of poroelasticity of a porous solids containing pressurized fluid within the pores. Without internal pressure, we know the mechanical stress-stain relation & compliances are determined through mechanical testing of bulk composite material. With internal pressure, the body will deform. This deformation or strain can be generally expressed as product of internal pressure and coefficients of pressure induce deformation. These coefficients can be found by test with measuring the deformation of a bulk material exposed to a pressurized fluid that can permeate the pores in the material. Finally elastic pressure-stress interaction coefficient can be obtained using the material stiffness and coefficients of pressure induce deformation.

Deliverables:

- Evaluation of mechanical properties (E_L,E_T,V_{LT}, V_{TL},G_{LT}) of bulk composite, fiber and matrix at 700k and RT.
- The pressure induce deformation can be found by measuring (through test) the deformation of a bulk material exposed to a pressurized fluid.
- Estimation of elastic pressure-stress interaction coefficient (biot's constant) from pressure induce deformation coefficients obtained through test & make use of poroelasticity, theory of elasticity of degrading composite.
- Matlab codes or Abaqus-based user material subroutines: poro-elasticity Biot's parameters estimation module (UMAT/VUMAT) need to be developed for decomposing ablative phenolic composite structures/ material.
- Detailed documentation and all the codes.

RES-VSSC-2022-015

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Experimental and Numerical investigations on the delamination modeling in composites.

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Area of Research

Delamination Modeling In Composites

Summary of the proposed research and expected deliverables

Nonlocal approaches for predicting fracture in materials is gaining attention of several researchers owing to the fact that it avoids the problem of stress singularity at the crack tip. The solutions of boundary value problems via nonlocal approach are proven to be mesh independent leading to a physical reality. The classical continuum models do not reproduce size effects commonly observed in quasi brittle materials. The nonlocal approach is also proven to be an effective regularization technique to accurately predict the softening behavior in case of quasi brittle materials without losing the elasticity. The proposed research should investigate the mechanical behavior of laminated composite plates under delamination via the nonlocal continuum mechanics.

Scope of the Work:

- Formulation of delamination modelling of composites using nonlocal damage mechanics. Finite element modelling of delamination.
- Numerical algorithm has to be developed to solve the complex delamination problem and the same is to be implemented by writing a software program.
- Validation of the numerical modelling of delamination in composites with experimental study.
- To estimate the load-deformation behaviour, the strain energy release rate for opening and mode decompositions, in shear and mixed modes as per the standards (Mode I fracture toughness testing, Mode II fracture toughness testing and the Mixed Mode I-Mode II Interlaminar Fracture Toughness of Unidirectional and Multi directional Fibber Reinforced Polymer Matrix Composites) and to use the resulting data for the analysis.
- Testing of a specimen realized as per the requirement of ISRO with/without induced defects and correlation with analytical data using the software developed.

Deliverables:

- Software shall be developed for delamination initiation, propagation and migration in laminated composites, which would be validated using suitable methods. The source code of this software along with the complete documentation (including examples) shall be handed over for the use of ISRO. Comparisons of the proposed approach and the existing approaches shall be made and novelty, advantages and limitations of the proposed scheme shall also be brought out.

RES-VSSC-2022-016

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

Development of Porous Media Based Condensing Heat Exchanger for Space Systems.

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Area of Research

Material Science and Chemical / Mechanical Engineering

Summary of the proposed research and expected deliverables

Condensing Heat Exchangers (CHX) are essential for thermal and humidity control in manned space flight system. The control of temperature and humidity within a spacecraft requires removal of both sensible heat generated by power consuming equipment and crew (humans) and water vapor primarily generated by evaporation from humans. A CHX is designed to accomplish both of these functions. The conventional system for control and humidity removal in the crew module utilizes a two- stage process. First, moisture is condensed onto the fins of a plate-fin heat exchanger which is then forced through the "slurper bars" by the air flow. The slurper bars take in a two-phase mixture of air and water that is then separated by a rotary separator. A more efficient design of a CHX would condense and remove the water directly from the air stream without the need for an additional water separator downstream.

Scope of the Work:

- This proposal envisages to develop a novel CHX based on a porous substrate with high thermal conductivity as the cold surface over which condensation occurs. The condensed water can then be removed by an embedded porous media connected to a suction device. The thermal properties, the porosity and the wetting characteristics of the porous materials required to be chosen judiciously so that efficient condensation is promoted and at the same time air penetration into the suction lines is avoided. It is anticipated that the porous media based condensing heat exchanger can provide a robust, lightweight passive condenser and liquid separator and it will be operationally simple. The unique geometrical configuration of the heat exchanger and the need for it to operate in varying gravity field including microgravity are the major challenges in development of the proposed CHX based on porous media.

Deliverables:

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

RES-VSSC-2022-017

Name of ISRO Centre/Unit

Vikram Sarabhai Space Centre, Thiruvananthapuram

Title of the research proposal

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

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Area of Research

Fuel Cells

Summary of the proposed research and expected deliverables

The main objective of the proposal is to develop novel catalysts for the cathode of a Proton Exchange membrane fuel cell (PEMFC) with the objective of replacing platinum catalyst.

Scope of the Work:

- The work would be to evaluate the performance of these cathode catalysts in PEM fuel cell as compared to a Platinum catalyst, study the performance degradation of these catalysts in an operating PEM fuel cell and understand the life term performance of these novel catalyst.

Deliverables:

- Novel cathode catalysts synthesized for testing in a PEM fuel cells (along with the synthesized catalysts, the synthesis procedures and electrochemical characterization studies), for further full-level characterization and field trials at VSSC.

SPACE APPLICATIONS CENTRE
AHMEDABAD

RES-SAC-2022-001

Name of ISRO Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
PIC based Tx and Rx with multiplexed optical channels employing polarization modulation and homodyne/ heterodyne detection.

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Shri. Jay Bhatt

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Area of Research
Optoelectronics and Optical Communication

Summary of the proposed research and expected deliverables

- The integration of optical components and functions into a large scale PIC shows significant benefits when it is integrated into an optical communication system. It enables significant power, space and cost savings, new functionality and so new significant increasing transmission capacity of communication systems.
- In satellite communication multiple channels are being multiplexed to increase the throughput. Optical Tx using QPSK and DP-QPSK are commercially available. Multilevel modulation techniques like mQAM are also being used. Polarization modulation is a third dimension which can be included to increase the overall baud rate.
- In the present research, we propose to design Optical Tx and Rx chips using PICs employing multilevel modulation with amplitude, phase and polarization. Using this technique multiples optical channles with different modulation can be sent over single channel to achieve terabytes of data over single channel.

Scope of the Work:

- In this research we intend to design photonic ICs for optical Tx and Rx with advance modulation techniques. Tx chip consists of multiple DFB lasers with electro optical modulators for amplitude/ phase/polarization modulation. DC and RF interfaces will be integrated within the PIC. At the Rx side coherent detection techniques with homodyne/ heterodyne detection will be employed for multiple channels.
- Finally these designed Tx an Rx should be packaged with RF, DC and Optical interfaces

Deliverables:

- Design details, Layout files, Fabricated Tx, Rx Chips, Characterization results.

RES-SAC-2022-002

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Study and realization of low Vpi Mach-Zender for OOK/BPSK/QPSK modulation up to 20 GHz.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Optoelectronics and Optical Communication

Summary of the proposed research and expected deliverables

Electro Optic Traveling wave modulators are used for high data rate optical communication. These are facricated over variety of substrates like LiNbO3, GaAs depeding on applications. Mach-Zender modulators are most promising solutions for high data rate optical communication with better extinction ratio as compared to other categories of modulators. To achieve the desirable modulation, message signal amplitude should be order of Vpi voltage. The existing commercially viable modulators have Vpi up to 12 V which adds the challenge to digital driver amplifier to boost the input signal (typ. 0.5 Vpp.) to Vpi (typ.12Vpp.) at wide frequency range from DC to 20GHz. Thus, to overcome this limitation, modulators with low Vpi (< 5V @ 20GHz) will be the promising solution for efficient design of system.

Scope of the Work:

- In this research we intend to design modulators for high daterate up 20 Gbps. These modulators should cater to amplitude , phase and IQ type of modulation, where RF drive voltage to minimized. These modulators should have different RF and DC electrodes and also integrated photo diode for power montoring. Substrates other than LiNbO3 and GaAs may be explored.
- Finally these designed modulators should be packaged with RF, DC and Optical interfaces.

Deliverables:

- Design details. Fabricated Mach-Zender modulators for OOK, BPSK, QPSK. Characterization results.

RES-SAC-2022-003

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Modeling and simulation of Maser/Laser Atomic Clock: microwave, optical and closed loop systems.

Name of Co PI from ISRO Centre/Unit

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Shri. Pratik Jain

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Area of Research

Frequency Standard, Atomic Clock

Summary of the proposed research and expected deliverables

Complete modelling of Maser/Laser-pumped Atomic Clocks. The modelling should include the physics package, optical, microwave and all other electronic subsystems.

The model should be configurable for different parameters of the Atomic Clock and should simulate the behaviour of the Atomic Clock under different operating, electrical and environmental conditions, short-term and long-term perturbations and other variations. Preferably the MATLAB software should be used to develop the model. Other software, such as pSpice and ADS, may also be used for interfacing analogue sections of Atomic Clock with the model developed in MATLAB.

It requires a detailed study of various fields such as physics, optics, microwave cavity and closed-loop systems concerning the Atomic Clock.

A successful model will help to analyze the Atomic Clock behaviour (long-term and short-term), failures and its mechanism, the ageing process, etc. Further, it could indicate the effects of various electrical and physical parameters like temperatures, magnetic field, pressure, etc.

Apart from this, a model would also require certain parameters/constants. Procedure to extract these parameters practically from an Atomic Clock would also be required to fine-tune the model as per requirement.

Scope of the Work:

- Study of Atomic Clock functioning and effects of various parameters on the behaviour of Atomic Clock.
- Behavioural modeling of Atomic Clock (configurable/tunable).
- Verification and validation with practical results.
- Detailed practical procedure to extract the parameters of the Model from an Atomic Clock.
- It does not include physical Atomic Clock design and development. Timeline required is around 2.5 years.

Deliverables:

- A complete Atomic Clock model in software with design details and operating/user manual. Detailed procedure and experimental setup to derive the software parameter from a working Atomic Clock.

RES-SAC-2022-004

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of techniques for ground-based source localization using sparse array on-board LEO satellite.

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Area of Research

Array Signal Processing

Summary of the proposed research and expected deliverables

Geolocation of ground sources from space based platforms has significant applications where the source itself may not be able to transmit its location, for example, low power sensors used for wildlife tracking. Such techniques are also important for search and rescue payloads. Considering the need to reduce the Size, Weight and Power (SWaP) of the payload, this project should aim to develop a technique which provides accurate source localization with the minimum possible number of sensors (sparse array) and optimum spacing between the sensors for a given performance requirement. Since the investigation is at the algorithm level, development of a software simulator for generating the signals as per the scenario will be necessary. The performance of the proposed technique should be compared to other known techniques such as TDOA, FDOA etc. in terms of geolocation accuracy and minimum SNR required for detection.

Scope of the Work:

- Development of source location algorithm for sparse array. The algorithm should be able to provide an array configuration based on the source location accuracy and SNR requirements.
- Software simulator for performance verification.

Deliverables:

- Algorithm for ground-based source location and software simulator for performance verification of the proposed algorithm.

RES-SAC-2022-005

Name of ISRO Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Techniques for coexistence & integration of communication satellites and terrestrial IMT systems.

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Area of Research
Satellite communication, channel modelling and simulation, coexistence studies between satellite and terrestrial networks

Summary of the proposed research and expected deliverables
The increasing proliferation of communication devices along with the demand for higher data rates has resulted in spectrum crunch. As a result, it is inevitable that satellite and terrestrial systems share frequencies in adjacent band or co-frequency mode. Recently, several satellite bands are being considered for use for terrestrial mobile networks in sharing/adjacent frequency mode. Unconstrained (or uncoordinated) widespread deployment of such networks would cause harmful interference to the incumbent satellite systems and possibly even to the terrestrial systems. With appropriate techniques, it would also be possible to integrate these services.

This project should aim to identify and model the characteristics of the interference channel between these two systems followed by modeling and simulation of deployment of both networks in adjacent and co-frequency sharing modes. Subsequently, physical layer and network techniques should be identified and proposed for coexistence of both services with minimal constraints and performance degradation. It should also be aimed to identify possible techniques for integration of satellite and terrestrial systems.

Scope of the Work:

- Modelling such future satellite-terrestrial systems and associated software simulation/hardware emulation.
- Identification and evaluation of algorithms/waveforms /techniques for seamless integration or coexistence of satellites and future terrestrial mobile systems.

Deliverables:

- Physical layer waveform/network strategy for coexistence of satellite and terrestrial networks.
- Algorithms and simulator for performance evaluation.

RES-SAC-2022-006

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design of satellite networks for efficient Integration with upcoming 6G terrestrial mobile communication systems.

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Area of Research

Satellite communication, mobile communication, physical and network layer design and simulation

Summary of the proposed research and expected deliverables

Terrestrial cellular networks have evolved to improve user experience by providing higher data rates to users, lower latency, support for dense networks etc. However, there are several domains where a complementary satellite provides edge, which is in the areas of service to maritime and aeronautical platforms, disaster management support, communication to geographically isolated and sparsely populated areas. As a result, upcoming standards such as 6G are expected to include satellites as an integral part of the network similar to current experiments of 5G-satellite integration. Under this umbrella, there are at least two forms of communication which require investigation. The first is low data rate communication for small battery powered terminals. One significant challenge in this case is design of waveforms for power limited operation and a network access algorithm for minimizing number of transmissions. The other form of communication is high data rate services to remote, mobile platforms which presents different challenges than the previous case. The study should aim to jointly design the terminals as well as the satellite payload since the 6G developments are in their nascent stage. Studies can be carried out physical and network layer design in both cases while considering seamless integration with the terrestrial network. Detailed plans may also be worked out for development of a test-bed for satellite-6G integrated networks.

Scope of the Work:

- Identification of physical and network layers for integrated satellite-6G networks for low and high data rate service.
- Working out the expected satellite performance parameters for efficient integration.

Deliverables:

- Physical layer wave form/network algorithms for satellite-6G integrated networks. Algorithms and simulator for performance evaluation.

RES-SAC-2022-007

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of Miniaturized Multi-Constellation Weak MBOC signal Real-Time GNSS Receiver.

Name of Co PI from ISRO Centre/Unit

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Area of Research

SATNAV Technology

Summary of the proposed research and expected deliverables

A Multi channel multi constellation GNSS receiver which can acquire /track and provide positioning solution in stand alone and hybrid constellation mode for following multiple MBOC modulated GNSS signals under weak signal condition.

Scope of the Work:

- NavIC SBOC(6,1,1/11) modulated L1 SPS signal.
- GPS TMBOC(6,1,4/33 and complete MBOC(6,1,1/11) modulated L1C civil signal.
- Galileo CBOC(6,1,1/11) modulated E1 civil signal.
- BDS QMBOC modulated B1 signal.
- Receiver should explore vectorized DLL and vector frequency lock loop for tracking weak signal (upto 15 dB/Hz) and to track signal under multipath condition.
- Developed reciever should hacve the capability of acquiring signal under weak signal conditions (acquisition below 25dB-Hz C/No) and the performance of the implemented reciever is to be evaluated in weak signal condition such as in urban and sub urban canyons.
- Other weak signal acquistion and tracking algorithms can also be explored to meet the specifications.
- The software of receiver to be preferably written in C/C++ , HDL, MATLAB languages.

Deliverables:

- Software: Functionally tested GNSS receiver Script/High-level source code HDL design files, simulation models and netlists (if developed), for complete design and executable.
- Installable controller software on any supported Windows PC.
- Installation manuals and technical manuals for the software as well as the hardware in soft copy (CD/DVD) and hard copy (print) format.

RES-SAC-2022-008

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Simulation of SOTM tracking and control algorithms and it's implementation.

Name of Co PI from ISRO Centre/Unit

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Smt. Ushma Dad

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Area of Research

Satellite communication, antenna and control system for antenna tracking

Summary of the proposed research and expected deliverables

Satellite communications On The Move (SOTM) is a communications capability used for high speed satellite connectivity in moving vehicle. SOTM terminal with vehicle mounted automatic tracking antenna will provide two-way, high-speed communications on the move under various operational conditions using HTS (High Throughput Satellite).

Scope of the Work:

- The proposed research includes automatic pointing and tracking algorithms for SOTM antennas to be studied and MATLAB and C simulations to be carried out. Different algorithms for mechanical scanning, electronic beam steering and hybrid scanning techniques to be studied and simulations to be carried out.

Deliverables:

- Study report containing literature survey, algorithm details for automatic pointing and tracking and other technical details.
- MATLAB and C Simulations for tracking algorithms.

RES-SAC-2022-009

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Fabrication of SIS tunnel junctions for SIS mixers in the 230 and 345 GHz bands.

Name of Co PI from ISRO Centre/Unit

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Area of Research

High Sensitivity Sub Millimeter-wave Receivers for Astronomical Applications

Summary of the proposed research and expected deliverables

The research proposal is for design and realization of SIS tunnel junction, required for SIS based fundamental mixers, operating at 230 GHz and 345 GHz frequency band. SIS mixer technology has provided mm-wave and sub mm-wave astronomers with remarkable sensitivity across a wide observational spectrum extending to sub mm-wave frequencies.

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

Scope of the Work:

- Design and development of cryogenically cooled (~ 4K) SIS based fundamental mixers at 230 and 345 GHz frequency band.

Deliverables:

- SIS Junction design document along with DXF files & 3D device model.
- Design Report comprising the simulation results.
- Mask set DXF files used for SIS Tunnel Junction.
- Report comprising SIS Tunnel Junction Fabrication Process.
- Testing and characterization report of SIS tunnel junction parameters for both the fabricated wafers.
- SEM/TEM (preferable) report of fabricated SIS junction.
- Characterization of the room temperature I-V characteristics of the junctions.
- Characterization of the low temperature (<4K) I-V characteristics of the junctions.

RES-SAC-2022-010

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and Implementation of Ka-Band Fractional-N Phase Locked Loop (PLL) based tunable frequency synthesizer.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Wide-band tunable frequency synthesizer for atmospheric sounder and astronomical applications.

Summary of the proposed research and expected deliverables

A phase-locked loop is a feedback system combining a Voltage Controlled Oscillator (VCO) and a phase comparator so connected that the oscillator maintains a constant phase angle relative to a reference signal. Phase-locked loops can be used, for example, to generate stable output high frequency signals from a fixed low-frequency signal.

For many applications (especially in atmospheric sounder and astronomical applications), it is desirable that the RF signal be tunable, potentially over a broad frequency range, that it have low phase noise or be capable of extending into the millimeter-wave regime.

Scope of the Work:

- Wideband tunable LO is used to serve different RF channels with single IF backend for each frequency band receiver chain and at the same time wideband tunable frequency synthesizer also helps to reduce the size of conventional system size drastically and making it a compact self-calibrating instrument, ideal for deployment in case of ground based application at remote sites.

Tunable frequency synthesizer shall have following salient features:

- Shall be capable of operating in Fractional-N and Integer-N Mode.
- Minimal output power variation over the frequency of operations.
- The tunable LO shall provide low phase noise.
- The tunable LO shall generate minimal spurious levels and suppressed harmonics.
- Thermo-vacuum Compatible.
- Must be radiation hardened by design.

Deliverables:

- .dxf/.pcb files containing circuit schematic and layout.
- Detailed report on circuit design and simulations results.
- Fabricated prototype and measured results.

RES-SAC-2022-011

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design of transceiver for On board Wireless interface of distributed control systems.

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Area of Research

Distributed control systems, Wireless communication

Summary of the proposed research and expected deliverables

Proposal is for design of transceiver for on board wireless interface of distributed control systems. The goal of this proposal is to develop wireless protocol and interface transceiver chip use in microwave remote sensing payload distributed control systems. Phased array based Synthetic Aperture Radar (SAR) payload contains hundreds of distributed control sub-systems, the existing scheme of wired interconnect among this distributed control sub-systems results in large number of cables and interconnect harness. Wireless interface among these sub-system will greatly reduce interconnect harness resulting in reduction of overall weight and volume. In the remote sensing payloads having rotating and static sections (for example radiometer with rotating antenna), it is advantageous to have wireless interface between static and rotating sub-systems rather than slip ring based interface. Wireless transceivers should operate in ISM (2.4GHz) band or other open frequency bands for data rate of 5 Mbps with range of 10m. The wireless data transfer should follow command/response protocol with a Master node and few hundred slave nodes. The transmitter and receiver section should configured for simple implementation on CMOS process along with digital protocol handing logic. It is preferable to target indigenous 180nm CMOS process for implementation of complete wireless interface ASIC chip. The design should have fault tolerant features so that it is suitable for space applications.

Scope of the Work:

- Literature survey and protocol design
- Simulation mode creation for wireless transceiver system
- Schematic design & simulation
- Physical design & verification, GDS-II signoff
- Proto ASIC Fabrication
- Functional testing of proto ASIC device

Deliverables:

- Design documents.
- Simulation results.
- Schematic and layout GDS-II files.
- All design & verification scripts, logs and result files.
- Proto ASIC with test results.

RES-SAC-2022-012

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

"Design, Development & Implementation of Real/Near Real Time Low SNR Target Detection & Tracking System"

Name of Co PI from ISRO Centre/Unit

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Smt. Dimple Garg

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Area of Research

Image processing with real/near real time data processing

Sumary of the proposed research and expected deliverables

Design, development & Implementation of Target detection & tracking system as RTL level IP core with Real /Near time performance. The algorithm should be configurable to detect object, motion and carry out tracking and trajectory prediction of Low SNR targets. The scope includes Machine learning and AI techniques for robust algorithm development & real time decision making and control with hardware implementation.

Scope of the Work:

- Configurable algorithm development using Low SNR targets.
- Machine learning and AI techniques usage & implementation.
- Test/ Characterization.
- Implemented as RTL IP core.

Deliverables:

- Algorithms.
- Configurable RTL IP core.
- Trained dataset if any.
- Test bench.
- Evaluation board.

RES-SAC-2022-013

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Polarisation Imaging Camera for characterisation of plantery atmosphere and surface

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Area of Research

Electro-optical sensors

Summary of the proposed research and expected deliverables

Polarimetry of reflected/scattered sunlight from planetary surface and atmosphere has emerged as a powerful tool for planetary science studies. Polarimetry involves measurement of the state of polarization of the scattered/reflected sunlight as it carries vital information of planetary surface properties and microphysical properties of its atmospheric constituents such as size, shape, and composition. Polarimatric measruements over various spectral bands and multi view observations will enable accurate retrieval of various physical parameters related to surface and atmospheric processes.

Globally, many spaceborne missions with optical polarization measurement capabilities have been successfully flown for Earth observations e.g. POLDER polarimeter and NASA's Aerosol Polarimetry Sensor (Glory mission). Many other optical sensors are being developed and are in phase of pilot projects by other space agencies.

Considering the significant advantages of the polarimetry observations.

Scope of the Work:

The responsibilities will include:

- Study of requirements for polarimetry applications and translating it to Polarimeter imaging system requirements.
- Sensor design and performance simulation studies.
- Generating system specifications to meet specific application requirements.
- Identification of components and end to end realization of system.
- Demonstration of performance to the specifications.

Deliverables:

- This research work envisages design and development of an optical polarization imaging camera suitable for ISRO's future Earth observation and planetary missions.

RES-SAC-2022-014

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Design and development of Focal Plane Processing (FPP) ASIC.

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Area of Research

VLSI

Summary of the proposed research and expected deliverables

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

Scope of the Work:

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

Deliverables:

- Functional chip.
- Design documents, schematic and layout files.
- Datasheets.

RES-SAC-2022-015

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

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

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Area of Research
Microelectronics

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

Scope of the Work:

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

Deliverables:

- Process recipes for fabrication of thin film BAW filters.

RES-SAC-2022-016

Name of ISRO Centre/Unit
Space Applications Centre, Ahmedabad

Title of the research proposal
Development of Cryocooler for 100-30K and 30-4.5 K temperature.

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

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Area of Research
Thermal Engineering, Cryogenics, Heat Transfer, sub Kelvin Cooling

Summary of the proposed research and expected deliverables
For development of a sub-Kelvin cooler system, intermediate temperature stages are required to reduce parasitic heat load into the system. Cryocoolers are preferred over stored cyrogens in space missions to achieve the intermediate temperatures of 30K and 4.5K, due to their compact volume and for prolonged mission life.

Scope of the Work:

- This research will target the overall cryocooler system design and its optimization. It is expected that a design methodology including code to simulate the cryocooler performance is developed

and validated with existing literature. A working prototype is to be developed with the validated design code and a cooling power of atlest 200mW and 20mW at 30K and 4.5K respectively is to be demonstrated. In addition to being used for sub-Kelvin cooler system, the cryocooler design methodology can be adopted for indigenous IDDCA development for Optical payloads. Preferred technology will be Pulse Tube Cryocooler , however other options also can be proposed.

Deliverables:

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

RES-SAC-2022-017

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Additive manufacturing (3D printing) using Carbon Allotropes.

Name of Co PI from ISRO Centre/Unit

Shri. Ravi Kumar Varma,
Shri. Dhaval A Vartak

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Area of Research

System Reliability

Summary of the proposed research and expected deliverables

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

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

Scope of the Work:

- Currently worldwide aerospace industry is producing parts through 3D printing for commercial flights, with same reliability as conventional method.
- Carbon Allotropes such as carbon nanotubes (CNT), graphene and metal particles, allows one to build objects with multifunctional properties having good electrical conductivity, thermal conductivity, mechanical strength, and stiffness at a relatively low cost.

Deliverables:

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

RES-SAC-2022-018

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Data Driven Approaches for Dehazing of High-Resolution Multispectral Remote Sensing Images.

Name of Co PI from ISRO Centre/Unit

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Shri. Abhishek Patil

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Area of Research

Satellite data processing, Image Processing, Deep learning

Summary of the proposed research and expected deliverables

The Objective is to build and implement image processing algorithms which can effectively restore pixels affected by presence of haze in order to improve image interpretability. Haze is caused due to presence of fine dust, smoke, or light vapors causing lack of transparency of the air. For satellite images, this creates a problem as the image regions affected by haze suffer lack of contrast resulting in difficulty of interpretation. In the mainstream, this issue is solved by applying atmospheric correction which is a tedious process and requires knowledge of several geo-physical quantities in order to give accurate results. However, recently, a set of algorithms to recover the contrast in such hazy regions called as dehazing algorithms are becoming popular in literature. These algorithms can be classified based on their manner of operation – reference based or blind. In this work, we are looking for a no (preferable) or limited-reference, image processing based solution to solve the dehazing problem for high-resolution (<5m resolution) multispectral images.

Scope of the Work:

- The Scope of the project is limited to development of a technique for quantifiable and effective dehazing of multispectral satellite images.

Deliverables:

- Documents explaining design of the algorithm.
- Software: source code and model definitions if any along with documentation on use of S/W.
- Report(s) which measurably enlistthe results achieved on real satellite datasets.

RES-SAC-2022-019

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Learning noise source invariant latent space for unsupervised denoising of high-resolution multispectral image.

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Area of Research

Signal & Image Processing and Data Product

Summary of the proposed research and expected deliverables

Images acquired by the satellite sensors are inherently subjected to many degradations due to systematic and random processes. Image restoration though an ill-posed inverse problem attempts to reconstruct clean representation of the image from the acquired corrupted observations. The state-of-the-art Denoising methods have done well but often involve parameters that require tuning for different thematic surfaces. Although deep Convolutional Neural Networks (Deep CNNs) and Generative Adversarial Networks (GANs) have shown superior denoising performance, these methods provide poor generality; scalability and practicality in handling real-world noise sources due to limited noisy-clean image paired training data. The self-supervised denoisers like Noise2Noise, Noise2Void attempts to overcome the practical problem of paired training data but their performance over image corrupted with multiple noise is not good enough.

To alleviate the above issues, the research proposal aims to solve the image-denoising problem as a domain transfer problem in an unsupervised manner. Specifically, the goal is to learn such a robust intermediate image representation that lies on manifold of pristine image distribution and later use it to reconstruct clean image. The learnt intermediate representation should be clearly distant from noise distribution domain and at the same time contain richer texture and semantic features from inputs to avoid over-smoothing. The proposed deliverables will be very useful as a pre-processing image correction step for ISRO's future high-resolution Electro-Optical missions.

Scope of the Work:

- The image denoiser is expected to work on high resolution multispectral images.
- It should handle image corrupted with thermal noise, Poisson-Gaussian noise, random valued impulse noise and periodic pattern noise. It is expected these noises would be jointly present in the image.
- The denoising algorithm should specify the extent of noise-levels it can handle w.r.t above noises.

Deliverables:

- An unsupervised image-denoising model capable to handle restoration of high-resolution multispectral images corrupted with multiple noise.
- It should aim to capture the generalized semantic and texture in the learned representation to avoid domain shift problems and thus provide high-quality image reconstruction.

RES-SAC-2022-020

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

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

Name of Co PI from ISRO Centre/Unit

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Area of Research

RS Applications

Summary of the proposed research and expected deliverables

The proposed research proposal is intended to simulate the climate change scenario on wind-wave energy production capacity of India using modelled data. This is first of its kind research work attempt in India. The research work will primarily focus on the impact of climate change on offshore wind and wave power potential in Indian Exclusive economic zone (EEZ). Coordinated Regional Climate Downscaling Experiment (CORDEX) RCMs are forced with CMIP5 GCMs and run at a resolution of 50 km (0.44° × 0.44°) over CORDEX South Asia Domain. With the aim of recognizing the most suitable GCM or RCM dataset for the estimation of future resources and the impact of climate change, the historical wind datasets will be validated with reference to the ECMWF reanalysis/satellite data.

Scope of the Work:

- The wave climate over Indian ocean region would be simulated using a third generation wave model (WAVEWATCH III) forced with wind inputs obtained from CMIP5 and CORDEX. The simulated wave characteristics will compare with ERA Interim reanalysis or satellite altimeter wave data or in-situ observations for the same period. Further, the aim is to develop a relation between climate models (GCMs/RCMs) data with reanalysis/satellite data. The spatial distribution maps of wind and wave properties for present and future Representative Concentration Pathways (RCP) emission scenarios will be developed. Also, the wind turbine and wave energy

converter characteristics, technical offshore wind and wave power potential in study area will be estimated. Finally, multi-criteria analysis will be used to identify the most suitable location by considering the technical, economical, environmental and socio-political factors for present and future emission scenarios.

Deliverables:

- High-resolution spatial distribution maps of wave resource for past, present and future climate scenarios (wave power potential, inter annual variability, capacity factor, annual energy production).
- Techno-economic analysis of offshore wind and wave energy potential by considering state of art offshore wind turbines and wave energy converters for past, present and future climate scenarios. Identification of favorable locations by applying multi-criteria decision making model for individual offshore wind and wave energy exploitation under climate change.

RES-SAC-2022-021

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of active learning algorithm for human in loop AI systems for satellite imagery analysis.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Artificial Intelligence

Summary of the proposed research and expected deliverables

There is a need to develop AI systems which can improve progressively through feedback from domain experts without requiring retraining on the entire dataset.

The goal of this project is to develop an "active learning" algorithm specifically for semantic segmentation where the system proposes samples where it requires assistance from "domain experts" and automatically incoporates "learning" from the new sample into the model without requiring retraining on the entire training set.

Scope of the Work:

- Develop an end-to-end active learning system complete with user interface and demonstrate on atleast 2 benchmark datasets involving satellite imagery.

Deliverables:

- Algorithm and software system.

RES-SAC-2022-022

Name of ISRO Centre/Unit

Space Applications Centre, Ahmedabad

Title of the research proposal

Development of Time domain measurement technique for very low frequency (10 MHz to 50 MHz) antenna radiation pattern measurements.

Name of Co PI from ISRO Centre/Unit

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Shri. Jaswant,
Scientist / Engineer - 'SF'

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Antenna Systems Group
Space Applications Centre, Ahmedabad

Area of Research

Antenna Systems

Summary of the proposed research and expected deliverables

Currently, SAC is working on very low frequency ultra wideband antenna system for inter planetary mission. At very low frequencies (below 50 MHz), anechoic chambers are in-effective due to poor reflectivity of absorbers. Hence, accurate assessment of low frequency antennas becomes difficult. The need is felt to carry out accurate antenna pattern measurements in reflective environment. The research problem involves the development of algorithms for Time-Domain Measurement Technique for radiation pattern measurements to mitigate multipath reflections. Simulation model is to be developed to compute the reflected wave from nearby scatterers and then minimize these with proper selection of pulse width, duration, rise time etc. This technique is essentially required to carry out measurements at low frequencies viz. VHF band below. so that it can avoid the need of large size absorbers at such low frequencies.

Scope of the Work:

- Development of algorithms for Time domain measurement of antenna radiation pattern measurement, modelling chamber reflections.
- Development of software gating algorithm.

Deliverables:

- Algorithm for time domain measurement of antenna radiation pattern measurements.
- Software tool for implementation.
- Validation of developed algorithms on VHF band antenna in anechoic chamber of SAC.

U R RAO SATELLITE CENTRE
BENGALURU.

RES-URSC-2022-001

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

Title of the research proposal
High conductive heat spreader plate.

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Area of Research
Thermal Control Systems

Summary of the proposed research and expected deliverables
High conductive heat spreaders are very essential in spacecraft thermal management. Experimentally and computationally identification and realization of ultrahigh thermal conductivity materials such as Boron Nitride etc. with applications to heat spreaders for spacecraft application.

Scope of the work:

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

Deliverables:

- Experimental data
- Fabrication methodology
- High conductive heat spreader plate- engineering model
- Final closure report

RES-URSC-2022-002

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

Title of the research proposal
Radiation-induced degradation of the thermal and electronic properties of materials.

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Area of Research

Thermal Systems

Summary of the proposed research and expected deliverables

This proposal is to investigate the degradation of the heat dissipation, thermal expansion and electronic transport properties of semiconductor materials caused by radiation-induced structural damage and use these fundamental inputs to search for new materials whose thermal and electronic properties are insensitive to radiation damage.

Scope of the Work:

- Computational prediction of the degradation of the thermal and electronic properties of materials due to structural defects.
- Experimental validation of the computational prediction.

Deliverables:

- Knowledge of degradation mechanisms for thermal control.
- Experimental data.
- Final closure report.

RES-URSC-2022-003

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

NLP based Solutions for Spacecraft Mission Health Management and Operations.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Natural Language Processing

Summary of the proposed research and expected deliverables

In spacecraft health monitoring current practices requires aid of new domain where operation user or subsystem user gives the input through natural language understandable devices or systems and in return system gives them results as they are viewing today by using multiple software and tools.

In a simple context, One of the objective is enabling the business user to submit a question such as "Give me the bar chart when battery temperature has gone beyond 40degrees in XXX Mission since 2015," or "Give me histogram for temperature of Battery A for last 6 years for all missions" and the device/software will convert that to a system understandable query and to numbers from the reporting period, and in present the results to the users with Visual Analytics. The business user is transparent to specify which database, report, server or software is used to get the answer.

Scope of the Work:

- Development of Natural processing model for Spacecraft Data Analysis. The model interprets query, interacts with offline or real-time software, format results and present in desired or specified formats.
- Development of Natural processing model for Spacecraft Command and Control, where the system in whole interprets the query, connect to databases; bring out combination of commands and uplink to spacecraft.
- Development or Explore models and devices for speech to text and vice versa to make system conversational.

Deliverables:

- Software/Hardware for Speech Conversion.
- Design methodology and Architecture.
- Software Development for Query System.
- Project Report and Demonstration.

RES-URSC-2022-004

Name of ISRO Centre/Unit
Laboratory For Electro Optics Systems, Bengaluru

Title of the research proposal
Development of wide bandgap semiconductor based Solar Blind Photodetectors.

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Area of Research
Detector Development

Summary of the proposed research and expected deliverables
Solar blind photodetectors are in ever increasing demand as these find applications in missile tracking. The conventional deep ultraviolet photo detectors which consist of photomultiplier and photodiodes are large, heavy and require high operation voltage which are the major drawbacks.

The monoclinic ß – Ga_2O_3 thin films were found to be promising for detection of wavelengths below 280nm. It also has good spectral responsivity, high electron mobility and good mechanical strength.

Scope of the Work:

- The research work focuses primarily on production of solar blind sensors with good qualities as well as rational design of novel conceptual devices. On the other hand, large-area uniformity of material preparation, long-term stability and durability, large-scale production and integration, as well as environmental-friendly processing techniques of the devices are the most pivotal issues that require more research efforts from the perspective of space applications.

Deliverables:

- Solar Blind Photodetector.

RES-URSC-2022-005

Name of ISRO Centre/Unit

Laboratory For Electro Optics Systems, Bengaluru

Title of the research proposal

Development of precision laser spectroscopy system for testing and characterization of MEMS based vapour cells for quantum technology applications in computing, communication, sensing and metrology.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Development of miniaturized atomic resonance devices and sensors

Summary of the proposed research and expected deliverables

LEOS is in the process of developing miniature alkali vapour cells using MEMS and other micro fabrication technologies. These cells contain precise quantities of vapours of alkali metals such as Rb and CS along with buffer gasses. The cells form critical component of atomic resonance devices such as frequency standards, THz imagers, gyroscopes and magnetic fields sensors to name a few. It is proposed to initiate a research project to develop a high precision spectroscopic characterization system to test and characterize the vapour cells. The system will be based on the technique of absorption spectroscopy. Spectroscopic characterization will quantitatively measure the position and line width of the spectral lines of technological importance. The effects of external influence such as temperature, magnetic fields, light intensity and presence of buffer gas on the spectral lines will be studied in the detail. These studies will provide valuable information required for using these cells in device applications. The proposed spectroscopic system will be designed such that it can

be augmented to perform other forms of spectroscopic studies such as saturated absorption and coherent population trapping (CPT).

Scope of the Work:

- The Scope of the proposed research is to carry out detailed experimental studies to gain a thorough understanding of characteristics of MEMS vapour cells developed in LEOS. The experiments will be based on precision absorption spectroscopy. A dedicated set up and analysis methods will be developed under this project to achieve these goals.

Deliverables:

- An absorption spectroscopy system to characterize MEMS alkali vapour cells will be built and tested under this project. This set up will be used to characterize the various types of miniature vapour cells being developed in LEOS.
- A quantitative understanding of the various effects such as temperature, laser power external magnetic fields, buffer gas pressure on the widths and positions of technologically relevant atomic resonances will be carried out. The system will be used to develop and optimize fabrication and operational parameters of the vapour cells for their applications in atomic resonance devices.

RES-URSC-2022-006

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

On-board software verification automation platform

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Area of Research

IVV automation
Design Patterns
ML enabled verification

Summary of the proposed research and expected deliverables

Automation platform is planned in two phases

- Phase1: Automation of code inspection level1 (traceability), and level2 activities (checklist automation) by linking in house and COTS tool chains.
- Phase-2: on-board software verification, data warehouse designing and predicting software reliability with the help of ML algorithm.

Scope of the Work:

- Applicable for all on-board software in spacecrafts.

Deliverables:

- AI enabled person independent verification platform & Software Reliability prediction.

RES-URSC-2022-007

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

(Multi Core) Leon3/4 core software simulator development for performance analysis of on board software.

Name of Co PI from ISRO Centre/Unit

Shri. Kiran Desai,
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URSC, SRQA, RQSG
U R Rao Satellite Centre, Bengaluru

Area of Research

Cycle Accurate Simulators of Single-Multi Core Architectures.

Summary of the proposed research and expected deliverables

The proposed research work were processor simulator based performance analysis of On-Board software execution which intended to address

- Timing Analysis, Cache Performance Analysis, runtime Memory Analysis and Effect of Compiler optimizations
- "Cycle Accurate Simulators" are to be developed for LEON3 and LEON4. SIMPLE SCALAR Simulator can be used as reference for the same
- Current LEON3 simulator developed lacks I & D L1/L2 Cache and MMU functionality.

Scope of the Work:

- With faster processors in On board computers like LEON4 which runs on a Quad Core with 250 MHz, there is a challenge of developing an ILS or cycle based simulator which can run faster or atleast match the speed of LEON 4, by taking into consideration the following concerns.
  - Achieving instruction level parallelism
  - Shared resource management of Caches, Memory Controllers
  - Multi threaded and Multi core environment simulation
  - Memory Coherence and Shared Memory Bus
  - WCET Analysis including - Determining impact of contention in the access to shared resources

Deliverables:

- A SILS test-bed that can be configured (with minimal changes only) as per the specifications of the OBC hardware that will be deployed in the forthcoming spacecraft.
- A SILS test-bed that can support functional validation of an entire spacecraft (all OBCs and their respective on-board software communicating and cooperating with their each other to accomplish a mission)
- A SILS test-bed that can track the status of defects in the on-board software through automated regression tests
- A cycle-accurate full-system simulation model of the OBC hardware that includes support for single-core and multi-core processors, Real-time Operating Systems (RTOS) based applications
- Support for extending the full-system simulator to accommodate changes to the OBC hardware in future.

RES-URSC-2022-008

Name of ISRO Centre/Unit

U. R. Rao Satellite Centre, Bengaluru

Title of the research proposal

Verification and Validation of Satellite Onboard Software written in ADA language using Model Checking.

Name of Co PI from ISRO Centre/Unit

Shri. Daffini Manoja J
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Reliability and Quality Software Group(RQSG),
Systems Reliability Quality Area(SRQA),
U. R. Rao Satellite Centre, Bengaluru

Area of Research

Model Checking and Automation

Summary of the proposed research and expected deliverables

Model Checking is a particular formal method which takes in "a finite model of the system" and "a formally written property" and verifies whether the system satisfies the property by making an exhaustive search for counter-examples. Models addresses how the system behaves. Properties prescribes what the system should do and what the system should not do.

For the verification and validation of Satellite Onboard software, the code written in ADA language need to be converted into abstract model and the system/software specifications to be converted to properties understandable by the model checker. Once the system is modeled, the model checker explores the systems state space in order to determine satisfaction or violation of property. The exploration of reachable and unreachable states are potential test cases which need to be executed in the testbed.

It is proposed to make a system that will automatically generate abstract model from the ADA implementation of code and extract properties from the system specification and should automatically generate test cases/test scripts which can be executed in the in-house developed Software in Loop Simulator (SILS).

Scope of the Work:

V&V of Satellite Onboard software using Model Checking.

- Automation of Model generation from onboard software implementation in ADA language.
- Automation of Property generation from System/software specifications.
- Automation of test cases /test script generation from properties.
- Building of test repository for future projects.

Deliverables:

- Automatically generated Software Model from source code.
- Automatically generated Properties from Specification document.
- Automatic generation of test cases.

RES-URSC-2022-009

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Design of Fault Tolerant On-Board Software design using commercial Multi Core Processors.

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Area of Research

Fault Tolerant Design
Multi Core Programming
Partitioning

Summary of the proposed research and expected deliverables

In on-orbit space environment, miniaturization of the processor multi cores results in the soft errors. In order to avoid the possibilities of the erroneous behavior due to soft error, an approach of Fault tolerant multi core systems using the N- Modular redundancy approach on N core partitions is though off.

Phase -1 The proposed approach will start with the Establishing the multi core processor code driven with RTOS on the commercially available board.

Phase-2 Implementing the N- Modular Redundancy on N numbered Core partitions to increase the system reliability.

Scope of the Work:

- Applicable as On-board computer in future on-board spacecrafts.

Deliverables:

- Methodology and demonstration of the fault tolerant in miniaturized multi cores technology and associated tools to achieve the same.

RES-URSC-2022-010

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Fabrication of super polished Aluminium mandrels for X ray optics substrate.

Name of Co PI from ISRO Centre/Unit

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Space Astronomy Group,
U R Rao Satellite Centre, Bengaluru

Area of Research

Space sciences (Optics Fabrication/Mechanical)

Summary of the proposed research and expected deliverables

X ray mirrors form the basic element for focusing X-rays either for imaging the source or to concentrate to a small spot: thus reducing the sensor area requirement. Soft X-ray Telescope on ASTROSAT employed a technique of coating a super-polished glass mandrel with gold which was then transferred to a thin Al foil. Individual elements were then assembled together onto a spider structure. The procedure was challenging and required very precise alignment of the individual shells to achieve the goal.

An alternate method is to fabricate a complete mirror as a continuous element using Ni electroforming on a mandrel. A first step towards this is to fabricate a super-polished Aluminium mandrel. This involves rough cutting the mandrel, Ni plating the surface, diamond turning to achieve the desired profile and finally polishing the surface to a roughness within a few nm rms. We seek collaborators to fabricate an Aluminium mandrel with a profile with tolerance of a few nm, polish (a few nm rms) and characterize it to establish the feasibility of the method. To begin with smaller versions of the mandrel (of the order of a few cm length) is acceptable. Once the quality of the mandrel is established, we will proceed with larger sizes. This will be a major step towards development of X ray mirrors for use in future astronomy and planetary science missions.

Deliverables:

- Polished (sub-micron roughness and profile) and characterized mandrel ready for Ni-electroforming along with documentation on the fabrication, testing and results.

RES-URSC-2022-011

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Autonomous Rotorcraft Modelling, Guidance, Navigation and Control (GNC) for Mapping Interplanetary Bodies with Atmosphere.

Name of Co PI from ISRO Centre/Unit

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Control Dynamics Design Group
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Area of Research

Guidance, Navigation and Control

Summary of the proposed research and expected deliverables

The motivation for this proposal is the Ingenuity flight on Mars that created history for first ever flight of an aerial vehicle on another planet. Martian atmosphere is about 1/50th as dense as sea level conditions. For a rotorcraft to operate at this low density the blade angular speeds have to be higher. For rotorcraft, aerodynamics and dynamics are strongly coupled and it is imperative that studies should include blade damping measurements in low densities. This research proposal is expected to design an aerial vehicle for Mars. The aeromechanics of Mars requires novel development of rotor blade aerodynamics and structural design. The high fidelity developed model can then be used to design an autonomous guidance, navigation and control algorithm capable of performing atmospheric powered flight on a planetary body.

Scope of the Work:

- Interplanetary Missions.

Deliverables:

- High Fidelity dynamics Model of a rotorcraft for Mars.
- Guidance, Navigation and Control Scheme for flying the rotorcraft on Mars.

RES-URSC-2022-012

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of robotic manipulator Arm Kinematics and Dynamics with Six-Degree-of-Freedom Orbit Raising and Control using Two Electric Propulsion Thrusters.

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Area of Research

Control of a Robotic Manipulator Arm

Summary of the proposed research and expected deliverables

Electric Propulsion System (EPS) provides advantage over conventional chemical propulsion due to its higher specific impulse. This leads to considerable mass saving by replacing a large chemical reservoir with a lower size gas reservoir. Additionally, it uses only two electric propulsion thrusters in place of a liquid apogee motor and more than six chemical thrusters. The EP thrusters are mounted on a robotic arm for orbit raising, momentum dumping and station keeping operations and provides 6- degree of freedom (DOF) control. Thus, allowing the increase in overall payload mass. This robotic manipulator arm should be positioned to generate required thrusts and torques, to accomplish the above-mentioned operations viz. GTO to GEO transfer, Momentum dumping and Station keeping operations. Hence, research proposal is for modelling forward kinematics, inverse kinematics and arm dynamics and demonstrate closed loop control of deployable robotic manipulator arm, to accomplish the required thrusts and torques.

Scope of the Work:

- Satellite Missions with EPS/ Robotics.

Deliverables:

- High-fidelity models for forward kinematics, inverse kinematics, dynamics and closed loop control for robotic manipulator arm.
- Autonomous orientation of the robotic arm to get the required thrusts and torques to accomplish 6 DOF attitude and orbit control.

RES-URSC-2022-013

Name of ISRO Centre/Unit

Laboratory for Electro Optics Systems (LEOS), Bengaluru

Title of the research proposal

Investigation on Raman scattering in minerals relevant to planetary exploration under varied atmospheric conditions.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Raman spectroscopy under low temperature and ultra-high vacuum.
Model analysis of Raman modes in minerals/materials relevant to planetary surfaces.
Planetary geology/mineralogy and evolution.

Summary of the proposed research and expected deliverables

Raman spectroscopy is based on the principles of inelastic light scattering with the atoms and molecules. It is a unique non-destructive finger printing technique, which provides detailed information about chemical structure, crystal structure and its phase etc. The ability to unambiguously identify both water as well as ice, organic and inorganic molecules makes the Raman spectrometer well suited for Planetary exploration. However, development and utilization of Raman Spectroscopy for planetary exploration requires a thorough understanding of experimental conditions to arrive at an optimum system configuration to understand the mineralogy of the planetary surfaces.

In this regard, below mentioned objectives of the proposed investigation/research are expected to help the development of a compact Raman Spectrometer with optimized specifications for on-board application and its utilization for studying planetary surfaces.

Scope of the Work:

- Experiments on the measurement of Raman modes in minerals (relevant to planetary exploration) under varied atmospheric/experimental conditions.
- Deduce optimized configuration of Raman Spectrometer for space/planetary exploration.
- Generate Raman database for system calibration and formulate suitable data analysis (model) scheme.

Deliverables:

- Optimized configuration of Raman Spectrometer for potential space/planetary exploration.
- Raman data base of experimental test results on minerals relevant to planetary exploration.
- Modeling of Raman spectra of minerals relevant to planetary exploration.

RES-URSC-2022-014

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Accurate Electromagnetic analysis of antenna radiation patterns in the presence of metallic appendages in spacecraft environment.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Computational Electromagnetics

Summary of the proposed research and expected deliverables

Computational electromagnetic methods are essential for predicting the radiation patterns of the omni directional antennas in the presence of other satellite subsystems like solar panels, metallic structures, and spacecraft body. Presently commercial EM solvers / softwares are being used for the prediction of antenna patterns for the spacecraft. High frequency techniques like Geometrical Theory of Diffraction, Uniform Theory of Diffraction, Physical Theory of Diffraction, Uniform Asymptotic Theory, Equivalent Current Method, Hybrid MoM and UTD techniques can be used for the antenna analysis or combination of two or more computational electromagnetic techniques can also be used for solving the above scattering problem. A generic electromagnetic software /codes shall be developed to take the inputs like, spacecraft geometry, materials and location of the omni directional antenna for predicting the radiation patterns of the antenna. Selected computational code (s) shall be accurate in prediction and shall take moderate time for computation.

Scope of the Work:

- Computational Electromagnetic codes to predict the antenna radiation patterns in the presence of metallic appendages in spacecraft environment.
- Software code shall have compatibility with Windows10 or Linux platform.

Deliverables:

- Developed software code.
- Predicted radiation patterns for the given spacecraft structure
- Project report.

RES-URSC-2022-015

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Surface Acoustic Wave Filters for UHF and L-Band frequencies.

Name of Co PI from ISRO Centre/Unit

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Shri. Aditya Anand Gupta

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Area of Research

Surface Acoustic Wave Filters

Summary of the proposed research and expected deliverables

Surface Acoustic Wave filters are used in microwave receivers in spacecraft applications for providing high selectivity performances. Conventional SAW filters are having sharp rejection characteristics but their insertion loss is very high. Development of new materials and new fabrication techniques in these filters area can result in low insertion loss and high frequency operations as per literature. SAW filters in UHF and L-Band are required with low insertion loss performances for future receivers of spacecraft applications. SAW filters with bandwidth of ~2 MHz and insertion loss of less than 3 dB are to be developed at L-band frequencies within 10 mm^2 size.

Scope of the Work:

- Presently SAW filters are developed at VHF band frequencies with moderate insertion loss. Proposal is to develop the SAW filters at UHF and L-Band frequencies with lower insertion loss.

Deliverables:

- The detailed working mechanism of SAW filters to be provided.
- Simulation results
- Optimization algorithm.
- Fabrication methodology (ISRO also can support)
- List of materials
- Samples 4 nos for evaluation
- Project report

RES-URSC-2022-016

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Direction of Arrival and localization system for Search and Rescue Applications.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Localization Model

Summary of the proposed research and expected deliverables

Electromagnetic sensors placed on a satellite platform are capable of determining the Angle of Arrival / Direction of Arrival (AoA/ DoA) of EM waves from the emitting source. Multiple such bearings received by a satellite along the orbit, can be combined to obtain a localization on the emitting source. Further, the localization can be achieved from a network of time synchronized spacecrafts, receiving the emissions simultaneously. Various mathematical/ interferometry techniques such as Time of Arrival, Time Difference of Arrival (TDOA), Angle of Arrival (AoA) etc. and a combination of these techniques, are presently used for a triangulation/ trilateration in such localization applications.

Scope of the Work:

- A high accuracy and resource efficient localization model shall be developed which would use the multiple bearing readings for its calculation.

Deliverables:

- Localization Model.
- Localization simulation
- Project report.

RES-URSC-2022-017

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

GNSS receivers for Lunar Applications.

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Area of Research

Navigation Algorithm

Summary of the proposed research and expected deliverables

Extending GNSS based state vector estimation from LEO / GEO experience to Lunar satellite missions.

Design and development of ultra-high sensitive (< 8 dB-Hz CNDR) GNSS receiver algorithms in DSP for Lunar orbiter and Rover position determination. The work shall have compatibility to be integrated with URSC receiver hardware based on Virtex-5 FPGA platform

Scope of the Work:

- Extending GNSS based state vector estimation to Lunar satellite missions.

Deliverables:

- Acquisition and tracking modules.
- Navigation solution algorithms
- Project report.

RES-URSC-2022-018

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

RFIC for wideband microwave receiver analog front end

Name of Co PI from ISRO Centre/Unit

Mr. Venkata Vinay Kuamr Doki
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Mr. Avjit Roy Choudary
Scientist / Engineer - 'SF'

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Area of Research

RFIC development using CMOS/BiCMOS technology

Summary of the proposed research and expected deliverables

Realisation of integrated RF down converter as a single chip using CMOS / Bi-CMOS technologies. The front end gain is programmable for the AGC requirement of the receiver with input signal strength indicator. It shall have protection against high power input. It shall have reconfigurable local oscillator. Downconverter shall accept input in the dynamic range of -60 to -120 dBm and provide 2v p-p output.Offchip filtering shall be available.

Design and Simulation shall be carried out and system performance to be demonstrated using Digital Signal Processing based demodulation. Design simulation files shall be shared periodically.

Scope of the Work:

- Integrated RF down converter chip using CMOS / Bi-CMOS technologies which can take input at L/ S/C/ X band and provide I and Q outputs for digital demodulation.

Deliverables:

- Design simulation files, design layouts of the block designs, complete system design and Final GDSII file

RES-URSC-2022-019

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Protocols for reconfigurable communication system on ultra-massive MIMO architecture.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Reconfigurable Communication Systems
UM-MIMO

Summary of the proposed research and expected deliverables

The mm-wave/ THz band Ultra-Massive MIMO (UM-MIMO) technology opens avenues for a variety of reconfigurable communication systems for short-range communication, between various packages/ devices and any human interfaces, in a networked environment. Various advantages such as avoidance of cabling complexity, inherent channel redundancy, lower power requirements, physical re-configurability, faster set-up time, etc. are all attributed to this type of a system.

Scope of the Work:

- Protocols shall be developed for such a reconfigurable communication system, based on existing / proposed industry protocols, operating on an ultra-massive MIMO architecture to set-up a network of such devices and enable reconfigurable communication channels between the various elements of the network. The networking shall be made possible wirelessly using the UM-MIMO concept.

Deliverables:

- Realisation of Reconfigurable Communication protocol.
- Design simulation files.
- Project report.

RES-URSC-2022-020

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Mechanical package design of light weight (<1Kg) and high RF power handling capability (20 Watts CW) for spacecraft applications. The mechanical design shall comply with EMI /EMC Mil standards.

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Area of Research

Metallic enclosure /package design for High power RF amplifiers

Summary of the proposed research and expected deliverables

Onboard High Power SSPAs are used in TTC transmit bands in GEO satellites to meet the downlink margins.

As all high power circuits are bulky, because of high power dissipation requirement, as power dissipation is proportional to the heat sink area. Usually aluminum enclosures are utilized for designing such enclosures, which has its own limitations and possibility of further miniaturization is very limited.

In recent years, more material choice and access to advanced fabrication technology is available. Modern packages are much higher power handling then before.

We want to use these materials and fab techniques to design SSPA enclosures with much smaller size and mass.

A typical GaAs/GaN based 20watt RF power Transmitter dissipates 100 watts DC power at Ku-band (10-12GHz)

Scope of the Work:

- Heat dissipation of the order of 100 watt in a mechanical housing, with minimum mass is a design challenge. This may be achieved through suitable material or suitable thermal design using micro-heat pipe etc. This design approach can be very useful in realizing light weight High power MMIC circuits/SSPAs.

Deliverables:

- Mechanical design files of enclosure in required format. Format to be compatible with all standard mechanical fabrication and 3D printer also. A prototype to be realized and tested to demonstrate the performance. Support for fabrication and testing can be provided by URSC, if needed.

RES-URSC-2022-021

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

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

Name of Co PI from ISRO Centre/Unit

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Ms. USHA G

Dr. Dineshkumar

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Area of Research

Hybrid solar cells

Summary of the proposed research and expected deliverables

The recent invention of Hybrid ferroelectric discotic liquid crystal solar cell has introduced a DLC-discotic liquid crystal - materials that have the properties of both crystals and liquids (tri phenylene core with two additives) in place of Iodine REDOX electrolyte in DSSC solar cell. The self-organization of disc-like or plate-like molecules leads to the formation of DLCs which are composed of polycyclic aromatic cores, such as triphenylene (TP), anthraquinone, phthalocyanine (Pc). In this columnar arrangement of aromatic cores, electrical conductivity along the columns have been observed to be many orders of magnitude greater than that in perpendicular direction. Long exciton diffusion length and high charge-carrier mobility are the key factors to realize efficient solar cells. This liquid crystal shows Ferro electric behavior and contributes to the increase in efficiency of HFLC solar cell. For a 0.2 cm2 solar cell, PCE is 24.4%, Jsc21.5 mA/cm2 and Voc is 2.14 V. The spectral response is observed from 300nm to 1100 nm. The conduction mechanism and factors depending has to be studied in detail.

Scope of the Work:

- The excitonic mechanism of HFLC solar cell especially multi exciton formation needs to be addressed along with origin of ferroelectric and ferromagnetic behavior of discotic liquid crystal redox. Support for testing the solar cells under sun simulator can be provided by URSC.

Deliverables:

- The detailed working mechanism of found HFLC solar cell to be addressed.
- 5 no. of HFLC solar cell prototypes with various photoactive areas, fabricated and characterized to be submitted to ISRO.
- HFLC solar cell fabrication technology to be transferred to ISRO.

RES-URSC-2022-022

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Cognitive agent for artificial-intelligent enabled cognizant space-crafts

Name of Co PI from ISRO Centre/Unit

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Area of Research

Artificial intelligence, machine-learning, cognitive architecture, Evolutionary algorithms, Re-enforcement Learning.

Summary of the proposed research and expected deliverables

The high RTT(round-trip time)of communication with ground stations in deep space missions demands an increase in autonomy of decision-making by the on-board computer. An intelligent agent capable of real-time reliable and interpretable decision-making could help prevent catastrophic situations.

Furthermore, with the ever-growing telemetry and telecommand dataset for numerous spacecrafts, development of a more universal method for analysis is required. The use of machine learning and artificial intelligence has seen significant advancements over the last few decades. These algorithms are designed to achieve a specific task with very little distraction and no irrelevant reasoning's. However, they suffer from overfitting to the task at hand. This causes a lack of generality and a need for human intervention at every stage further on.

The development of a cognitive agent which would interact with the dynamic environment of all the on-board data and telemetry performing innate as well as learned tasks is the objective of the project.

Scope of the Work:

- It should have the ability to interact with large and diverse body of information
- The machine learning algorithms should be customizable
- The architecture of the software needs to be modular.
- It needs to adapt and learn from both the onboard data and the telecommands provided from ground stations as the mission proceeds.
- Autonomous decision making should have an explanation on some level (eg- interpretable AI).

- The cognitive architecture should be capable of supporting multiple processes executing on multiple processors

Deliverables:

- A preliminary literature survey addressing the feasibility of development is to be conducted.
- A preliminary architecture capable of handling and processing data in real time to be developed.
- For various subsystems of power systems, the agent must show capability of performing autonomous tasks such as anomaly detection for diagnosis and signature search for prognosis.
- The agent performs looped-learning and meta-learning for improvement of the decision-making process.

RES-URSC-2022-023

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Cost effective tandem solar cell technologies for space and terrestrial applications

Name of Co PI from ISRO Centre/Unit

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Area of Research

Cost effective tandem Si-Perovskite Solar cells

Summary of the proposed research and expected deliverables

More than 90% of the terrestrial PV market is dominated by crystalline silicon solar cells and efficiencies have reached 26.7% in the laboratory and 20% at module level. Across the last decade, an efficiency improvement of 5% was reported. Silicon PV technology is mature and has come very close to its Shockley–Queisser (SQ) efficiency limit.

Perovskite Solar Cells (PSCs) have recently emerged and increased their efficiencies from 3.8% to 25.5% within a relatively short period with a specific power of 29.4 W/g. Due to the stability constraints in PSCs alone, opportunity lay in using them in tandem cells due to their tunable direct band gap (1.51 –3.0 eV), High diffusion lengths of charge carriers (in microns), defect tolerance (radiation hardened).

III-V tandem solar cells are the leading PV technology but limited for space application with commercial device efficiencies around 30-32% (one sun, AM0) with a specific power of approx. 0.5 W/g. In the past two decades, the power conversion efficiency of commercially available triple-junction solar cells was saturated around 27%-30% with a specific cost of around $150/W. Space community looking for a high efficiency light weight solar cells and at the same time, the terrestrial

community is exploring high efficiency and low-cost solar cells, that can be achieved by fabricating a tandem cell with another absorber layer of high bandgap material.

In only 5 years, the efficiency of silicon (Si)—perovskite tandems have rapidly increased from 14% in 2015 to 29.4% in 2020, surpassing the efficiency record of single-junction-Si solar cell. A dual junction Si-perovskite have a promising solution to improve the efficiency, decrease the cost and to cater the both terrestrial and space needs.

Scope of the Work:

- To increase the stability of the perovskite absorber layer in tandem silicon-perovskite configuration
- Report the power conversion efficiency with resulted perovskite
- Report on the stability properties of the resulted perovskite materials as well as fabricated tandem perovskite solar cells

Deliverables:

- Expected deliverables are detailed study and analysis of optimized device layers and samples along with programming codes if any.

RES-URSC-2022-024

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Numerical simulation of III-V semiconductor thin films growth in MOCVD Process for Solar cell applications

Name of Co PI from ISRO Centre/Unit

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Area of Research

III-V Multijunction Solar cells

Summary of the proposed research

Triple junction III-V semiconductor solar cells (Ge/InGaAs/InGaP) are the leading PV technology limited for space applications with commercial device efficiencies around 30-32% in one sun, AM0. In the past two decades, the power conversion efficiency of these devices was saturated around 27%-30% although ideal theoretically efficiencies of a triple junction solar cells are around 60% (0.69 / 1.17 / 1.74 eV). So, the understanding of device parameters such as film growth rate, composition, thickness uniformity, dopant incorporation and defect distribution are critical for device fabrication. Metal-Organic Chemical Vapor Deposition (MOCVD) technique is considered as one of the most versatile and economical techniques used for deposition of large area III-V semiconductor thin films

and devices such as LEDs and solar cells. Thin films are deposited using process gases of very high-level purity eliminating the possibility of contamination from sources. This is the reason why CVD is more ideal for depositing semiconductor thin films compared to sputtering or evaporation. MOCVD process involves complex chemical and transports mechanisms which contains parameters such as growth Reactor pressure, Susceptor temperature, Inlet velocity, Precursors volumetric flow rate etc. Relying on experimental approach needs numerous trials which consumes time and money to reach an optimum device structure. MOCVD process simulation can help shorten the time to reach the optimized efficient device structure and reduce overall manufacturing cost.

Scope of the Work:

- Obtaining the III-V semiconductor growth parameters such as growth Reactor pressure, Susceptor temperature, Inlet velocity, Precursors volumetric flow rate etc. and their effect on thin film growth. Also, optimization of thin film layers to obtain cost-effective multijunction solar cell structures.

Deliverables:

- Expected deliverables are detailed study, simulation results along with programming codes. In addition, identifying the ratio and composition of different III-V precursors that is ideal for achieving the desired thin film characteristics.

RES-URSC-2022-025

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Numerical simulation of Parallel gap resistance welding Process for Solar cell interconnection

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Area of Research

Parallel Gap welding of III-V Multijunction Solar cells

Summary of the proposed research and expected deliverables

The Interconnection of solar cells is accomplished by using Parallel gap resistance welding (PGRW) which have a Silver (Ag) metal contact on its rear side and an interconnect (IC) in the front side. The electrical continuity is achieved by interconnecting the front side IC of one solar cell to the backside Ag metal contact of another solar cell. The IC is made up of Kovar (a Nickel-Cobalt and Ferrous alloy), with Ag surfaces on top and bottom. In PGRW electrodes are held with some force, over the IC which is kept on the rear side of another solar cell, and a potential difference is applied across the electrodes. As current passes through the IC and the Ag surface on the rear side of the solar cell, it

heats up the material and a thermo compression weld are formed at the interface. The resistance at the interface is a function of the force applied by the electrodes, and the presence of impurities at the interface. Apart from the contact resistance, the resistance of the IC layers and the back contact controls the current drawn from the electrode. The heat produced due to Joule's heating increases the temperature of the IC and the contact, and this changes the resistivity of the material. In order to understand the quality of the weld, it is essential to understand the temperature distribution in the IC and the contact.

Scope of the Work:

- PGRW simulation needs a coupled modeling of electrical, thermal, mechanical, metallurgical processes which are essential for simulation of resistance welding process to predict the welding results. The electric current flows from one electrode to the other through the IC and the solar cell contact. The current generates Joule heating in its path. The heat generated due to Joule's heating is then distributed to the entire IC and the solar cell through conduction. The heat loss from the system is due to radiation from the IC and solar cell surface to the ambient atmosphere, convection currents of the air over the system, and conduction to the solar cell material. The proposed research is to model and analyze the PGRW to find the temperature distribution in the system.

Deliverables:

- Expected deliverables are detailed study, code developed, simulation and experimental results.

RES-URSC-2022-026

Name of ISRO Centre/Unit

U R Rao Satellite Centre, Bengaluru

Title of the research proposal

Development of Printable CIGS ink for Flexible Solar Cell

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Area of Research

Thin Film Flexible Solar Cell

Summary of the proposed research and expected deliverables

Copper Indium Gallium Selenide (CIGS) based solar cells have become one of the most promising candidates among thin-film solar cells. The current record photo-conversion efficiency (PCE) has reached ~ 23% in the lab-scale devices and ~17% in modules, which is comparable to the crystalline silicon solar cells. While crystalline Si-solar cells are generally rigid, thin-film CIGS solar cells with >15% PCE has been reported on flexible substrates such as stainless steel, aluminium and polyimide.

High-performance CIGS cells are conventionally fabricated using vacuum-based techniques such as co-evaporation and multistage sputtering. However, vacuum-based processes are costly and cannot be easily adopted in large scale production. On the other hand, Ink-based printing technologies are cost-effective, industrially scalable, and can be adopted for roll-to-roll processing on flexible substrates. In recent years, printing technologies have evolved rapidly, especially in the field of printed electronics. This technology can also be used to develop CIGS solar cells. To use this technology, the critical requirement is to develop a suitable ink in terms of viscosity, surface tension and stability, which leads to compact and homogeneous films suitable for fabricating solar cells.

Scope of the Work:

- This approach of printable CIGS will lead to an inexpensive fabrication route for CIGS-based PV devices. This approach can be applied to the roll to roll manufacturing process for large-area devices.

Deliverables

- Printable CIGS ink and printing protocol

NATIONAL REMOTE SENSING CENTRE
HYDERABAD

RES-NRSC-2022-001

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

Title of the research proposal
Comprehensive Agricultural Drought Assessment.

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Area of Research
Agricultural drought assessment & monitoring

Summary of the proposed research and expected deliverables
Quantifying agricultural drought is very important in addressing both farmer's distress as well as efficient governance in addressing crop situation by the state departments in this proposal an attempt is made to develop a comprehensive drought assessment technique integrating satellite data, ground based weather information, crop simulation models.

Scope of the Work:

- There are several remote sensing indices to visualize, monitor the crop growth and development to help facilitate agricultural drought monitoring. However, a unified reliable index which gives information on available soil water, precipitation and its influence on crop response is very essential to forecast regions of agricultural drought / impacts on agricultural yields at monthly or seasonal scale are still in their development process.
- The study aims to identify location specific indices or parameters for agricultural drought and testing of new indices/models and development of quantifiable techniques towards integrating remote sensing and ground based agricultural drought assessment indicators for kharif and rabi seasons. This helps in realizing a comprehensive drought assessment technique and further a protocol development to address yield loss due to agricultural drought.

Deliverables:

- Comprehensive drought assessment indicators integrating satellite data meteorology and crop simulation models suitable for Indian regions.
- Development of protocol for crop loss assessment due to agricultural drought.

RES-NRSC-2022-002

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Development of Fluorescence Line Height (FLH) based algorithm for chlorophyll and phytoplankton blooms detection

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Area of Research

Ocean Colour Remote Sensing / Biological Oceanography / Ocean Bio-Geo-Chemistry

Summary of the proposed research and expected deliverables

Phytoplankton is a microscopic, single cellular organism drifting on the surface water, human eyes or sensors cannot observe it. And in fact, a bulk effect of more than hundreds of cells is what human or remote sensors observe. Therefore, the interaction of bulk cells with light might be described by the theory of single-particle scattering, which is a framework to understand the microscopic level of light interaction with a single cell and present the fundamental theories needed for Chl-a bio-optical modeling. Phytoplankton cells are considerably variable in size, from less than 1 mm to larger than 10 mm. The cells are not only varied by six orders of magnitude in size but can be seen in the form of unicells to a cluster of cells, filaments or colonies. The structure of cells can be different between each phytoplankton species and show different behaviors, for instance, in diatoms silica cell morphology or cyanobacteria gas vacuoles. Despite the diversity in size, form, structure, and behavior that influence the specific optical properties of the phytoplankton, all phytoplankton species contain a green pigment Chl-a. Chl-a is an essential indicator for estimating phytoplankton biomass and lake productivity using Chl-a bio-optical models. These models estimate Chl-a through three pathways: phytoplankton absorption, fluorescence, and backscattering.

However, several reflectance based algorithms were developed well validated in the open oceans. However, due to the complexity of the coastal waters estimation of Chl-a is still needs to evolved beyond the reflectance based methods towards the fluorescence based techniques. Given that the Chl-a is proportional to the Sun Induced Fluorescence (SICF) emission, many studiesstarted to examine its validity to measure Chl-aconcentration in coastal waters, results showed agood correlation between Chl-a and SICF using MODIS and MERIS sensors.

The present study aims at developing and validating the FLH based models / algorithms in the turbid coastal waters all along the Indian coast using the upcoming Oceansat-3 OCM sensor.

Scope of the Work:

- This above project is one component of the ongoing research activities under Oceansat-3 (EOS-6) ocean colour monitor.

Deliverables:

- Developing and validation of techniques / methodologies /a algorithms for retrieval of surface chlorophyll in the turbid coastal waters using fluorescence / FLH based methods.
- Detection / identification of phytoplankton blooms using fluorescence / FLH based method.

RES-NRSC-2022-003

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Ocean Surface currents variability in the Bay of Bengal using satellite, In-situ and Numerical models.

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Area of Research

Generation and analysis of ocean surface currents in the Indian Ocean using multi satellite data.

Summary of the proposed research and expected deliverables

Ocean currents play an important role in the distribution of heat and salt distribution in the global ocean. Satellite observations since the last 25 years will be utilized for the identification of the intra-seasonal to interannual oscillation in the Bay of Bengal (BoB) circulation. The coastal radar network-based surface currents and the OMNI and RAMA buoys in the BoB will be utilized for understanding of the high frequency variability in the ocean current. Investigation of intra-seasonal (monsoon Intraseasonal oscillation (MISO) and MJO) to interannual variability (Indian Ocean Dipole - IOD) of currents on the heat and salt budget will be carried out. The coastal upwelling, which is one of the coastal processes required for potential fishing zone will be analyzed. Finally, the ocean model using Regional ocean modeling system (ROMS) experiments will be carried out for studying the role of local winds and the coastal trapped Kelvin waves on explaining the observed ocean current variability. This work will identify the ocean surface currents variability in the Bay of Bengal, which has larger impacts on the navigation, oil-spill, heat and salt, sedimentation, eddies and potential fishing zones.

Scope of the Work:

- Identification of the intra-seasonal to interannual variability in the ocean currents in the Indian ocean from satellite derivedcurrent and in-situ data.

- Investigation on the role of intra-seasonal to Interannual variability of the surface currents on the oceanic processes; coastal upwelling, heat, and salt budget.
- Ocean model experiments on the role of atmospheric forces on the observed ocean current variability.

Deliverables:

- Identifying the hot-spot regions with large variability in ocean surface currents.
- Assessing the role of ocean currents variability in explaining the Indian Ocean warming.
- Different variability scale of the surface currents using satellite, in-situ and model, which will be useful for different applications like heat and salt transport, eddies, PFZ etc.

RES-NRSC-2022-004

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Modelling Gross Primary Production and Evapotranspiration for Drought Monitoring over India.

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Area of Research

· Earth, Ocean, Atmosphere, Planetary Sciences and Applications
· Water Resources Studies
· Drought Assessment and monitoring using remote sensing

Summary of the proposed research and expected deliverables

Precipitation and vegetation indices such as NDVI have been frequently used for drought monitoring because of the complete understanding of the performance such indicators and near-real time data availability. Even in the Indian context, these two variables have been used for a long time for drought monitoring. However, ET and GPP have not been used for drought monitoring and impact assessment over India primarily owing to the lack of long term consistent datasets on ET and GPP.

We have developed an algorithm to map ET using TIR data from INSAT-3D, MODIS, NPP-Soumi and Lansat TM which can be used operationally to generate ET product towards drought monitoring. The class of ET model which will be beneficial across different parts of India to monitor droughts is questionable.

The global GPP products are not available on a continuous basis except MODIS 17 GPP product. However, the performance of the MOD 17 GPP product had varied across the globe and not been studied over India. In addition, almost all the GPP models require biome/plant functional type specific calibration. The calibration has been carried out based on flux tower data obtained predominantly

over North America, Europe, China and Australia. Thus, it is not sure if the datasets will be performing better over India which has diverse climatic and land use practices when compared these countries.

Hence, it is necessary to compare the performance of different ET and GPP models over Indian region and to understand their co-evolution particularly during and after drought events. This will help in developing a model for GPP estimation over India and include ET and GPP in a multi-variate drought index.

Scope of the Work:

- The aim of this study is to test the use of ET and GPP for drought monitoring and drought impact assessment. Towards this aim, the following objectives are framed:
  - To estimate the Gross Primary Productivity using semi-empirical and physical models over India.
  - To compare and understand how ET and GPP estimated using different models captures and respond to drought conditions.
  - To compare the modelled ET and GPP with variables/indices such as Solar Induced Chlorophyll Fluorescence (SIF) and LST that are directly observable from satellites to understand their relative advantages and disadvantages for drought monitoring.
  - To develop a multivariate drought index that can potentially monitor water stress and vegetation productivity and compare it with traditionally used drought indices.

Deliverables:

- Detailed analysis of existing ET and GPP products (both global products and the ET products developed over India from the PI's research group) in order to understand the relationship between ET and GPP as indicated by different products especially during drought events.
- Development of algorithms for GPP modelling.
- Development of ET based drought Indices & GPP and comparison with different variables and traditional drought indices.
- Development of a multi-variate, composite drought index.

RES-NRSC-2022-005

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Development of Low cost Remotely operated platform for Bathymetry & water resource applications.

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Area of Research

Bathymetry applications

Summary of the proposed research and expected deliverables

Primary objective of this project is –

- Design & development of low cost remotely operated platform comprises customised rugged platform with propulsion, telemetry and control electronics.
- Mechanically stable platform with payload capacity upto 10 kg and speed upto 5 m/s shall be tested in open water bodies for its performance and endurance.
- For validating aerial bathymetry lidar and UAV bathymetry data, it is pre-requisite to have accurate bathymetry system with remotely operated platform to acquire the survey data over water body in optimum time for generating & evaluating results in fast manner.

Scope of the Work:

- The developed remotely operated platform will be used with in-house developed bathymetry system of ASDMA/NRSC for bathymetry & water resource applications in open water bodies'deep upto 100 m.

Deliverables:

- Full-fledged, low cost, customized remotely operated surface platform to cater the requirement of bathymetry survey & water resource applications.
- Furthermore it will reduce the survey time and logistic efforts which are critical in bathymetry survey.
- When installed with in-house developed bathymetry system, can be used as in-situ bathymetry system for validating airborne/UAV bathymetry survey data.
- Also it will cater the requirements of ground truth bathymetry & water quality assessments for evaluating water quality parameters derived from satellite remote sensing techniques.

RES-NRSC-2022-006

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Big Geospatial data analysis for Climate Change with special emphasis on land use / land cover dynamics in Western Rajasthan.

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Area of Research

Bigdata based assessment of historic environmental parameters / variables and anthropogenic activities which drives the land use / land cover dynamics which in turn affect the climate. Similarly impact assessment of climatic conditions on the land use / land cover dynamics.

Summary of the proposed research and expected deliverables

Geographically, the maximum part of the Western Rajasthan is situated / covered under Thar Desert Area which is also known as semiarid area in climatic terms.It has been observed that due to various anthropogenic activities(mining, agriculture activities, urbanization etc.) for economic development in the region,impacting the land use / land cover over a period of time.Hence, there is as temporal change in the land use / land cover and it has been captured by remote sensing data and other source of data. At the same time natural phenomenon viz.; dust storms, drought, flood, desertification etc. also plays the key role for changes in the land use / land cover of the region over a period of time. Hence, it is very much essential to capture these temporal changes and its impact assessment over climate and reversibly assessment of impact of climate on land use / land cover over a period of time. Which is a very challenging and complex task in nature.

The Bigdata / Big Geospatial data analysis approach would allow to attempt / deal with above mentioned complexity or capture the such temporal behaviour of the regional ecosystem and allow us to visualize the semiarid / desert ecosystem in depth to further formulate the policies addressing the Sustainable Development Goal (SDG) 13 & 15.

Scope of the Work:

- Investigation of the impact of land use / land cover dynamics on climate change and vice versa, over a period of time is highly complex in nature and Bigdata / Big geospatial data approach would support and can bring out the insights for climate change. Further, it would be helpful for defining the sustainable measures for prevention / exploitation of natural resources in the regions addressing the Sustainable Development Goal (SDG) 13 & 15.

Deliverables:

- Anthropogenic factors driving the temporal land use / land cover changes in the region (Western Rajasthan) viz.; mining & agriculture activities, urbanization, harnessing of renewable energy etc.
- Environmental factors driving the land use / land cover changes in the region (Western Rajasthan) viz.; dust storm, drought, flood, desertification, extreme weather conditions etc.
- Role of preventive measure viz.; afforestation, sand dune stabilization, green area development etc.
- In totality factors affecting the climate and visa-a-vis climate affecting the land use / land cover in the region.
- Policy formulation for sustainable resource management based on Bigdata analysisto support Sustainable Development Goal (SDG) 13 &15in the region(Western Rajasthan).

RES-NRSC-2022-007

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Village Level Web Enabled Data Analytics Tools for Geospatial Database of rural assets using open source tools.

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Area of Research

Spatial Pattern Analysis, Development and Planning of rural assets

Summary of the proposed research and expected deliverables

Geo-tagged data is emerging as an important source of information, both in traditional and big data analytics. Rich repository of geotagged data is available in Bhuvan portal which is highly amenable to spatial analysis and research for rural development and planning. It possesses 3V properties such as Volume, Velocity and Variety that are attributed for any big data sources. These geo-spatial assets exceed the capacity of current computing systems and hence need for specialized computing platforms such as big data platforms and data analytic tools. Further, to deliver various decisions making models on the basis of available heterogenic data sources, pattern driven data analytical techniques such as machine learning and deep learning techniques could also be deployed on the top of the big data platform.

By incorporating prediction models such as decision tree induction, clustering and others in the existing Bhuvan-Rural applications, effective online decision making activities would be benefited for various stakeholders such as Government officials and policy practitioners.

Scope of the Work:

- The project envisages providing click of mouse solution to perform spatial pattern analysis of rural works implemented under various programms over the area of interest based on administrative unit upto the village level. It would use the geotagged data of Bhuvan rural applications as an primary imput. Since the data is collected dynamically by the field staff on near real time basis, the analysis will also be taken up on the dynamic basis defined in terms of the timeline (date specific) by the user. The project is expected to help the researchers and decision makers in understanding the project impacts on ground by providing them with spatial variation of works executed.

Deliverables:

- Enhanced visualization of Geo-tagged assets using exploratory spatial analysis tools both in time and space domain.

- Web enabled reporting of spatial pattern of works implemented in the form of Dashboard to assist the decision making and implementing models for land and resource planning towards improving rural livelihoods.

RES-NRSC-2022-008

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

Title of the research proposal
Development of techniques for correction of artefacts in Remote Sensing Images

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Area of Research
Satellite data processing

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

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

Scope of the Work:

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

Deliverables:

- Tool / utility with GUI and code.
- User document.

RES-NRSC-2022-009

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

Title of the research proposal
Urban Object Detection using UAV Remote Sensing.

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Area of Research

Remote Sensing Application for Urban Infrastructure Assessment.

Summary of the proposed research and expected deliverables

In an Urban environment Urban Objects like Roads, Trees, Foot paths, Buildings, Man holes, Street lights, Water supply vents etc play a vital role in urban planning. Information about these urban objects in terms of locations, usability, capacity and monitoring is need of the hour for policymakers, administrators and impacts their planning decisions.

Existing approaches for urban objects detection rely on manual feature extraction procedures using data from various platforms like aircrafts, satellites, UAV/Drones etc. Automatic Object detection is a challenging problem in the field of remote sensing (aerial/UAV and satellite image analysis) and requires approaches related to knowledge based, Object based, Machine Learning based methods / techniques to achieve the required goal. The current study aims to explore UAV data and develop Techniques/ algorithm along with a methodology for detection of urban Objects.

Scope of the Work:

- Develop Techniques/ algorithms along with a methodology for detection of urban Objects from UAV data.
- Applications related to Urban infrastructure planning and monitoring, illegal constructions, Green spaces/ trees, impervious surfaces and slum management require a location-based inventory.

Deliverables:

- Detailed Methodology.
- Algorithms/Techniques.
- Inventory of location based Urban Objects.

RES-NRSC-2022-010

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Bundle Block adjustment of Large scale Indian Remote Sensing Data for large area ortho product generation using combination of AI/ML/DL technologies along with mathematical models.

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Area of Research
Orthorectification, Bundle block adjustment, Large scale large area remote sensing data.

Summary of the proposed research and expected deliverables
With the launch of sub meter spatial resolution remote sensing satellites, the need for the geometric adjustment with subpixel accuracy for large scale mapping applications involving large area mosaics is on the rise. These HR sensors can obtain large-scale remote sensing data which consist of a great number of images. Bundle block adjustment of large-scale data with conventional algorithm is very time and memory consuming due to the super large normal matrix arising from large-scale data. Hence, there is a requirement to develop new efficient hybrid technology algorithms combining the power of AI/ML/DL techniques during image matching and statistical methods for arriving at the mathematical models for geometry adjustment across the scenes in the block.

Scope of the Work:

- The Scope of the proposal is to realize the state of the art bundle block adjustment algorithm for large scale data to generate large area ortho products. This will include software for bundle block adjustment of the all the scenes in the block and their ortho rectification.

Deliverables:

- Algorithm implementation code and the results along with the complete documentation.

RES-NRSC-2022-011

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

Title of the research proposal
Development of deep learning framework for auto quality certification of all IRS optical Satellite Images.

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Area of Research
Satellite Image Processing, Pattern Recognition, Machine Learning, Deep Learning

Summary of the proposed research and expected deliverables

Multi mission quality evaluation software package with the capability of handling the highly voluminous, various data formats and different data types of Resourcesat and Cartosat Missions and similar Optical missions satellites data needed for validating and qualifying the products generated in automatic production chain. This will facilitates the generated products to be in harmony wrt to radiometry and geometry across all optical missions. To meet this a new indigenous software is proposed to be developed using AI/ML and machine learning techniques with embedded capabilities for adding future optical missions and SAR missions, to evaluate product quality parameters. Both in spatial and spectral fronts like spatial inaccuracy, noise patterns, artifacts, saturations, streaking, Repeated coupling image(Ghost patterns), Band to band miss- registrations in case of multispectral data and any other specific sensor related issues which are known, the database of which is available with us and expected occasionally.

Scope of the Work:

- It is essentially required to design and develop highly accurate optical data products quality evaluation software that uses deep learning techniques to automatically certify the IRS products for the parameters of geometric accuracy using reference image, Ground Control Point Library (GCPL) using pattern recognition/better approaches by AI/ML techniques, stagger correction evaluation, side lap /overlap evaluation, band to band registration (BBR) evaluation and radiometric quality evaluation including noise ,detecting the artifacts.

Deliverables:

- State of art computing architecture/Optimal computing software system for processing certifying and processing of large volume RS data products for systematic and non-systematic errors.

RES-NRSC-2022-012

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Web GIS and Data Dissemination for geoportal applications and services

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Area of Research

Geospatial Web Applications and analytics

Summary of the proposed research and expected deliverables

GIS today encompasses many critical aspects of geospatial data dissemination, including metadata information, geospatial web services, information retrieval, automated discovery, geotagging, geospatial data sharing and interoperability. Data dissemination was always a significant activity in all types of ISRO Operational Programmes and its legislative framework has to be continuously updated

with new regulations and decisions. The objectives of the research shall focus on the development of Web-GIS tools to support decision making and also provide various data and information to the scientific community interested in natural resource applications. Some of the applications to be addressed are Augmented Reality, Real-time geospatial intelligence, Indoor Mapping with Wi-Fi/ Bluetooth, Passive GIS sync with Social media. Sensor Web with Uniform Resource identifier, Open source data centre computing. Geo intelligence of crowd sourced information, Trend Analysis on Time series thematic data.

Scope of the Work:

- Development of Web-GIS tools to support decision making and also provide various data and information to the scientific community interested in natural resource and Disaster related applications.

Deliverables:

- Geospatial Web Application Framework having capabilities to do trend analysis on Time Series thematic data, Geo-intelligence of crowd sourced data, Real-time geospatial intelligence, Passive GIS sync with Social media in a simple web browser with low bandwidth.

RES-NRSC-2022-013

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Crowd sourcing for landslide inventory using IoT.

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Area of Research

Area - Earth and Ocean Applications
Sub-area - Geosciences

Summary of the proposed research and expected deliverables

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

Scope of the Work:

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

Deliverables:

- A computer program that will be executed everyday to create a landslide database of India.

RES-NRSC-2022-014

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Physics Aware AI Models for Target Detection in SAR Imagery

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Area of Research

AI, Machine learning, SAR, Target Detection, Natural Hazards, Hyperspectral

Summary of the proposed research and expected deliverables

Deep learning Neural networks is one of the most popular AI tool for classification of remote sensing imagery. However, lack of labeled data is one of the bottle necks in training the models and obtaining better accuracies. Transfer learning has been successful in overcoming certain limitations, however at what level of learning in the NN layer of Deep learning model has been a subject of research. Synthetic aperture radar has been quite useful as a complementary to optical data. Not only that the scattering phenomenon helps in obtaining more information on the physical properties of the target. In this regard including the physics of the scattering process in the AI models would greatly benefit the target detection and characterization. In this research detection based on underlying phenomenon of the targets such is of primary concern. Also, studying physical laws of conservation and other laws and its incorporation in the learning models is of prime importance.

Scope of the Work:

- Develop physics aware AI models for target classification.
- The role of multi frequency and multi temporal SAR data for characterization of the phenomenon and/or targets.
- Study physics of Kelvin waves, Bernoulli hump, movement of ships and other manmade hazards in the oceans.

Deliverables:

- Deep learning algorithms based on physics aware processing and learning.
- Detection of targets on land and ocean.

- Understanding physics of scattering among the scatters in multi frequency and multi temporal SAR imagery and its characterization.

RES-NRSC-2022-015

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Predictive yield modeling under climate change scenarios.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Agriculture/Spatial Crop Model/Climate Change Impact assessment on crop

Summary of the proposed research and expected deliverables

Impact Assessment of climate change projections on cotton growth and yield under different emission scenarios will be carried out in the major cotton growing region of India. The climate projection and the baseline climate data for historical years will be generated by downscaling using ensemble products of global circulation models under different emission scenarios. The response of cotton crop to the climate change projections will be evaluated through crop growth simulation model after proper calibration and validation in the major cotton growing region of India followed by Risk zonation Crop growth simulation modelling will be again used to formulate region wise mitigation strategies by fixing alternate crop management practices.

Scope of the Work:

- Impact assessment of climate change projections on Indian Agriculture is carried out by few researchers but all these studies are based on point based crop models where the spatial distribution of the crop and yield simulation is missing. The proposed study will address this issue using a spatialised crop growth model using finer resolution downscaled climate data. In addition, a hybrid approach is proposed where ML/DL techniques will be used to train a model using the ensembles of simulation results obtained for the baseline period.
- Risk zonation and mitigation strategies evolved through this study will be very useful and informative for policy makers and researchers working in different aspects of cotton crop including marketing and insurance sector.

Deliverables:

- Quantification of Impact of climate change projections on cotton yield in major cotton growing regions of India along with mitigation strategies in terms of alternate crop management strategies

RES-NRSC-2022-016

Name of ISRO Centre/Unit

National Remote Sensing Centre, Hyderabad

Title of the research proposal

Automated seasonal crop mapping using machine learning approach.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Remote sensing Applications in crop classification

Summary of the proposed research and expected deliverables

The automated satellite based crop mapping is a still challenge in India because of heterogeneous and fragmented land holdings, complex crop sowing windows and limited ground data. With the increasing spatial and temporal resolution of satellite data time-series in different wavelength range like Sentinel-2, Sentinel-1 etc. provides new possibilities for generating crop type map at local/ regional level.

Keeping the high dimensionality of voluminous satellite data, efficient methodologies for mapping seasonal crop type need to be established. This project will aim in exploring different supervised machine learning models and arriving at an optimum model type (Decision tree, Neural network architecture etc) for regional crop mapping and testing its robustness over different time scale. Automation protocols for crop mapping will be another objective of this proposal.

Scope of the Work:

- The scope of current proposal is to develop an operational automated crop mapping technique employing multi-temporal optical and synthetic aperture radar data.

Deliverables:

- Automated approach for in-season crop mapping.
- Protocols for ground data collection
- Validation approach

LIQUID PROPULSION SYSTEMS CENTRE
VALIAMALA

RES-LPSC-2022-001

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

Title of the research proposal
Development of a model for the estimation of pressure & temperature evolution inside a cryogenic super critical double walled storage vessel (Hydrogen& Oxygen) in space environment.

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Shri. Sunil M, Engr,
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Area of Research
Propulsion

Summary of the proposed research and expected deliverables
A super critical spherical storage system with double walled tank for hydrogen and oxygen is to be developed for space environment. During the outflow of the propellant, the pressure inside the storage tank will be maintained above critical pressure using electrical heaters.Propellant is expected to transit from trans-critical to super critical state during operation. Model should include all modes of heat transfer from space environment to the storage fluid. The model must be validated with available literature data.

The evolution of pressure and temperature is to be estimated for the following scenarios.

- During ground servicing in gravity field.
- During operational condition in microgravity field with & without fluid outflow (for different flow rates depending on consumption).
- Estimation of minimum flow rate required to avoid tank venting for different heat in leak conditions.

Expected outcome from the study

- Estimation of various modes of heat transfer
- Thermal stratification inside the storage system.
- Evolution of pressure and temperature.
- Heater power requirement for maintaining tank pressure above critical value.
- Requirement of anti-stratification device and its configuration.

Scope of the Work:

- Scope is to develop a mathematical model for predicting temperature and pressure evolution along with heater power requirements in a given set of conditions of heat in leak and varying consumption of reactants (mass out flow) and varying heat leak.

Deliverables:

- A model which can predict the temperature and pressure evolution of reactant vessel along with heater power requirements.
- The model should be able to extend later to digital twin of the flight system.

RES-LPSC-2022-002

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Evaluation of leak-proof surfaces in fluid components using image processing and machine learning technique.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Image processing and Machine learning

Summary of the proposed research and expected deliverables

The efficiency of fluid components like valves and regulators are mainly decided by the quality of sliding and sealing surfaces. Essential criteria for a defect-less sealing surface shall be as free from scratches, line marks, dents, protrusions etc. when viewed with 20X magnification. Generally, defects are in the order of 500nm approximately. Sample defects on sealing surfaces with 30 X magnification are given below. Sealing surfaces are generally made out of various grades of stainless steel and polymers like PTFE, PCTFE, Nylon etc. Surface texture evaluation helps in predicting the success or failure of a fluid component when put into service. Generally, quality of sealing surfaces can be evaluated by contact as well as non-contact methods. Contact method(stylus technique) is a line sampling method and hence may not represent the real characteristics of the surface. Also it has the inherent limitations of making scratches and line marks on machined surfaces. Quantitative assessment of a 3-D surface is only possible by an image processing technique, which is a non-contact method. Hence, a computer assisted non-contact evaluation technique using image processing and machine learning is desirable for leak-proofing in fluid components. Therefore there exists a need of developing a suitable machine visionsetup based on image processing software for surface texture evaluation in component parts.

Scope of the Work:

- Development of machine vision systemcontaining stereo microscopic camera, graphic card and a computer.
- Development of an algorithm for surface texture evaluation.
- Implementation of the developed technology incomponent qualification process.

Deliverables:

- Machine vision system encompassing related hardware and surface evaluation software including source code for evaluating leak-proof surfaces in fluid control components.

RES-LPSC-2022-003

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Generation of TTT and CCT diagramsfor 3 nickel base superalloys (XH67, XH55 and XH43) for application in liquid engines.

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Area of Research

Metallurgical Engg. (Physical metallurgy)

Summary of the proposed research and expected deliverables

Time-Temperature-Transformation (TTT) diagrams and Continuous–Cooling-Transformation (CCT) diagrams are used to determine the nature of phase transformations in a material with temperature & time. They provide the temperature & time required for the start or finish of a transformation, effect of cooling & heating rates on the size & volume of precipitates& indications on the microstructure & properties of the transformed products. There exists a dire need for this type of data for non-standard superalloys used in semicryo applications.

Scope of the Work:

- The Scope of proposed research is generation of TTT and CCT diagrams for 3 nickel base superalloys (XH67, XH55 and XH43) for application in liquid engines. The composition of the 3 nickel base superalloys are provided in Table-1, 2, 3 while the mechanical properties of the above alloys are mentioned in Table-4, 5, 6. and the sample material shall be provided by LPSC.A total of 116 Nos. of data points is essential to generate each curve and each CCT curve for each of the 3 superalloys.Subsequently based on the samples heat treated at various conditions, CCT and TTT curves shall be plotted using data collected from detailed characterization (OM, XRD, SEM, EBSD, TEM etc.

Deliverables:

The following deliverables are expected:

- One CCT and One TTT diagram shall be obtained for each of the alloy.
- An extensive & comprehensive data based on phases in non-standard super-alloys used in liquid engine applications.
- The effect of heat treatment parameters, effect of sequence of manufacturing operations etc. This data base would aid in optimising heat treatment processes and fine tuning specifications.
- The study also envisages extraction of second phases to study the morphology, chemistry, distribution of second phase & obtained crystal structure in fully heat treated samples.

RES-LPSC-2022-004

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Valiamala

Title of the research proposal

Development of novel Non-Destructive Procedure for detection and quantification of discontinuities in the bonding interfaces of explosively welded dissimilar metallic plates

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Area of Research

Non-destructive Evaluation

Summary of the proposed research and expected deliverables

Aluminum Alloy AA2219 to Stainless Steel ICSS-1218-321(SS) Bi-metallic Adapters (BMAs) are being used for the transition between AA2219 propellant tanks to SS pipes & valves. BMAs are realized with AA2219 T87 and ICSS-1218-321 plates with pure aluminum interlayer by explosive bonding process. The bond integrity between AA2219, Pure aluminum and SS decides the quality of the final BMA and detection of de-bond, if any, at these interfaces is of paramount importance. Presently, conventional Ultrasonic testing is carried out to assess the bond integrity of the metal to metal interfaces at 3mm FBH level. It is observed that, due to the limitations there are difficulties in distinguishing de-bond indications that led to failure at product level. Due to higher acoustic impedance mismatch between SS and AA2219, there is an inherent echo from this interface at considerable amplitude which makes the detection of de-bond challenging. Spurious indications from the AA2219 and pure Al interface also introduce uncertainty in proper assessment. Other volumetric NDE like Radiographic Testing and Computed Tomography also did not yield promising results.

The proposal is to develop a novel NDE solution for reliable and feasible inspection of the metallic interfaces in the BMAs (i.e. SS to pure Al and AA2219 to pure Al) for detecting de-bonds with minimum area of 3.14mm2 (Equivalent to 2mm FBH) or lesser at any stage of realization (Plate, Semi or final machined).

Scope of the Work:

- Bi-metallic adaptors for CUS and C-25.

Deliverables:

- NDE technique and procedure for the above application

RES-LPSC-2022-005

Name of ISRO Centre/Unit
Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal
Thermal imaging of EB welds.

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Area of Research
NDE (Thermal imaging)

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

Scope of the Project:

- The present NDE techniques cater to defect detection in the welds after welding, many a times there are possibility of reworks that take time and effort in choosing the location for rework as the hardware would have been un-mounted from the weld set-up. A technique in-situ the weld chamber to evaluate the weld during welding in vacuum is proposed to be developed using thermal imaging in order to detect and characterize the defects.

Deliverables:

- The deliverables at the end of the research shall be the thermal camera along with the associated software for defect mapping and characterisation.
- Further, a study is to monitor weld pool formation using non-invasive methods during welding and gain insights on the material behavior, weld pool dynamics and thermal behavior, thereby enabling better quality EB welds shall be a part of the above scheme.

RES-LPSC-2022-006

Name of ISRO Centre/Unit
Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal
Development of “DMAZ” fuel that is hypergolic with hydrogen peroxide.

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Area of Research

Green hypergolic bipropellants: Green alternative fuel option that is hypergolic with hydrogen peroxide for use in spacecraft propulsion.

Summary of the proposed research and expected deliverables

Fuels such as Hydrazine, MMH are in use for spacecraft propulsion since 1960s. Due to the recent environmental concerns, green alternative propellants are being explored to replace the existing hazardous and carcinogenic propellants.

DMAZ (2-Dimethyl amino ethyl azide) is a new energetic, storable, non toxic and non carcinogenic liquid fuel. It has similar physical properties as MMH. Already it is demonstrated to be hypergolic with N2O4.

Worldwide it is being investigated as a greener replacement of MMH and to work with hydrogen peroxide as oxidizer in green hypergolic bipropellant systems.

Scope of the Work:

- The proposal is to develop a viable route for synthesis of DMAZ and characterize the same to evaluate physical, chemical, thermal and safety properties and finally, bring out the specification.
- Development of suitable catalysts or promoters for hypergolic ignition for DMAZ / H_2O_2 system. Characterise the catalysts for physical, chemical and thermal properties. Optimise the catalyst % in DMAZ based on drop test results to achieve the hypergolic ignition.
- Demonstrate the hypergolic ignition of DMAZ+catalyst (Fuel) / H_2O_2 (OX) system in a drop test. Here, the ignition delay allowed is maximum of 1-2ms.

Deliverables:

- Procedure for synthesis of DMAZ including the process details like process steps, sequence, process conditions etc.
- Characterization data of DMAZ for its physical, chemical, thermal and safety properties.
- The report shall also contain the process and characterization details of the developed catalyst, its optimum weight % in DMAZ to achieve the hypergolic ignition.
- 10 kg of the DMAZ mixed with optimum ratio of catalyst or promoters for thruster firing test.
- Samples for characterization of properties.
- 500 g of promoter
- 1 kg of DMAZ

RES-LPSC-2022-007

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal

Residual stress measurement on Ti6Al4V welds using LASER technique.

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Area of Research

Non-destructive testing- Residual stress measurement-LASER based technique

Summary of the proposed research and expected deliverables

The measurement of residual stress is an important aspect of Quality control for a process such as electron beam welding.

- Conventional techniques like X-ray diffraction etc. are feasible on small samples. In this case the sample is a large spacecraft propellant tank.
- The proposed respond basket proposal will help us understand the residual stress generated due to electron beam welds. Satellite propellant tanks of Ti6Al4V material.
- The weld specimens of Satellite propellant tanks with different sizes and weld parameters shall be taken up for study and the residual stress measurement using LASER based technique shall be carried out.
- The results will enable optimization of power input during EB welding and also the assessment of the effect of EB welding on the structural integrity of the hardware.
- The accuracy expected shall be within ±10Mpa.

Scope of the Work:

- To measure residual stress using non-contact, non-destructive method using LASERS.

Deliverables:

- Detailed report on technique and procedure used for measurement
- Measurement set-up including LASER, data acquisition etc.
- Test reports on samples supplied by LPSC(B)

RES-LPSC-2022-008

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal

Geometry independent Ultrasonics NDE

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Area of Research

NDE (Ultrasonics)

Summary of the proposed research and expected deliverables

Ultrasonics is a widely used NDE technique in aerospace for structural integrity assessment. Often any test using Ultrasonics requires a reference standard simulating the material of test, required defect sizes, beam path of travel and a host of other test parameters are finalised based on the reference standard. The finalised parameters are replicated on the actual test article and the results are interpreted. The Ultrasonic test data is a cumulative result of reflection, refraction and absorption of the sound waves in the material medium. These phenomenon are dependent on various variables like attenuation, velocity of the sound waves, nature of the geometry available for reflection, transducer frequency, size, shape, couplant etc. Hence, the present practice of referencing the parameters with a standard is essential.The proposal is a disruptive technology where in all the variables affecting the Ultrasonic test data are standardised and an algorithm is generated which gives the required parameters for the test without the need of the reference standard. This will make paradigm shift in the Ultrasonic test methodology wherein it will make the process more adaptable and flexible. The variables affecting the test data are categorized into mainly four viz.

- Material
- Transducer
- Geometry
- Test conditions

The study is initially experimental with Ti6Al4V as the test material wherein it is expected to study the dependence of the test characteristics on the variables by performing trials by varying the parameters. The test data shall be analyzed for generating the numerical model for predicting the Ultrasonic parameters and interpreting the output. The developed numerical model shall be validated experimentally.

Scope of the Work:

- LPSC shall support in providing the test samples with defects that shall be used for experimentation. Over 100 samples with defects shall be used for the study.

Deliverables:

- A report on the experimentation with the variables and the data analysis.
- A numerical model in software (Matlab, Phyton etc.) to be used for prediction of the Ultrasonic parameters along with the code.
- Report on validation experiments of the numerical model and the results obtained.

RES-LPSC-2022-009

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

Title of the research proposal
High Cycle Fatigue Testing of Metallic Materials.

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Area of Research
Metal Fatigue

Summary of the proposed research and expected deliverables
Fatigue failure is commonly encountered in structural elements which are subjected to severe cyclic loads. In launch vehicles, several structures like plumbing lines, gas bottle/ module mountings, etc. are subjected severe dynamic or cyclic loads and it is important to know the fatigue characteristics of commonly employed materials for space applications like Stainless Steels, Aluminum alloys, Nickel alloys etc.

The objective of the present study is to carry out high cycle fatigue testing of metallic materials namely, SS321, AA2219 and Inconel 718 in both parent and weldment forms and experimentally obtain the fatigue characteristics (endurance strength, S-N curve) for a fully reversed loading(R=-1).

For obtaining the S-N curve, experiments have to be carried out for a minimum of 10 stress levels. For each stress level, a minimum of 5 specimens can be chosen for carrying out the experiments. An additional 3 specimens will be provided to obtain the tensile properties for each lot of specimens supplied. Hence, for each material a minimum of 106(53(parent)+53(weldment)) specimens will be supplied.

To study the phenomenon of fatigue scatter, a statistical assessment of the experimental data has to be carried out and an average S-N curve can be provided. Finally, an empirical model for the experimentally obtained S-N curve has to be provided.

Scope of the Work:

- To carryout high cycle fatigue testing of metallic materials and determine the S-N curve and endurance strength.
- To study the fatigue scatter of the experimental data using appropriate statistical models.

Deliverables:

- Fatigue characteristics like S-N curve and Endurance strength of SS321, AA2219, Inconel 718 in parent and weldment forms.
- Empirical model of the experimentally obtained S-N curves of SS321, AA2219, Inconel 718 in parent and weldment forms.

RES-LPSC-2022-010

Name of ISRO Centre/Unit

Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal

Design and Development of continuous level sensor using Fiber optic technology for LH2, LOX and Semi Cryo applications.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Fiber Optic Sensors

Summary of the proposed research and expected deliverables

The advantages of Fiber optic technology for Cryogenic level sensing is in it light weight, spark free, low power consumption, remote sensing, dielectric material, immunity to corrosion environment. Evanescent wave absorption principle is one method that is far less sensitive to surface contamination, can operate well in conditions of small refractive index contrast between fluid and gas above the fluid (a common problem in cryogenic applications) and is considerably less sensitive to fluid composition change and the fluid properties changes due to temperature. In the present CUS, C25, C32 and SC120 stages, there is level and depletion measurement. Level measurement is done for a finite length and depletion sensing is done at the bottom of the tanks. With the freedom to run the optical fiber along the full length of the tank with low weight, level sensing can be done for the whole length of the tank. Since measurement of level will be in discrete steps, stacking of fibers with adequate overlap will result in effective continuous level measurement. Long period grating technique, Etched D shaped optical fiber, bent side polished optical fiber have been used for continuous level sensing in liquids with distinct difference in density of gas and thus refractive index of liquid state. This should be studied for LH2 (18-22K), LOX (70-90K) and ISROSENE (288-310K) level sensing. This development will include characterisation of the Fiber, cladding and coating at

LH2 and LOX environment. This needs to be done prior to sensor development. Level sensing should be proposed for a measuring length of minimum of 3 meter to maximum of 8 meter measuring length.

Scope of the Work:

- The design involves, demonstration of proof of concept with good resolution of signal since this is intensity based optical sensor. The selection of choice of fiber core, cladding and coating, suitable laser source, detection and interrogation technique is critical. The input voltage of the system should not exceed 32 V. The required circuitry should be designed.

  The targetted specifications are

  Measurement length : 3 meter to 8 meter

  Accuracy: ± 3 mm of liquid level

Deliverables:

- Prototype LH2 level sensor – 1 no.
- Prototype LOX level sensor -1 no.
- Both along with suitable light source, detection circuitry and signal conditioner.
- Detailed design document covering specifications of components, source of supply and assembly process. Design document of detection circuitary and signal conditioner.

RES-LPSC-2022-011

Name of ISRO Centre/Unit
Liquid Propulsion Systems Centre, Bengaluru

Title of the research proposal
Development of Interrogator for FBG based sensors.

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Area of Research
Fiber Optic Sensors.

Summary of the proposed research and expected deliverables
A gauge type fiber optic pressure sensor was developed in LPSC(B). The design will be optimised using bend insensitive fibers and modifying the configuration to suit multiplexing. This will be available for field trials use and can be multiplexed with temperature sensing as well. Thus the measurement of pressure and temperature in a given sub system can be addressed. Further a

flight worthy interrogator is required for signal processing. Interrogator is a device that houses light source along with the peak detection circuitry for an FBG based sensor. There are various methods of interrogation. Interrogation with a tunable laser source is one option with no movable parts. Considering the vibration level in launch vehicles, this seems most suitable for space application. The interrogator should have inbuilt suitable multiplexing architecture to sense multiple FBG sensors. Interrogator should have 2 channels, each channel with multiplexing capability. Bandwidth of the interrogator should be 1520 – 1570 nm with accuracy of less than 2pm and resolution of 1 pm. Scanning frequency to be of 1 KHz minimum. Peak detection algorithm preferably, $\Delta\lambda$ like Fast phase correlation or cross correlation algorithm has to be incorporated in the signal processing. The Input voltage to the Interrogator should not exceed 32 V DC. This will find application in PSLV and GSLV flights where the measurements of pressure and temperature in subsystem can be multiplexed and processed with almost Zero signal loss.

Scope of the Work:

- The scope includes selection of appropriate components and their assembly for detection of wavelength shift in FBG sensors. Further, multiplexing for sensing of multiple sensors in each channel to be demonstrated.

Deliverables:

- One number prototype of packaged Interrogator with FC/ APC connections and suitable software with GUI.
- Detailed Design document with specifications of components and their source of supply and assembly process document.

ISRO PROPULSION COMPLEX
MAHENDRAGIRI

RES-IPRC-2022-001

Name of ISRO Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Automation of engine and stage integration/testing activities in assembly and test facilities area.

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Area of Research
Mechanism

Summary of the proposed research and expected deliverables
IPRC is entrusted not only with engine and stage integration activities in assembly area but also with the test activities at test stand, handling of harmful propellants, leak testing, NDT of weld joints, etc.

The need of automation in such areas will increase the productivity of such activities, reduce time lag between activities like NDT activities and ensure precise control.

In IPRC, automation can be applied to:

- Foam insulation of stage tanks wherein precise control over the thickness of insulation is one of the mandate required to be achieved.
- Leak tightness of joints in Test stand area which are nearly inaccessible or difficult to access.
- Thickness measurement using Ultrasonic Examination.
- Propellant handling.
- NDT activities.
- Activities requiring human intervention near the engine/stage when the propellant loading is over.

These are some of the areas where automation with robotic manipulator can be applied. The need of a robotic system is very much preferred for the above mentioned activities as it involves cumbersome operations, critical alignments, leak tightness and the safety of the person working in the confined space. Such activities can be extended to flight operations also in future. Many such requirements can be generated from different users based on their experience and the robotic manipulator can be taught using teach pendant or automated to perform required functionalities.

Scope of the Work:

- Automation of day to day activities in IPRC like Foam insulation of stage tanks with the use of spray gun with multiple degree of freedom. The system must be capable of accurately position the spray gun relative to tank and the gun should move normal to tank and along the length of tank. The tank shall be positioned in a fixture where the tank is rotated relative to spray gun and the spray gun shall uniformly provide foam insulation over the tank to the thickness required.

Deliverables:

The participating agency is required to

- Provide a 3D simulation of activities to be performed.
- Mathematical model of manipulator.
- Design a robotic manipulator with teach pendant.
- Design of some universal grippers for different tasks and ability to change over from one gripper to other.
- Demonstration of foam insulation on a small tank.

RES-IPRC-2022-002

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Natural frequency measurement of steel components by the sound signal.

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Area of Research

Vibration analysis

Summary of the proposed research and expected deliverables

A new test method based on sound signals for natural frequencies of steel components is proposed. The proposed method is a non-contact measurement method which does not need to install any sensors and therefore generates no measurement errors.

The method consists of three steps.

- First, a steel component is placed in suspension state, and the sound signals of this component are collected under artificial excitation by a recording device.
- Second, the collected sound signals are analysed by the periodogram method to obtain the power spectral density curves.

- Finally, the first few natural frequencies of the steel component are readily obtained through the power spectral density curves.

The first three natural frequencies of this beam can be successfully obtained by the proposed method. For comparison, the values of the first three natural frequencies of this beam can be analyzed by the traditional modal test method using the acceleration sensors. Compared with the traditional modal test methods, the proposed method is more economical, fast, and precise to obtain the natural frequencies of steel components. It may be a promising testing method for the natural frequencies of steel components.

Scope of the Work:

- The proposed method is a new strategy for the test of natural frequencies based on sound signals of the common steel components. By comparison, it can be proven that the proposed method only have slight deviations compared with the values obtained by the traditional modal test method. The proposed method can be proven to be economical, fast, and precise to test the natural frequencies of steel components. It may be a promising testing method for the natural frequencies of the common steel components. The work can be carried out in the laboratory without special sound insulation for the test environment. The proposed method is not affected by the environment. It is important to study this method further to confirm the sensitive of the test towards ambient noise, impacts etc.,

Deliverables:

- The improvement in the process of measurement of Natural frequency will enhance the repeatability and the consistency of results for further analysis of the integrated engine system before clearance for testing/ flight.

RES-IPRC-2022-003

Name of ISRO Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Development of High-strain rate coaxial atomizer with Gallelian invariance for rocket application.

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Area of Research
Liquid Atomization, combustion, concentration mapping

Summary of the proposed research and expected deliverables
Atomization plays vital role in distribution of reactive species inside combustion systems, where disintegration of fluid continuum is due to various fundamental instabilities originating from different fluid dynamic processes both in near field and far field. Relative motion between fluids

by its very existence develops instabilities that grow either in absolute sense or in convective sense depending on local Weber number of resulting sheet. Hence it becomes essential to configure atomizers that induce higher relative motion by virtue of it geometry.

It is aimed to systematically investigate the interaction of various physical processes happening simultaneously. Experiments are to be conducted to understand the role of

- Hydro-dynamic instabilities of different origins. (RT type, KH type, RP type).
- Associated rate of growth or decay in these instabilities using non-linear dimensionality reducing decomposition techniques.
- Coupling mechanics of these instabilities with external fluctuations like turbulence, vortices and acoustic excitation.
- Role of these mechanisms on secondary atomization zone that finally sets up the droplet distribution pattern inside combustor.
- External forcing of different origins viz., thermo-acoustic oscillations, inherent feed system based fluctuations etc. on final outcome of particle size, inertial distribution, temporal evolution of species, spatio-temporal stationality of species under Gallelian invariance condition.
- Penetration depth. (in terms of L*).
- Time averaged species mapping at identified spatial location.
- Space averaged species concentration for 10-15 cycles of external forcing as specified a priori.
- Size-velocity correlation giving Gallelian Invariance of spray field and establishing spray stationality.

Scope of the Work:

- These kind of high strain rate coaxial atomizer will find wide application in rocket application ranging from multi-propellant capability, wider thrust augmentation capability under sustained thermo-acoustic oscillation giving a stable C* characteristics.

Deliverables:

- Experimental results obtained as described in section 6 together with Linear measurement parameters like size and velocity field, divergence field, dispersion, penetration etc.
- Atomizer assembly.

RES-IPRC-2022-004

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Experimental investigation of suitable solvents for removal and quantification of oil contaminants found in a Semi-cryo Engine.

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Shri. Sundaresan G

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Area of Research

Chemistry of Aliphatic/aromatic hydrocarbons, spectroscopy, etc.

Summary of the proposed research and expected deliverables

Semi-cryogenic and Cryogenic engine systems contain various intricate components, exposed to Oxygen, where visual or manual access is not possible. In those areas, it is imperative to use an effective solvent which can remove every trace of oil contaminants (E.g.: TRIM E709, SERVO Cut S, etc.) to avoid undesired auto-ignition. Each engine consists of various components, fabricated by different means and at different places. This leads to presence of various oil contaminants. Each oil contaminant, in general, is unique in its composition and hence varied properties (miscibility, fluorescence peak, etc.). This project involves determination of the best solvent by carrying out experimental trials with each of those oil contaminants (about 8 Nos.). Presently, fluorescence spectrometer is used to ensure the presence of a few of these contaminants to be below 3 mg per liter in the solvent after final cleaning. Fluorescence spectrometer is a highly sensitive instrument depending on fluorescence of contaminants. However, the quantification of non-fluorescent contaminants is not possible by this instrument. Hence, this project involves exploration of other techniques (UV/Vis spectroscopy, Raman spectroscopy, etc.) for quantification of these contaminants.

Scope of the Work:

- Literature survey of various solvents – considering economic constraints.
- Experimental trials of solvent compatibility with each oil contaminant.
- Experimental study of oil contaminant removal by solvent.
- Quantification of oil contaminant using suitable instrument in solvent in the range of 3 mg/l.

Deliverables:

- Detailed report of experiments: methodology and end results.

RES-IPRC-2022-005

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Development of self-healing refractory and investigation on the mechanism.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Refractory castables

Summary of the proposed research and expected deliverables

The objective of this work is to develop a self-healing refractory castable for the use in Vikas engine. The same shall be used for thermal protection systems in the reusable vehicles. The refractory material will crack at service conditions under temperature and mechanical stress. Research work on the self-healing material was initiated only with concretes. Thus by adding healing particles into the refractory, the system is made for healing the crack during service. The proposal is to evaluate simultaneous mass loss, thermal and fluid dynamic changes in a refractory castables, hydration kinetics, rheological properties and curing conditions at different water to refractory cement ratio. Tests need to be performed with high-alumina refractory castables with different type of hydraulic binders, healing particles and included evaluation of permeability changes due to thermal expansion effects. Removal of physical (moisture) and chemical (hydrates) water at different heating rates is also to be evaluated for refractory castable. A method to be proposed for understanding how variables such as the curing environment and the type of binder agent, healing agent or permeability-aid additives influence the occurrence of voids and crack formation, thereby helping to define the best castable composition.

Scope of the Work:

- The current proposal aids in resolving the issues pertaining with the refractory castables being used for Vikas engine thrust chambers. The same technology can be used for the future high thrust engines also. The advantage of the proposed technology will be useful for the manned mission.

Deliverables:

- Self-healing technology of refractory castables.
- Healing agents and its composition.
- Samples of self-healing refractory castables.

RES-IPRC-2022-006

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Combustion Dynamics of Rocket Engine and its active control using high energy Plasma Discharge for phase desynchronization.

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Area of Research

Combustion Dynamics, Rocket combustors, Dynamical systems, Complex system analysis, MFDF Analysis.

Summary of the proposed research and expected deliverables

Rockets are prone to excite the high amplitude pressure fluctuations which is generally referred as thermo-acoustics oscillations having positive or negative growth rates. Such oscillations have a potency to damage the engine structurally and also the performance of engines. Also the nonlinear behavior of such phenomena has posed a greater challenge in the forecasting behavior of the engine under various operating conditions.

It is aimed to systematically work on thermo-acoustic oscillations that can be controlled actively by desynchronizing the heat-pressure flucutations by introducing high energy plasma disturbances in flame zone.

The proposed work is divided into two phases

- Characterizing the nonlinear acoustic behavior of the rocket engine using non-linear tools viz., MFDFA, recurrence quantification in reconstructed phase space under rated operating condition and off-nominal conditions.
- Active control of the high frequency oscillations using the plasma discharge. This second phase is dedicated to the development of effective direct current discharge plasma for combustion dynamics control. This can affect the local heat release rate and pressure fluctuations and their phase relations, which may suppress thermo-acoutstic oscillations by desyncing them in both temporal and spatial sense.

Scope of the Work:

- Develop a methane-air or kerosene air diffusion flame combustor operating at 4-5 bar without optical access and demonstrate the stable operation. Induce thermo-acoustic forcing in the system and carryout MFDFA, Recurrence quantification mapping, stability margins of engine in terms of various engine operating parameters.
- Develop a high energy DC plasma system inside combustor for desynchronizing the pressure-heat phase oscillations and mitigate the onset of oscillations.

Deliverables:

- Stability margins of combustor under various operating conditions.
- Correlation map between Thermo-acoustics oscillations and operating parameters in rocket engines.
- Multi-fractal detrended fluctuation analysis (MFDFA) system developed and validated for methane-air or kerosene –air combustor.

- Recurrence quantification analysis system of pressure fluctuations data obtained from developed combustor.
- Active control system developed for controlling high frequency Thermo-acoustic fluctuation of high magnitude.

RES-IPRC-2022-007

Name of ISRO Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Artificial Intelligence based welding systems

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Area of Research
Artificial Intelligence

Summary of the proposed research and expected deliverables
A master welder uses his sensory perceptions to evaluate the process and connect them with his knowledge base to take the necessary corrective measures with his acquired skills to make a good weld. All these actions must take place in real time. Success depends on intuition and skills, and the procedure is labor-intensive and frequently unreliable. The solution is intelligent weld manufacturing. Intelligent manufacturing is real-time-based optimization through the entire value chain. Welding is ideally suited for intelligent manufacturing. The ultimate goal of intelligent weld manufacturing would involve sensing and control of heat source position, weld temperature, weld penetration, defect formation and ultimately control of microstructure and properties. This involves a solution to a problem (welding) with many highly coupled and nonlinear variables. The trend is to use an emerging tool known as intelligent control. This approach enables to choose a desirable end factor such as properties, defect control, or productivity to derive the selection of process parameters such as current, voltage, or speed to provide for appropriate control of the process. The intelligent welding aims at controlling for microstructure properties and performance of the welded parts. Important elements of intelligent manufacturing are sensing and control theory and design, process modelling, and artificial intelligence. Artificial Intelligence based Integrated computational welding engineering is an emerging field that will aid in the realization of intelligent weld manufacturing. Following are the four key elements:

- Process and its modelling
- Microstructure

- Properties
- Process control and automation

Adaptive weld control is a closed loop approach that relies on measurements of relevant physical characteristics of the weld pool as the feedback and feedback control algorithms that decide how to respond to the feedback. The framework for research and technology of intelligent weld manufacturing includes computer vision systems for visual feedback sensing, and control, neural network modelling of the process dynamics, and fuzzy logic and neurons self-leaving learning for control algorithms of arc welding. The needed sensors, controls, and control software, robots, and automatic machines are being integrated. The welding processes involved in the realization of Cryo and Semi-Cryogenic systems shall be adopted with AI-ICWE for the execution of defect free weld joints and for the better reliability.

Scope of the Work:

- The proposed research will be useful for the productionization of welding systems. As the demands of the launch vehicles are increasing, the prior prediction of the process parameters and corresponding weld joint quality is mandatory for enhancing the production.

Deliverables:

- AI codes for welding systems.

RES-IPRC-2022-008

Name of ISRO Centre/Unit
ISRO Propulsion Complex, Mahendragiri

Title of the research proposal
Development of advanced thermal barrier coatings for high thrust rocket engines and components

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Area of Research
Thermal Barrier Coatings

Summary of the proposed research and expected deliverables
Conventional thermal barrier coating (TBC) systems consist of a duplex structure with a metallic bond coat and a ceramic, heat-isolative topcoat. Several recent research activities are concentrating on developing improved bond-coat or top-coat materials; for the topcoat especially, those with reduced thermal conductivity are investigated. Using advanced topcoat materials, the ceramic coating can be further divided into layers with different functions. One example is the double-layer system in which conventional yttria-stabilized zirconia (YSZ) is used as bottom and new materials such as

pyrochlores or perovskites are used as topcoat layers. These systems demonstrated an improved temperature capability compared to standard YSZ. In addition, new functions are introduced within the TBCs. These can be sensorial properties that can be used for an improved temperature control. Further increased application temperatures will also lead to efforts for a further improvement of the reflectivity of the coatings to reduce the radiative heat transfer through the TBC.

Among the interesting candidates for thermal barrier coatings, those materials with pyrochlore (e.g., La2Zr2O7,Gd2Zr2O7), spinel (MgAl2O4), perovskite (e.g., SrZrO3), or magnetoplumbite (e.g., LaMgAl11O19) structures and high melting points show especially promising thermophysical properties. However, the thermal expansion coefficient is typically lower than that of YSZ, which leads to higher thermal stresses in the TBC system, as both substrate and bondcoat have higher thermal expansion coefficients (about 15X10-6/K). In addition, relatively low toughness values are observed in these materials.

Scope of the Work:

- As a result, the thermal cycling properties are worse than those of YSZ coatings. This problem is probably relevant for most of the new TBC materials, as the need for thermal stability seems to contradict the ability to show efficient toughening effects. A way to overcome this shortcoming is to use layered topcoats. Failure of TBC systems often occur within the TBC close to the bondcoat/topcoat interface. At this location YSZ is used as a TBC material with a relatively high thermal expansion coefficient and high toughness. Typically, a thickness of 100 to 200 µm shall be employed. The YSZ layer is then coated with the new TBC material (e.g., La2Z, which is able to withstand the typically higher temperatures at this location. A temperature increase compared to YSZ of 100 K could be demonstrated. Major problem in the Perovskite is the partial evaporation of constituents of the perovskite phase during plasma spraying. This leads to impurity phases in the coating, which often have detrimental effects on the coating performance. Since the much information on aluminates are not available, it is proposed to investigate La2Zr2O7 top coat over YSZ. In addition, this study shall be combined with the process introduction of HVOF spraying which gives better bond strength than the conventional air plasma spraying. In this work, coating properties within the spray booth will be optimised. In addition, the exploration of both in-flight particle state (temperature and velocity) as well as non-parametric parameters (substrate temperature, spray distance, and deposition rate), enabling a comprehensive correlation with process conditions will be evaluated. The maximum temperature gradient, heat flux and number cycles will be demonstrated.

Deliverables:

- AI codes for welding systems.

RES-IPRC-2022-009

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Development of molten regolith electrolysis process for oxygen production from simulated lunar soil

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Area of Research

Interplanetary Missions & Engineering

Summary of the proposed research and expected deliverables

Oxygen production using the resources available on the Moon is the most important factor in developing In-Situ Resource Utilization technology in the view of potential application of oxygen for life-support system and propellant for ascent vehicles. Maturing the energy efficient & compact oxygen synthesis unit using Lunar regolith plays a critical role for interplanetary mission planning towards lunar exploration. There are diverse methodologies available for generation of O2 from lunar soil, for example, chemical reduction, pyrolysis, acid treatment, or molten regolith electrolysis are the widely used processes. Out of this molten regolith electrolysis has been considered to be potential approach; however molten regolith electrolysis process is not explored in detail due to the fact of oxidation of anode at high temperature with oxygen environment. In molten electrolysis process, Entire lunar regolith can be used as the raw material. In this process, consisting of an electrolytic cell, regolith is melted and potential is applied such that Oxygen is deposited at the anode and metal is deposited at the cathode. Major challenge is on development of high temperature anode in where oxygen is deposited.

Scope of the Work:

- Design of a prototype molten regolith electrolysis process.
- Selection of a suitable anode material considering the oxygen environment at high temperature.
- Development of the anode and electrolysis process for the given condition.
- Energy utilization and efficiency mapping of the developed process.
- Utilization of ISRO's Lunar Simulant Soil for demonstration of the developed process.

Deliverables:

- Detailed Design Report comprising the literature and design calculation for molten electrolysis process.
- Optimized electrolytic process for the production of O2 at 1 Kg per day.
- Prototype unit developed to validate & characterize at ISRO.
- Experimental results including energy requirement & efficiency for the process developed.
- Anode material developed as part of electrolysis process.

RES-IPRC-2022-010

Name of ISRO Centre/Unit

ISRO Propulsion Complex, Mahendragiri

Title of the research proposal

Experimental characterization & parametric sudy on liquid jet penetration and break-up in a free supersonic gas jet.

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Area of Research

Propulsion - Testing of high thrust liquid rocket engines

Summary of the proposed research and expected deliverables

Configuration of a liquid jet injected into a subsonic or supersonic cross-flow of gas is well known as Jet-In-Cross-Flow (JICF) which is having the wide range of application from high-speed air breathing engines to cooling of exhaust plume generated during ground testing of rockets. Traditional JICF configuration for the application to air breathing engines is a very well-researched subject area. However, the behavior of a liquid jet injected into a free supersonic gas jet has been studied to a much smaller extent. A free supersonic gas jet refers to the unbounded, finite-area jet, where the gas flow is at supersonic speed and exhibits a shock train structure consisting of Mach diamonds. Free supersonic gas jets are commonly observed at the exit of exhaust nozzles used in rocket propulsion. During testing of a high thrust rocket engines, it is extremely important to accurately quantify and mitigate the thermal and acoustic loads on test stand infrastructure generated by engine firing. Liquid jet injected into a free-supersonic gas jet needs a thorough understanding on liquid penetration depth, break-up & surface density of water particles. This preliminary study using the small-scale experiments with GN2/Air as the gas jet will deliver the meaningful analytical co-relation on liquid jet in cross-flow. Available hot test data shall be used for the scale-down of the experiments and validation.

Scope of the Work:

- Scale-down configuration of liquid jet in a free-supersonic gas based on the inputs provided by IPRC.
- Identification of Non-intrusive diagnostic tools used to examine the behavior of the internal shockwave structure in the over-expanded gas jet with and without liquid injection.
- Mapping of primary break-up mechanism of a liquid jet using diffused backlit imaging with pulsed laser.
- Geometric & kinetic parametric study of liquid jet in a free supersonic gas.

Deliverables:

- Scale down methodology for Jet-In-Cross-Flow.
- Experimental results using non-intrusive diagnostic tools for studying the primary breakup.
- Surface density of water particles upon interaction with gas jet for the scale-down experiments.
- Mapping of penetration depth with reference to non-dimensional numbers.
- Analytical correlation using geometric & kinetic parameter of liquid and gas jet.
- Realized scale-down water and gas nozzle.

PHYSICAL RESEARCH LABORATORY
AHMEDABAD

RES-PRL-2022-001

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
On-chip based single photon source with high brightness and spectral purity.

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

Summary of the proposed research and expected deliverables
Among all entangled quantum systems, photon entanglement is very much important in quantum information as they can be sent from one location to another with relative ease. Typically, nonlinear effects are used to generate pair photons for heralded single photon source or entangled source. However, the intrinsic bulkiness of those systems limits their use for on-chip experiments. Therefore, it is essential to develop on-chip based pair photon source with high brightness and narrow bandwidth for easy integration and compact systems for future quantum optics experiments with on-chip devices.

Recently, all-dielectric resonant metasurfaces have been explored to realize high quality factor optical resonances for passive narrow bandwidth optical filtering, nonlinear optical enhancement studies and for quantum photon applications. These dielectric metasurfaces have also been used to engineering the wavefront, polarization, and spatial profile of the incident or generated light with applications in spatial mode control for free-space communication or imaging/sensing applications. Such resonant structures can also be combined with high nonlinearity two-dimensional materials for enhance nonlinear signal generation and photon-pair generation for quantum applications.

Proposals are invited for the development of dielectric metasurface based quantum source for brightness single photon and entangled photons with narrow linewidth to strengthen the quantum technology program of ISRO.

Scope of the Work:

- Scope of the proposed research is to develop on-chip based pair photon source with high brightness and narrow linewidth. It is also expected to implement the developed source for the implementation of entanglement study.

Deliverables:

- Knowhow of the dielectric metasurface based system for pair photon generation. The use of metasurface as spectral filter to restrict the bandwidth of the output photons to improve the overall spectral brightness of the source. On-chip based system for entangled photons with high brightness and spectral purity. The compact on-chip source can be used for quantum imaging experiments.

RES-PRL-2022-002

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Quantum Radar.

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Area of Research
Quantum optics, Nonlinear optics, Singular optics, Light scattering

Summary of the proposed research and expected deliverables
To design a proto-type Quantum radar (Q-radar) which can detect stealth objects better than the conventional radar.

Since the quantum-states used in quantum sensing are highly sensitive to environment, therefore, to overcome this problem, application of quantum-states will be restricted to the detection and analysis part of the Q-radar. This makes the Q-radar relatively robust as the quantum states are not exposed to the outer environment disturbances.

This will be achieved through quantum back-action nullifying meter technology.

Scope of the Work:

- The combination of quantum back-action nullifying technology and quantum correlations will lead sensitivities better than the present established limits.
- The principle and technology developed could be used for many quantum sensing applications beyond Q-Radar.

Deliverables:

- A quantum back-action nullifying meter (QBNM) will be designed.
- A Q-radar based on QBNM will have much better sensitivity than the normal radar.

RES-PRL-2022-003

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Machine learning assisted optical communication using Optical Angular momentum.

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Area of Research
Quantum optics, Quantum communication, Nonlinear optics, Singular optics

Summary of the proposed research and expected deliverables
Machine Learning (ML) and deep learning techniques will be used to study the features of vortex beams and build a model which can predict the topological charge of Orbital Angular Momentum (OAM) beams. A Neural Network (NN) will be trained to identify and classify different OAM modes carrying information. The self-learning properties of NNs will be used to reveal the hidden features of OAM beams and these features would form the basis for novel experiments in classical and quantum communication. These features will help us to understand the linkage between macroscopic physical optics and microscopic quantum optics along with increasing the density of information.

Scope of the Work:

- These OAM beams can be used for communication purposes providing theoretically infinite bandwidth and hence the higher information capacity.

Deliverables:

- A classical and quantum channel which can carry more information along with higher security.

RES-PRL-2022-004

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Catastrophic Events and Mass Extinctions during the geological past and the late Quaternary period.

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Area of Research

Earth & Planetary Sciences

Summary of the proposed research and expected deliverables

During the course of evolution of the planet earth, there were periods in Earth's history when large-scale extinction of flora and fauna got extinct which are marked by major geological transitions such as K/T and P/T events. The cause of the extinction is still being debated whether they were triggered within the earth by events like volcanism or climate change or caused by the extra-terrestrial meteoritic impact (the bolide impact theory for K/T extinction).

Working on freshly fallen Indian meteorites which have been collected over the years which gives an advantage to assess the role of extra-terrestrial impact (if any) in the mass extinction.

Similarly working with meteorites and planetary analogues samples as well as geological features from Indian geology helps in providing clues to the evolution of planet like Mars or Moon.

On the recent geological time scale, Work is being carried on the causes and consequences of esteem whether events and the late Quaternary glacier fluctuations in Himalaya with emphasis on the past climate variability.

Scope of the Work:

- The study would help in providing the answers to questions like what drove the mass extinctions at different geological time period as also provide insight into the planetary evolution which in turn will be a contribution towards the planetary exploration program of Indian Space Research organization.
- The extreme event and glacier fluctuation study during the late Quaternary period (~100 ka) would be helpful in understanding the role of natural climate variability of geomorphic processes and can be used as a base line data towards interpreting the impact of anthropogenically induced climate change (global warming) on extreme events and Himalayan glaciers.

Deliverables:

- The proposal shall provide the answers to some of the challenging scientific questions as to whether the P/T transition was an outcome of the large-scale volcanism that has led to the global anoxia causing >90% marine life extinction. Or was triggered by processes which was extraterrestrial in nature. Similar would be the contribution towards K/T boundary extinction which still hinges between Deccan volcanism or bolide impact.
- The Late Quaternary extreme events and the glacier fluctuations study would not only help in understating the pattern of natural forcing factors responsible for the past events but would provide base line data for future climate projections under the global warming scenario.

RES-PRL-2022-005

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Groundwater dynamics in India: investigation using radiocarbon, stable isotope ratios and satellite data.

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Area of Research

Isotope geochemistry, hydrogeology, geochronology and satellite data

Summary of the proposed research and expected deliverables

Groundwater is an easily accessible storage of freshwater especially in semi-arid and arid regions for irrigation and other day to activities where surface waters are inadequate and plays a vital role in human sustenance and food security. Major parts of India face acute shortages of freshwater due to steep rise in water demand combined with changes in water use patterns because of rapid urbanization and economic and lifestyle changes. To avoid future crisis of groundwater, a sustainable management policy needs to be formulated for which a detailed understanding of the groundwater dynamics and its storage variation is essential. Also, to maintain the quality of the groundwater a detailed understanding the sources of pollutants in groundwater aquifers are important. The broad objectives of the research are:

- Estimation of turnover time of groundwater in shallow and deep aquifers using radiocarbon and stable carbon isotopes in dissolved inorganic carbon.
- Estimation of the recharge rates and mixing between different groundwater aquifers using radiocarbon.
- Long term change in the groundwater storage in different regions of India using satellite data.
- Identification and quantification of sources of anthropogenic pollutants using stable nitrogen and oxygen isotopes in dissolved nitrate and their geographical variations.
- Identification of the processes responsible for the changes in the groundwater storage due to extraction, evaporative loss, submarine discharge and interaction between surface and groundwater and among different aquifers using stable isotopes and radiocarbon.
- Impact of artificial reservoirs on groundwater dynamics using stable isotopes and radiocarbon.

Scope of the Work:

- The study will be carried out on the groundwater in different regions of India with initial focus on the areas suffering from acute depletion of groundwater due extensive groundwater extraction for agricultural and industrial activities such as Indo Gangetic Plain. With extensive analysis of satellite data, the variation in the groundwater storage during the last decade will be assessed and regions with strongly depleted groundwater level will be identified and large scale field sampling in those regions will be carried out. Extensive measurements of radiocarbon and stable isotopes in dissolved inorganic carbon and stable isotopes in dissolved nitrates will be carried out to estimate residence times of groundwater in different aquifers, flow rate and direction, recharge rates, interaction with surface water and among different aquifers and identification and quantification of contributions of anthropogenic pollutants from different sources. Additionally,

model studies for future projection of groundwater storage will be carried out. Impact of large artificial reservoirs on groundwater dynamics will be carried out using radiocarbon and stable isotope data in groundwater of some selected river dams in the Himalayan and plain regions of India.

Deliverables:

- Satellite based survey of groundwater storage change in last decade.
- Sampling and method development.
- Residence times of groundwater in shallow and deep aquifers.
- Impacts of artificial dams on groundwater dynamics.
- Anthropogenic pollutants in groundwater aquifers.
- Archival of data and model results.
- Publications in journals and project execution documents.

RES-PRL-2022-006

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Role of physical and chemical processes on the climate of Mars and Venus.

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Area of Research
Planetary Atmospheres

Summary of the proposed research and expected deliverables
Scientists have gained important insights into the atmospheres of (i) Venus and (ii) Mars, through observations and modelling. However, several aspects of their climates are yet not well understood.

- The Venusian dense cloud layer at about 50-70 km plays a vital role in determining the atmospheric dynamics and driving the surface-atmospheric coupling. We are still far from a full detailed understanding of the sulfur chemistry in this region and its role in lightning. On the other hand, there are still several features of the Venusian ionosphere which have remained un-explained. The cause of the vanishing night-side ionosphere is still not well understood. We also do not understand the effect of external forcing on the sporadic layer formed due to ablation by meteors.
- The dust and water vapor cycle are important components of the Martian climate. However, the effect of boundary layer processes on dust distribution and photochemistry is not well understood.

Scope of the Work:

- The project will deal with the (i) use of complex models and develop them further, and (ii) analyze data from existing missions, in order to address the above missing gaps in our understanding of the climate of Mars and Venus. The overall aim is to gainfully utilise the data from ISRO's future missions to Mars and Venus. This will be achieved by building trained human infrastructure in terms of appropriate model development and data anaylsis, for the atmospheres of Mars and Venus.

Deliverables:

- PRL has a repertoire of photochemical models for the neutral atmosphere and ionosphere, as well as GCMs. These can be taken as starting points to further develop them, so that at the end of the project we have more comprehensive models. The scientific objectives outlined in the summary, will be addressed, and results will be published.

RES-PRL-2022-007

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Studies of Meteorites, Studies of Impact craters, Studies of terrestrial analogue sites for Moon and Mars.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Meteoritics, Impact craters and Planetary geology

Summary of the proposed research and expected deliverables

Study of different meteorites is an ongoing process that enriches the database and knowledge of the solar system members like Moon, Mars and Asteroids. One important objective of this study is to provide additional inputs for the deep interior of the terrestrial planets including earth, especially for the high pressure silicate mineralogy of lower mantle and metallographic inner core. Second objective of this study is to find the nature of secondary aqueous / hydrothermal alterations that prevailed on the parent bodies due to rock-fluid interactions. How and when life appeared on the earth is still poorly understood and therefore the third objective of meteorite study is to investigate the origin of life on the earth and its possibility on other planets. Planetary scientists are motivating for future robotic exploration including the return of samples from the terrestrial planets as well as the far distant targets, both within and outside the solar system.

When meteorites strike on the earth's surface, a circular or elliptical depression structure is produced, called impact craters. Impact cratering being the fundamental process of the solar system we

observe the highly cratered surface of rocky planets including moon. Poor record of impact craters on the earth is due to the natural weathering over geological periods and human activities. It is, therefore, important and equally challenging to identify the older records of impact structures. Though the impact craters look inhospitable for life, but detailed laboratory studies of impactites may provide clues to planetary habitability from the stages of micro-deformation in mineral phases, aqueous alteration in parent asteroids and hydrothermally induced secondary minerals. Recently, two NASA led Martian rovers landed in the proximities of two impact craters, MSL Curiosity in Gale crater and Mars 2020 in Jazero crater, to search for life and habitability.

There is no perfect analogue for Moon and Mars on Earth. However, the geochemical evolution of Moon and Mars can be studied through apparently similar mineralogical and geochemical condition on Earth based on sample return mission. Since human and robotic planetary exploration necessitate the development of specific protocols and methods it, therefore, requires multiple stages of testing and validations in order to optimise instrumental setups and improve data interpretation; this can occur prior to, during, or even after a mission in the pre-selected terrestrial analog sites.

Scope of the Work:

- Three-fold proposed research covers (i) a basic knowledge of the primary, secondary and tertiary processes and their end-products of the meteorites derived from asteroids and other rocky planets, (ii) impact craters could be the important sites for probing the internal structure and composition of the rocky planets through the identification of high P-T mineral phases and the melt composition and testing bed of the planetary habitability for future planetary exploration (iii) terrestrial analog sites will assess the condition and formation process of minerals in Earth and their compatibility in other terrestrial planets so that potential landing site could be pre-selected for future planetary missions.

Deliverables:

- Integrated data from ongoing researches of available meteorites and impact crater studies on the earth till date would be expected to provide the nature of macro- and micro-level shock deformations, aqueous alterations and hydrothermal alterations leading to geological evolution of the asteroidal bodies and rocky planets including of early warm and wet Mars and Moon.
- A comprehensive list of terrestrial materials (rocks, soils and sediments) and ideal analog sites of different geological periods are the expected testing beds for Flight instruments, and/or performance check of their spare models.

RES-PRL-2022-008

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Constraining the distribution of water in the lunar interior by integrating latest lunar remote sensing data with high-temperature high-pressure experiments.

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Area of Research

Lunar research

Summary of the proposed research and expected deliverables

This project proposes to integrate latest lunar remote sensing data with high-temperature high-pressure (HPHT) experiments to constrain the distribution of water in the lunar interior, by investigating partitioning behavior of water at lunar relevant high pressures and temperatures. Until Chandrayaan-I first discovered the presence of lunar water, the Moon was considered to be completely dry. Data from the imaging infrared spectrometer (IIRS) on Chandrayaan-2 has demonstrated the presence of widespread lunar hydration and unambiguous detection of OH and H2O signatures on the Moon, with plagioclase-rich rocks being relatively enriched in OH/H2O concentrations compared to mare regions. The observed total water concentration was found to vary from near zero in the volcanic mare regions to ~800 ppm in plagioclase-rich highland regions, indicating a strong role of mineralogy. Recent high precision measurements of lunar glasses, melt inclusion and apatite phases, also confirm the presence of water in the lunar interior. The bulk water content of the Moon and the degree to which the lunar interior contains water is very crucial for constraining lunar formation models. This is challenged due to limited information about the mineralogy and melting behavior of different mantle source rocks that lead to the large diversity of primary lunar magmas, along with scarcity of lunar relevant partition coefficients for water in mantle mineral and melts. This project proposes to address these challenges through HPHT experiments to constrain new partition coefficients for water in lunar-relevant systems, along with investigating the melting behavior of the different mantle lithology.

Scope of the Work:

- The results will facilitate the development of a new generation of thermo-chemical models for the evolution of the lunar interior.

Deliverables:

- Mapping out of the water content in the lunar interior by integrating new partition coefficients obtained through HPHT experiments, lunar remote sensing data, and published water contents of lunar materials.

RES-PRL-2022-009

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Interaction between Fe-Ti-bearing cumulates and primitive lunar mantle with application to the composition and evolution of lunar crust.

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Area of Research

Planetary sciences

Summary of the proposed research and expected deliverables

The origin of the variable TiO_2 contents in the lunar mare basalts, ranging from <3 to 16 wt. %, is yet to be completely understood by planetary scientists. This range of TiO_2 content is very different from that found on Earth, between 1.5 to 5 wt. %. During the crystallization of the lunar magma Ocean (hereafter LMO), Ti being a relatively incompatible element, will partition more into the melt than in the initial cumulates (olivine and orthopyroxene). Along with that, as crystallization of the LMO progresses, the melt becomes increasingly enriched in Fe. As a result, the final bits of melt remaining in almost all models of LMO crystallization is enriched in both Fe and Ti, which on crystallization would form Fe-Ti oxides and Fe-rich pyroxenes. The objective of this project will be to investigate how these last stage Fe-Ti- oxides found their way into the mare basaltic magmas on the lunar surface. Understanding the phase equilibria of the Fe-Ti-bearing cumulates and their interaction with the surrounding mantle as well as with later uprising basaltic magmas to understand the origin of the variably Ti-rich lunar mare basalts.

Scope of the Work:

- A systematic new composition of the Fe-Ti cumulates will be considered along with the entire range of pressures in the upper to mid-lower lunar mantle, at pressures of 1, 2 and 3 GPa.
- It's a general High pressure experiments, with well thought, systematic inputs.

Deliverables:

- The wider range of input proportions would be explored in this study to identify the most appropriate proportion that will help in generating melts comparable to observed Ti-rich basalt compositions from the obtained Apollo samples. Should not take more than two years to compare and understand the origin of the variably Ti-rich lunar mare basalts.

RES-PRL-2022-010

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Plasma Physics in Shadowed Region on Moon.

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Area of Research

Interdisciplinary Plasma Physics:

Basic physics, Complex Plasma Kinetics, Application to Space and Industries: Modeling & Plasma Consequences.

Physics of Plasmas in connection with Planetary atmosphere and interplanetary medium

Summary of the proposed research and expected deliverables

In due course of a month, Moon undergoes different phases under the solar illumination that illuminates its various features. However, due to nearly normal incidence, there are some parts near terminator that never see the sunlight, called permanently shadowed regions. The craters nearby poles (e.g., Shoemaker, Shackleton) have been of particular interest, which is supposed to be in the dark for over billion years, and are like cold traps. These cold trap regions might not only be confining water, and other hydrogen-based compounds, but also the pristine signatures of the Moon evolution, and hence, these locations are of prime focus for the forthcoming lunar exploration programs. These locations however irradiated by diffused solar wind and other vibrant transport mechanisms that creates an exotic electrical plasma environment in such dark regions, and it has always been the quest that how sensitive the maned/ robotic missions are in such a scenario.

This proposal aims to understand the characteristic plasma behaviour in such regions, initiating with the simple models and then by including the complexities like orographic effects and magnetic field anomalies. This growing understanding will parallelly be applied to explore the electrostatic effects of such complex plasm environment on the moving/ robotic objects. The proposed work is of theoretical in nature and conceptual basis, physics modelling and numerical modelling will be conducted in this program.

Scope of the Work:

- In-depth understanding of the electrostatic behaviour of the complex plasma environment in shadowed region.
- Conceptual design of test experiments for the future manned/ robotic missions in the Shadowed region/ PSCs.

Deliverables:

- Physics understanding of the plasma/ electrostatic behaviour of darker Moon – particularly, an interpretation for charged particles and plasma transport over Moon around terminator.
- Conceptual & numerical modelling of the complex plasma environment in the shadowed region.

RES-PRL-2022-011

Name of ISRO Centre/Unit
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Title of the research proposal
Polar cold traps of Moon and Mercury as a scientific resource.

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Area of Research
Infrared spectroscopic analysis/Remote Sensing

Summary of the proposed research and expected deliverables
PSRs are a scientific resource to understand volatile transport system on airless planetary bodies because they act as a key sink in this transport system. Volatiles have been reported at Moon and Mercury poles but the time history of volatiles within the PSRs and nature is still not understood in detail. With Chandrayaan-2 in orbit to Moon and BepiColombo on its way to Mercury a detailed mapping of poles is expected. A new set of high resolution data will provide an opportunity to understand origin and volatile distributions. Such a comparative study will address to the question; why the nature of volatiles different at the Moon and Mercury?

Scope of the Work::

- The planned work is first step towards comparative planetology we intent to pursue. The work will have implications towards understanding how water-ice environment evolved in the inner solar system.

Deliverables:

- A better understanding of why the nature of volatiles different at the Moon and Mercury?
- Better resolution polar maps.

RES-PRL-2022-012

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Estimation of water abundance on the Moon using Chandrayaan data-sets.

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Area of Research

Infrared spectroscopic analysis/Remote Sensing

Summary of the proposed research and expected deliverables

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

Scope of the Work::

- The planned work is in line to one of the Chandrayaan-2 defined science objectives. The proposal is based on the Chandrayaan-1 and Chandrayaan-2 NIR data-sets

Deliverables:

- Detailed site specific and global maps of water ice exposures.
- Final processed data products to the lunar science community which can be further explored

RES-PRL-2022-013

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Analogous Studies and Geo-physical Modeling of Moon/Mars.

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Area of Research

Planetary Surface Science

Summary of the proposed research and expected deliverables

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

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

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

Scope of the Work:

- The scope of the proposed research work includes different components as mentioned below each of which can carried out independently
- Literature survey to assess the current state of knowledge in the field
- Development of facility to create simulated environment of Moon/Mars
- Carryout target experiments on analogous samples viz. thermo physical properties, electrical properties, surface-atmosphere exchange.
- Develop numerical models

Deliverables:

- Design and development of an experimental facility for carrying out various experiments under simulated environments, which are otherwise not possible.
- Provide database of experimentally derived geophysical (Moon/Mars) parameters of planetary surface that can be used in calculations/models in lieu of in-situ data.
- Availability of more sophisticated geophysical Models.
- Aid interpretation of in-situ data and planning of future surface missions.

RES-PRL-2022-014

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

- Instrumentation for future planetary missions/modelling/data analysis of planetary lightning.
- Instrumentation for future planetary missions/modelling/data analysis of interplanetary/ planetary dust/dusty plasma on Moon.

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Area of Research
- Planetary Lightning
- Interplanetary/Planetary Dust Science

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

The Interplanetary Dust Particles (IDPs) are originated from asteroid belt and other sources. These IDPs sometimes are trapped between two planets and create the resonance. Also, planetary dust like dust storms/devils is of scientific interest. The dust on Moon is charged and may be levitated. It can create dusty plasma in the lunar environment, which needs investigation. The properties of the dust at a planet may be understood using the instrument on future planetary missions/ modelling/data analysis. The project can cover such aspects related to the interplanetary/planetary dust science.

Scope of the Work:

- The projects focus on making a lab model of instrument or modelling the process (like lightning/ dust dynamics, as applicable) or analyzing the past mission data to understand the process and its effect on the planet. The project can also cover any related research in the given area.

Deliverables:

- The expected outcomes can explain the physical process on a planet as well as the effects on atmosphere or surrounding environment. The expected deliverables can also provide an extension to existing model or a new model.

RES-PRL-2022-015

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Martian fluvial channels, deposits and their Earth analogue.

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Area of Research

Remote sensing of Mars

Summary of the proposed research and expected deliverables

Mars is well known for its large number of fluvial channels and their associated fan/delta deposits. These channels and deposits are preserved for more than 3 billion years. However, on Earth there are similar channels and deposits which are currently inactive. These channels and their deposits are of interesting areas to do comparative studies among the Planets. In India, there are potential sites which have similar deposits and mineralogical assemblage. This proposal aims to explore such new analogue sites.

Scope of the Work:

- To bring out the potential sites within India which have fluvial channels and associated deposits which are comparable to Mars.

Deliverables:

- New Martian analogue sites within India will be highlighted which have more relevant comparison.

RES-PRL-2022-016

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Ionospheric Characterization Through Observations and Modelling.

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Area of Research

- Equatorial ionospheric dynamics
- Space weather Effects on low and equatorial latitudes
- Ionospheric Empirical modelling

Summary of the proposed research and expected deliverables

The equatorial and low latitude ionosphere exhibits high degree of variability being characterized with electro dynamical processes namely the Equatorial Electrojet (EEJ), Equatorial Ionization Anomaly (EIA) and Equatorial Spread-F (ESF). Spatio temporal distribution of ionospheric plasma in the equatorial and low latitudes is dominantly controlled by these electrodynamic processes,

especially by the extremely variable EIA phenomena. Consequently, the day-to-day variability of various parameters to characterize the structure and dynamics of ionospheric plasma remains as an enigma. Also, geomagnetic storm induced disturbances like the Prompt Penetration and Disturbance Dynamo Electric Fields (PPEF & DDEF) can severely modify the equatorial zonal electric field and in turn disturb the electrodynamic processes. Understanding the interplay of storm induced disturbances from different sources is crucial to comprehend the space weather impacts on ionospheric dynamics and subsequent modifications in the plasma distribution. A broad range of user applications are crucially reliant or affected by the state of the ionosphere. For instance, highly variable electron density governed by the electrodynamic processes leads to ambiguous range delays threatening the fail safe performance of satellite based technologies. Irregular structures in the night time ionosphere cause loss-of-locks in trans-ionospheric signals effecting the reliability of satellite based communication systems. As such, modeling and correction of these impacts is subsequently highly sensitive to the choice of ionospheric representation.

Scope of the Work:

- It is important to characterize the ionospheric features in horizontal and vertical scales, their short and long term variations and response during active space weather conditions. Employing advanced machine learning tools is worthwhile for the comprehensive validation of ionospheric models.

Deliverables:

- Deliverables include the quantitative understanding of physical processes governing the variability of ionospheric structure and dynamics; evaluation and improvements in the prediction capabilities of equatorial and low latitude ionospheric characteristics.

RES-PRL-2022-017

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Wave dynamical coupling in lower and middle atmosphere.

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Area of Research
- Waves and tides
- Middle atmosphere dynamics
- Coupling of lower and middle atmosphere

Summary of the proposed research and expected deliverables

Atmospheric waves (gravity waves, tides, planetary waves) are most important coupling agents in the lower and upper atmospheric processes. They are generated in the lower atmosphere due to various disturbances and propagate upwards. Their interaction with background wind and other waves leads exchange of their energy with the surroundings at different altitudes. Additionally, the low latitude regions are substantially influenced by a number of unique wave activities due to maximum solar incident radiation and resulting large scale convection activities compared to the mid and high latitudes. Therefore, investigation of equatorial dynamics draws an additional importance to address global scale atmospheric dynamics.

Scope of the Work:

- The objective of the proposed research program is to study low latitude middle atmosphere and associated dynamical coupling processes between the lower and middle atmosphere with the help of multi-platform database to explore the features of the unique atmospheric dynamics associated to gravity waves, planetary waves, tides, and long period oscillations. Furthermore, impact of the longer period oscillations on the small-scale wave features and associated alteration of the MLT dynamics could be assessed.

Deliverables:

- The proposed research is expected to lend important insights into the various wave associated physical processes taking place in the atmosphere.

RES-PRL-2022-018

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Exploration of solar coronal jets and associated small-scale flaring processes during solar cycle 24 and 25.

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Area of Research

Solar Physics, Space Weather

Summary of the proposed research and expected deliverables

Solar jets are small-scale plasma ejections from the solar lower atmosphere towards the solar corona. These are one of the important small-scale solar eruptions, which needs through investigations because of their role in mass and energy input to the upper solar atmosphere and the solar

wind. Further, although jets are small-scale phenomenon, they exhibit characteristics of explosive magnetically driven dynamical events. We, therefore, propose to conduct systematic study of solar jets and related mini/micro flares observed during solar cycle 24 and 25. We will perform in-depth multi-wavelength analysis of the jets along with coronal magnetic field modeling of the activity site. The cases of blowout jets leading to narrow CMEs will also be studied.

To achieve the aim of the proposal, we will use the high spatial and temporal resolution data from various space-based solar telescopes observing in X-rays, extreme ultraviolet (EUV), and Ultraviolet (UV) energy bands. In particular, we will explore novel data from XSM/Chandrayan-2 spacecraft. We will also analyze data from ISRO/DOS ground-based solar observing facilities (e.g., MAST and Udaipur-CALLISTO). We propose detailed multi-wavelength investigations of solar coronal jets which are small-scale eruptive phenomena occurring in solar corona. While the energy involved in a jet-like event is smaller than that of "nominal" solar flares and coronal mass ejections (CMEs), jets share many common properties with these phenomena, in particular, the explosive magnetically driven dynamics. Studies of jets could, therefore, provide critical insight for understanding the larger, more complex drivers of the solar activity.

The proposal will focus on the observational aspects of energy release and particle acceleration during jet events. This goal will be accomplished by analyzing the high spatial, temporal and spectral resolution data sets.

Scope of the Work:

- To analyze the kinematics and dynamics of the solar jets/surges using the high spatial, temporal and spectral resolution data sets.
- To look into the association between solar jets and the mini/micro flares.
- To diagnose the magnetic field configuration and topology of the sources of small-scale energetic transients.
- To explore the association between jet, X-ray bright points, solar energetic particles, and CMEs.

Deliverables:

- Exploration of the physical parameters of small-scale solar transients and their role toward the build-up of complex drivers of the solar activity that effect space weather conditions.
- Characterization of magnetic reconnection at much smaller-scale, as evidenced by jet-associated microflares and mini-flares by analyzing comprehensive solar X-ray observations by XSM/Chandrayaan-2.
- Advancement toward the formation process of small-scale magnetic flux ropes and subsequent instabilities which will have important implications in understanding the onset and evolution of coronal mass ejections.
- Contribution toward training of young researchers.

RES-PRL-2022-019

Name of ISRO Centre/Unit

Physical Research Laboratory, Ahmedabad

Title of the research proposal

Developing Deep (Machine) Learning techniques in the area of fundamental and space physics.

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Area of Research

Theoretical Particle Physics, AI and computer application

Summary of the proposed research and expected deliverables

Modern Machine Learning (ML) frameworks aim to utilize different deep neural networks over large data sets to find hidden features in data and solve diverse problems. Although its impact is overwhelmingly evident in our everyday life, from a simple Google search to the autonomous car, it is still at an evolving phase with fundamental research. In the last few years, such techniques have demonstrated their exceptional capability in theoretical and experimental research. For instance, remarkable progress is achieved in developing different algorithms in event classification, particle identification, jet characteristics and energy estimation, various applications in experimental measurements and pile-up suppression in high energy particle physics experiments.

With these in mind, it is high time to prioritize, invest in capacity building for this critical component of future capability. Deep neural networks are incredibly versatile, applicable in diverse areas of research. So, it is envisaged that the techniques developed in this project would generate opportunity and zeal to explore them further in different fields, including space physics.

Scope of the Work:

- Use a range of neural network architectures to localize and identify particles in detector simulations with specific physics scenarios to probe new and exotic physics beyond the standard model of particle physics.
- Use of networks to exploit three-dimensional data from high-granularity calorimeter and tracker information to probe new physics at the collider experiment.
- Study of soft and hard jets and their sub-structures using ML models to probe new physics.
- Study on anomaly detection in detector images (applicable to remote sensing directly).

Deliverables:

- The research outcome from this project is expected to be published in international journals with a high impact factor.

- Simulation data and ML codes will be available for use and modification in the application for different streams of research. This will attract national and international collaborations and visibility subsequently.
- Training of human resources (students, postdoctoral fellows and young faculties) to use ML methods in image/data processing for various particle physics and space science applications.

RES-PRL-2022-020

Name of ISRO Centre/Unit
Physical Research Laboratory, Ahmedabad

Title of the research proposal
Exploring the Dark Matter in ground and space-based experiments.

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Area of Research
Theoretical Particle Physics, Astrophysics and Cosmology

Summary of the proposed research and expected deliverables
The existence of a non-luminous and non-baryonic form of matter, popularly known as dark matter (DM), is already well established and measured at different length scales of the Universe by the observations like galaxy rotation curve, gravitational lensing, bullet cluster etc. Besides that, the current relic density of DM has been measured quite precisely in satellite-borne experiments like Planck, WMAP. A dominant part of the matter in the present Universe is in the form of DM. However, the nature and production mechanism of the same remains a mystery and an open question to date!

This proposed research aims to study the properties and interactions of possible candidates of DM, be it weakly or feebly interacting fundamental particles originated through particle interactions in the early Universe. It is essential to look into such models and study the possible signature of such new physics in the present and upcoming experiments that comprises direct, indirect and collider searches of dark matter. It will add to our understanding in perspective to the broad area of Astrophysics, Cosmology and High energy physics.

Scope of the Work:

- To probe classes of dark matter which are generated through freeze-out or freeze-in mechanism and test them in perturbative as well as, effective field theory framework.
- To investigate fundamental properties of dark matter, such as, mass, spin, parity, couplings etc. through the collider experiments (e.g. Large Hadron Collider, future linear collider) and astrophysical searches (e.g. relic density, SN1987A cooling etc.).

Deliverables:

- Development of New Physics model(s) on dark matter, pointing out possible search strategies.
- The outcome of the project work is expected to be published in International journals of high impact factor and presented in National/International Workshops/Conferences.
- Possible work force development in this area of research.
- It will also generate potential collaborative activities among other premier institutes.

SATISH DHAWAN SPACE CENTRE SHAR
SRIHARIKOTA

RES-SDSC-2022-001

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

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

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Area of Research
Supersonic jet acoustics

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

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

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.,

Deliverables:

- Development of supersonic jet noise source localization tool applicable to free and impinging jets

RES-SDSC-2022-002

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Fatigue Life Estimation of Structural Members Under Random Vibrations through Strain Gauge Measurements.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Structural dynamics

Summary of the proposed research and expected deliverables

During the lift-off of a launch vehicle, ground structures and also launch vehicle structures/ components experience intense vibration load due to lift-off acoustics. Also, during flight induced vibrations have a tremendous impact on the structural integrity of the flight sub-systems. Most of these vibration loads are random in nature. Structural members subjected to these random vibration loads will be damaged due to fatigue. The problem of fatigue damage is more severe with respect to ground structures at launch pad. As these structures are critical with respect to safe launching of the rocket, proper estimation of fatigue damage is highly essential. As the launch pad structures are huge in size and are subjected to harsh environment viz. lift-off loads (thermal, static/ dynamic pressure), atmospheric conditions, etc., the fatigue life assessment mechanism shall implement practically feasible measurements with minimum sacrificing of the sensors. Due to this, strain gauge based measurements are proposed for fatigue life estimation of these large structures.

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

Scope of the Work:

- Identification the critical and most vulnerable structures of launch vehicle as well as launch pad for carrying out the fatigue life estimation study.
- Estimation of launch induced loads and its statistical distribution.
- Demonstrating the use of strain gauges for structural health monitoring under various random loads (broadband and narrow band loads).
- Implementation of the scheme for the actual Launchpad structures after validation of the methodology.

Deliverables:

- To quantify the extent of damage (if exists) on critical structures and assess the residual life.

RES-SDSC-2022-003

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

Name of Co PI from ISRO Centre/Unit

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Area of Research

Structural dynamics

Summary of the proposed research and expected deliverables

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

Scope of the Work:

- Theoretical modelling of damping mechanism of threaded joints.
- Estimation of effect of this damping on the dynamic load transfer characteristics of load cells.
- Demonstration of the model using a lab scale test set-up.
- Characterization of full scale load cell test set-up damping characteristics.

Deliverables:

- Proper modelling and accounting the damping and quantifying its impact on the measured dynamic force components during the static firing of solid rocket motors on ground.

RES-SDSC-2022-004

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Size reduction in hammer mill

Summary of the proposed research and expected deliverables

Ammonium Perchlorate (AP) is used as oxidizer in Solid Propellant processing with wide particle size distribution. Coarse AP of ~300 microns average size is ground into fine size of 50 micron average particle size using hammer mill and conveyed to the collection point pneumatically. To achieve desired mechanical and ballistic properties of solid propellant, AP particle size plays significant role.

Understanding the mechanism of particle breakage during grinding operation at different operating conditions is very much essential to control the average particle size. Simulation of particle breakdown due to impact with particle to particle, and housing surfaces under different operating conditions like rotor speed, air velocity, feed rate, is required.

It will help in optimizing the process conditions to achieve the targeted properties at propellant level.

Scope of the Work:

- To simulate all the possible load conditions on AP particle inside a hammer mill under different process parameters.
- To validate and provide model to assess different parameters effect on the output AP particle characteristics, size and microstructure.

Deliverables:

- Modeling, simulation and parametric model evaluation of ground product characteristics at different operating conditions.

RES-SDSC-2022-005

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Size Reduction

Summary of the proposed research and expected deliverables

Ammonium Perchlorate (AP) is a major ingredient in solid propellant which occupies around 68 weight percent in propellant formulation. Bimodal AP is prepared by AP coarse and AP fine for achieving desired burn rate. Ammonium Perchlorate is currently being ground by Hammer mill to produce AP fine, Hammer mill has impact mechanism to break the particles.This process gives a wide distribution of particle size, which is suspected to affect burn rate of propellant. AP fine particle size distribution control is achieved with great difficulty due to various factors like residency of the grinder usage, selection of Mill RPMs and screens. It is difficult to get the desired PSD in the range of less than ±1 weight percentage, even with great care. With the requirement of control burn rate between paired motors, the variation in PSD upto the extent of ±1 weight percentage may not be meeting the requirement. Hence, it is proposed to explore for alternative methods to achieve the required specifications.

Scope of the Work:

- Arriving at a method which can produce uniform particle size from different input.
- Developing a lab scale equipment utilizing the above-mentioned method.
- Demonstration of the equipment with different input sizes.

Deliverables:

- Lab scale equipment to obtain uniform particle size output from a defined input.

RES-SDSC-2022-006

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Experimental studies on Oxygen Deficiency Environments due to accidental spillage or release of gases.

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Area of Research

Ground Safety

Summary of the proposed research and expected deliverables

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

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

Scope of the Work:

- To study the oxygen exhaust environments which poses life threatening factor to the operational personnel in a closed room or confine Space operations.

Deliverables:

- Box Model Studies with provision for monitoring of gases at different elevations by releasing a known gas to establish the Oxygen deficiency zones is required.

RES-SDSC-2022-007

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Smoke Extractor system for Solid motors exhaust gas during testing.

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Area of Research

Ground Safety

Summary of the proposed research and expected deliverables

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

Scope of the Work:

- Theoretical and experimental setup studies for a smoke extractor system towards safe collection of exhaust gases for disposal.

Deliverables:

- The results of the studies with the locations of the smoke extractor system towards safe collection of exhaust gases for disposal.

RES-SDSC-2022-008

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Safety / loss prevention

Summary of the proposed research and expected deliverables

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

Scope of the Work:

- To derive the dispersion of liquid propellants due to accidental release or spillages by considering various credible scenarios. This will ultimately estimate the toxic corridors with pollution levels from the source of leak by considering prevailing meteorological conditions.

Deliverables:

- Estimating the toxic corridors with pollution levels from the source of leak by considering prevailing meteorological conditions. Also, to optimize the location of the sensors for a faster response and for initiating the safing actions.

RES-SDSC-2022-009

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Safety / loss prevention

Summary of the proposed research and expected deliverables

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

Scope of the Work:

- To design an effective Fire Detection Alarm system for High rise and High bay buildings with the smoke modeling/capturing techniques through high-tech visualization cameras.

Deliverables:

- An effective Fire Detection Alarm system with wide range of scope to detect even in remote areas in a bay where conventional detectors are unable to route/implemented.

RES-SDSC-2022-010

Name of ISRO Center
Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal
FPGA based IRIG-B Time Decoder and Time Insertion in 2K video

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Area of Research
Image and video Processing in FPGA

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

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

Scope of the Work:

- To study the requirements and implement a FPGA based IRIG-B time Decoder and Time insertion in 2K video in real time.

Deliverables:

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

RES-SDSC-2022-011

Name of ISRO Center

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Radar Data Processing

Summary of the proposed research and expected deliverables

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

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

Scope of the Work:

- To implement JPDA in Real time and MHT in near real time application of MOTR for tracking multiple targets.

Deliverables:

- 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-2022-012

Name of ISRO Center

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

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

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Area of Research

Radar Data Processing

Summary of the proposed research and expected deliverables

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

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

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

Scope of the Work:

- To study on the Dynamic characteristics and RCS estimation of Space debris from MOTR tracked data.

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-2022-013

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Development of observer based robust controller for vibration mitigation designed for 3 storey benchmark structure and its force validation using Magneto Rheological damper.

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Area of Research

Vibration Control

Summary of the proposed research and expected deliverables

Natural hazards like earthquake, high wind and tsunami are threat all the times for the multi-storey structures. The environmental forces cannot be clogged but the structures can be prevented from these natural hazards by using protective systems for the structures. Therefore, a semi-active protective system, Magneto- Rheological (MR) damper for the earthquake forces is proposed in this work. Simulation studies has to be carried out to mitigate the vibration of the structure by using the semi-active system. The simulation results have to be validated towards developing a vibration control system which will drastically reduce the vibration of a benchmark structure even in presence of uncertainties like earth quake. This makes it a safety critical control system which makes the tall structures safer by reducing the vibrations.

Scope of the Work:

- Survey on Vibration control strategies for tall buildings/ structures under earth quake induced loads.
- Developing a semi-active vibration control methodology using Magneto- rheologial dampers or any other suitable device.
- Validation of the method and model using experimental studies.

Deliverables:

- Semi-active vibration control methodology using Magneto-rheological dampers or any other suitable actuators will be devised to protect the tall structures/ buildings under natural hazards like earth quakes.

RES-SDSC-2022-014

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Implementation of infrared thermographic technique for bond line evaluation at insulation layer interface of solid rocket motors.

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Area of Research

Non-Destructive Testing (Infrared Thermography)

Summary of the proposed research and expected deliverables

The solid rocket motor cases are lined with rocasin insulation in order to protect the case from the hot gases during propellant burning. The insulation build-up is laid layer by layer from the case until required thickness is achieved. The interface between the first insulation layer and the case is very critical and should be intact for normal performance of the motor during flight. Hence, after the completion of first layer, the interface between the case/insulation base layer is to be checked through NDT to confirm the bond integrity.

Presently, Radiography testing and Ultrasonic testing are being implemented for solid rocket motor cases. These techniques are time consuming, requires handling & transportation and are limited to line scans or a fraction of the total interface area.

Scope of the Work:

- To study and implement Infrared thermographic technique which is faster, offers 100% coverage of the interface and increases the confidence level of testing for identifying defects/debonds.

Deliverables:

- Expected deliverables include detailed literature study, experimentations on various test objects using IR camera, obtaining data using ALTAIR software and validating the results with RT/UT.

RES-SDSC-2022-015

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Extraction of energetic materials from residual propellant.

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Area of Research
Solid Propellant System

Summary of the proposed research and expected deliverables
Residual propellant is hazardous to store and shall be disposed at the earliest. Presently, open pit burning is adopted for disposal. Open pit burning shall be carried out carefully in view of safety of operating personnel and nearby infrastructure. The combustion products also pose health issue and cause deposition of harmful chemicals on facilities, flora and fauna.

Alternatively, the residual propellant may be attempted for extraction of energetic materials like Ammonium Perchlorate and Aluminum powder. The left-over propellant after extraction are safe to dispose through burning or landfill. The residual and extracted material are also viable for recycling after due evaluation. Economical extraction of material and alternative applications are of paramount importance.

Scope of the Work:

- Development of methodology for economical and ecological extraction of energetic material.
- Different methodologies may be adopted for extraction at different stages like uncured propellant, cured propellant, spills, contaminants etc.,

Deliverables:

- Methodology and reagents for extraction of energetic materials.
- Qualification and grading of extracted materials.
- Applications for extracted materials.

RES-SDSC-2022-016

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

Title of the research proposal
Development of process for producing Ammonium Perchlorate of defined size distribution from crystallization process.

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Area of Research

Solid Propellant System

Summary of the proposed research and expected deliverables

Ammonium Perchlorate (AP) is used with wide particle distribution and defined specific surface area for application in Solid Motor grain. The AP produced from crystallization has wide size distribution. The produced AP is screened and collected into different grades of material. The required AP particle size distribution is achieved by mixing material of different grades (Coarse and fine). Fine grade of AP is made through grinding coarse grade. The operations like grinding, mixing introduce hazard and quality issues when stringent parameters are considered.

The crystallization process shall be designed and optimized to produce product with pre-defined size distribution, ready for use in solid propellant production without further processing.

Scope of the Work:

- Process parameters, solvent – Non solvent system etc for particle size control from crystallization
- Sensitivity of the parameters towards fine tuning of properties

Deliverables:

- Methodology for achieving desired particle size

RES-SDSC-2022-017

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Alternative solvent for TCE.

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Area of Research

Development of chemical solvent

Summary of the proposed research and expected deliverables

Trichloroethylene is used as a solvent for degreasing of solid rocket motor segments. It is used on maraging steel and Aluminum, before and after blasting operations. It is also used to wipe clean the abraded rocasin surface before preheating operation. TCE is a popular degreasing agent for many years in the metal finishing industry. Alternatives to trichloroethylene (TCE) are becoming essential due to the following ill-effects:

- It is a proven carcinogen with a R45 risk assignment.
- It is identified as one of the main agent in the ozone depletion. Its usage is banned as per Montreal protocol

Due to this, many countries have banned the usage of TCE. In India also many manufacturers are stopping the production of TCE. As per their assessment, TCE is going to be banned in India also, in the near future. The commercial solvents, which claim as alternative to TCE are very costly and their usage in large quantities are impractical due to their abnormal cost. Hence it is essential to develop an alternative solvent for TCE which suite the requirements of the solid rocket motor processing.

Scope of the Work:

- Development of new chemical solvent which can be used as degreasing and cleaning agent in solid rocket motor processing.

Deliverables:

- Shall be suitable/compatible for solid rocket motor processing.
- Shall have low flammability, low reactivity, less health hazards and shall be environmental friendly.
- Shall be produced at low cost.
- Shall be recoverable form the spent solvent after usage.

RES-SDSC-2022-018

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Risk analysis, impact assessment during solid propellant mixing and storage by using CFD.

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Area of Research

CFD

Summary of the proposed research and expected deliverables

The siting of solid propellant mixing and storage facilities are based on the quantity distance criteria. Considering the worst-case scenario, Risk analysis studies help us to estimate the risk levels of the solid propellant during mixing and storage.

It helps us the adequacy of protection level and preparation of emergency response plan.

Scope of the Work:

- Identification of the vulnerable locations in and around the facilities.

Deliverables:

- Detailed map showing the vulnerable locations based on the analysis.

RES-SDSC-2022-019

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Evaluation of environment friendly disposal method for residual Ammonium Perchlorate (AP).

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Area of Research

Process Safety - Solid Propellant

Summary of the proposed research and expected deliverables

At present the disposal of AP is being carried out by open burning in burn pits. This method of disposal releases toxic / ODP gases like HCl, Cl_2, N_2O and NO etc. Perchlorate seepage in water is also a potential health concern because of its interference with the uptake of iodide by the thyroid gland, thus inhibiting the production of thyroid hormone which is required for normal human metabolism. This work is for the evaluation of environmental friendly disposal methods / incinerator burning method in order to avoid pollution of the environment.

Scope of the Work:

- To study the different environmental friendly disposal methods for disposal of AP and to work on the environment friendly biodegradation disposal method (Using wolinella succinogenes and HAP-1 bacteria) / incinerator burning method. This evaluation of the methods will help us to find an alternate method to dispose the residual AP in environment-friendly manner in the near future.

Deliverables:

- This environment friendly disposal method for AP enables to avoid I minimise the emission of toxic/ODP gases into atmosphere and maintain healthy and sustainable environment.

RES-SDSC-2022-020

Name of ISRO Centre/Unit

Satish Dhawan Space Centre SHAR, Sriharikota

Title of the research proposal

Evaluation of environment friendly disposal method for residual Solid Propellant generated during processing of Solid propellant.

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Area of Research

Process Safety - Solid Propellant

Summary of the proposed research and expected deliverables

Residual propellant is generated during the processing of solid propellant at SDSC, SHAR. The present method of disposal of residual solid propellant is by burning the propellant in an open burn pit. After ensuring that all the propellant is completely burnt in the open burn pit, the bed is drenched with water in order to put off the smoldering fire (if any) and also to cool the bed. This method of residual propellant disposal releases toxic gases like HCl, CO, CO2 and Al2O3 which pollutes the environment. Also, the percolation of perchlorate into the soil also causes potential health concern due to its interference with the uptake of iodide by the thyroid gland, thereby inhibiting the production of thyroid hormone which is required for normal human metabolism. This work is for the evaluation of environment friendly disposal methods like controlled burning with combustion cleanup method, ingredient recovery method, energy conservation methods etc., to find out the best alternate method in order to avoid polluting the environment.

Scope of the Work:

To evaluate the different environment friendly disposal methods for disposal of the residual solid propellant and to work on the environment friendly

- Controlled burning with combustion gas cleanup method.
- Reclamation methods (Ingredient recovery method).
- Energy conservation methods

This evaluation of the methods will help us to find an alternate method to dispose the residual solid propellant generated during processing of solid propellant in environment-friendly manner in the near future.

Deliverables:

- This environment friendly disposal method for residual solid propellant enables to avoid / minimise the emission of toxic gases into atmosphere and also to maintain healthy and sustainable environment.

ISRO INERTIAL SYSTEMS UNIT
THIRUVANANTHAPURAM

RES-IISU-2022-001

Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal
Non-contact machining of optics to improve surface quality and integrity.

Name of Co PI from ISRO Centre/Unit
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Area of Research
Machining and fabrication of optics

Summary of the proposed research and expected deliverables
Precision optics is one of the critical elements for realization of advance optical sensors for space craft and launch vehicle application. Machining of brittle optics is always challenging. Such precise optics is generally realized by conventional lapping and chemo mechanical polishing (cmp) process with strict control of optimized process parameters. As this machining is contact in type, the tool physically approaches the brittle substrate. Hence these kinds of machining induce numerous mechanical, structural and chemical defects on the substrate. These defects lead to color centers, scatter sites; mechanical damping etc. causing significant loss at the substrate interface. These losses hamper the useful life time and performance of the optical sensor.

For high quality optics such as for total internal reflecting prisms (TIR) used in ISRO Laser Gyro, which has been processed with chemo mechanical polishing method, the index matched damaged layer may present in nanometer range only. Hence, it poses challenge not only characterizing and quantifying this damaged layer but also eliminating it without altering the surface topography. Only known method for eliminating this damaged layer is controlled etching. The etching can remove the molecular strain but changes surface topography.

It is always challenging to polish complex form optics Hemi spherical resonator shell, where no tool can approach to finish internal surface and achieve damage free surface. Hence the existing methods are not deterministic enough to eliminate the damage completely. In this proposal it is proposed to have non-contact methodology to address the machining issues of brittle optical substrates.

This topic also aims;

- To establish new set of processing methodology to realize high quality precision optics for achieving long life and trouble free optical ILG sensor.

- To establish new polishing methodology for achieving high Q and better surface finish HRG resonator shell.

Scope of the Work:

- To improve the surface quality of Total Internal reflecting prisms of ILG, hence enhance the life time of the sensor and improve the quality factor Q of HRG shell

Deliverables:

- To establish new set of processing methodology to realize high quality precision optics for achieving long life and trouble free optical ILG sensor.
- To establish new polishing methodology for achieving high Q and better surface finish HRG resonator shell.

RES-IISU-2022-002

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Realization of plasma gun for atmospheric plasma polishing.

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Area of Research

Machining and fabrication of optics

Summary of the proposed research and expected deliverables

Conventional contact machining of brittle materials like Fused silica, Zerodur etc introduces sub surface cracks and stress at the optics application surface. Hence the performance of the optical sensors cannot be met. The proposed gun should be capable of removal of the material from the substrate by non-contact method. So it minimizes the sub surface damage and increases the yield of the processes.Plasma polishing at atmospheric pressure utilizes only surface chemical reaction to remove the substrate material by converting it to volatile molecules; hence it is purely chemical in nature and removes the material atom by atom.

As literature suggests the plasma source is like a torch of maximum width of ~ 6 mm, local selective area correction is possible to improve the surface finish as well as reduce the subsurface defects which cause local scattering.

As this helps in removal of selective area of the substrate, it finds critical application in Hemi spherical Resonator Gyro (HRG) shell balancing where it requires material removal of local selected area.

This machine comes with four axis movement features hence; it helps in not only local correction but also final polishing of the free form complex structures like HRG components and other critical ILG components like prisms etc without subsurface damage.

This topic also aims;

1. Realization of plasma gun for enabling plasma polishing at atmospheric pressure.
2. Gun should have provision for flow of reactive gas for polishing of fused silica components.

Scope of the Work:

- For selective correction of Hemispherical Resonator gyro and enhancing the surface quality of the prisms of ILG.

Deliverables:

- Realization of plasma gun for enabling plasma polishing at atmospheric pressure.
- Gun should have provision for flow of reactive gas for polishing of fused silica components.

RES-IISU-2022-003

Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal
Design and Development of Oven-controlled MEMS (Microelectromechanical Systems) Resonator.

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Area of Research
MEMS Inertial Sensors with In-situ Temperature Control.

Summary of the proposed research and expected deliverables
Design and investigation of oven-controlled based MEMS resonator. In typical launch vehicle and space-craft applications require better thermal stability of inertial sensors. Though MEMS technology offers low-cost, light weight, compact systems, the MEMS based sensors are more susceptible to thermal affects in comparison to conventional inertial sensors. In application, to meet the requirements, typically the sensor package (includes electronics) is placed in temperature controlled environment, demanding more power consumption.

The objective of the proposal is to find a design methodology and investigate an in-situ temperature controlled MEMS resonator. It involves identification of appropriate support materials to meet the required thermal environment in conjunction with minimal mechanical stress generation.

The MEMS Resonators shall integrate with appropriate electrodes for measuring frequency response in the influence of temperature environment. The MEMS device shall constitute monolithic resonator, thin-film heater, and an appropriate temperature readout element such as thermistor, thermocouple, and temperature sensor etc....The proposal shall also investigate the suitable materials for thin-film heaters, temperature readout elements, thermal isolation, mechanical support and adhesives. The proposal shall also explore hybrid integration of MEMS resonators, off-the shelf temperature sensor, heater and appropriate PID control system

Scope of the Work:

- The proposed work is essential in development of thermally stable MEMS inertial sensors for space-craft applications.

Deliverables:

- Theory and simulation (Design Methodology),
- Demonstration and supply of oven-controlled MEMS Resonators.

RES-IISU-2022-004

Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal
Negative Stiffness Mechanism based Low Frequency Passive Vibration Isolation platform.

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Area of Research
Mechanical Vibrations

Summary of the proposed research and expected deliverables
To develop a Negative Stiffness Mechanism Based passive vibration isolation platform. The platform is intended to be used in attenuating ground vibrations for a LASER based optical experiment.

The isolator must be capable of attenuating ground vibrations above 0.7 Hz, in all six degrees of freedom. Natural frequency of the system shall be 0.5Hz or below. Mode of operation shall be passive.

Payload capacity: 30 Kg. Isolation requirement: Attenuation of 90% or more at 2Hz and 99% or more at 5Hz.

Scope of the Work:

- The design shall be scalable for any payload mass. A general purpose numerical model capable of sizing the design element based on a given payload mass shall be developed. A design prototype demonstrating the above requirements/specifications shall be developed.

Deliverables:

- A general purpose numerical model capable of sizing the design elements/components based on a given payload mass
- A design prototype demonstrating the above requirements/specifications

RES-IISU-2022-005

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Design and developed Navigation Grade Voltage to Frequency Converter in SCL-CMOS180nm with Temperature drift compensation and auto zeroing.

Name of Co PI from ISRO Centre/Unit

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Area of Research

VLSI, ASIC Design Expertise, Analog Design Expertise

Summary of the proposed research and expected deliverables

Synchronous voltage-to-frequency converter (SVFC) is a simple and powerful building block for precision analog-to-digital conversion, offering very high linearity of the order of 0.002 percentages. The inherent monotonicity of the transfer function and wide range of clock frequencies allow the conversion time and resolution to be optimized for specific applications.

The capability to provide higher performance with larger time interval (Infinite resolution over infinite time windows) and self-integrating capability make it a unique solution for navigation kind of application.

Scope of the Work:

- Design of the indigenous high linear Analog to digital converter
- Adding auto zeroing and self-calibration features
- Circuitry for temperature sensing and compensation
- Develop new architectures and methodology for high performance

Deliverables:

- Design documents
- Schematics and layout of the design
- Reports for Tapeout and Fabrication
- GDS Files
- Review by IISU

RES-IISU-2022-006

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Design and development of Mixed Signal SoC for Sensor Application in SCL180nm.

Name of Co PI from ISRO Centre/Unit

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Area of Research

VLSI, ASIC Design Expertise, Analog Design Expertise

Summary of the proposed research and expected deliverables

For all precision sensors, it is required to acquire the data accurately using precision data converters, process the acquired data for the sensor control and compensation requirement and then give the data back to the sensor for closed loop application. The processed data can be fed to a DAC, which can be used as a measure of sensor physical output. The accuracy requirement of the converter is mainly 12 bit for ADC and DAC. The devices should be insensitive to temperature and other environmental changes. The processor core should operate at 100MHz rate and the design should be fully available in VHDL/Verilog code, with verification test suit developed using UVM. The processor core has to be compatible to RISC-V 32 and has to work with certified compiler chain available to RISC-V. The configurability to add any peripheral to the bus for the future requirement to be present in the processor core design. The Design should be implemented in SCL-180nm technology node with 100MHz frequency and has to provide suitable time margins for operating in this frequency. A PLL for 100MHz frequency for the operation of the processor to be designed and to be incorporated.

Scope of the Work:

- Design and development of following modules according to specification given below :

Parameters	Specification	Area
ADC	SAR 12 bit X 2 numbers	1mm x 1mm
DAC	12 bit DAC X 2 numbers	1mm x 1mm
Processor	RISC_V compatible processor	3mm x 1mm
Internal PLL	Generate 100MHz clock to Processor from 1MHz master oscillator	0.5mm x0.5mm

ADC Specification

- The specification of AD7876 with operating input voltage as Differential 3.3V

DAC Specification

- The specification of AD7845 with output voltage as Differential 3.3V

Processor Specification

- RV-32I Instruction set
- SPI interface for ADC and DAC(4 Numbers)
- Debug Interface
- Interrupt controller
- DMA
- UART interface (2 Numbers)
- 2 Timers

Deliverables:

- Design Documents of ADC,DAC
- Design schematics and Layout of ADC and DAC
- Design document of Processor
- Fully verifiable VHDL code with Verification Engine(UVM based)
- Chip Level Integration Document
- Verification plan and test scripts for the Processor
- Integrated Schematics
- Design clearance report for Tapeout
- GDS for Fabrication
- Design review by IISU

RES-IISU-2022-007

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Denoising Algorithm for Noise reduction in MEMS Sensors.

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Area of Research

Optimal Filtering

Summary of the proposed research and expected deliverables

The microelectromechanical systems (MEMS) gyroscope featuring low cost, small device size, low power consumption and high reliability lead to increasing applications in various inertial fields.

However, the performance of MEMS gyroscope quickly degrades over time because of high level of the noise and drift, the lower accuracy is the major disadvantage that limits the application of MEMS gyroscope. The bias drift is a crucial factor that affects the measurement precision of accuracy of MEMS gyroscope. Therefore, to estimate and compensate for the bias drift is an important aspect forenhancing the performance of MEMS gyroscope along with improvement of sensors itself.

Optimal Filtering Algorithm using direct modelling for the angular rate signal could reduce the measurement noise and improve the accuracy of the single MEMS gyroscope considerably. If the trueangular rate signal together with the bias drift will be directly modeled to design an optimal filter to reduce the noise and drift of the MEMS gyroscope. The greatest advantage of such an approach is thatan estimation of the bias drift can be achieved to compensate for the outputs of gyroscope.

Furthermore, an improved estimation of the true angular rate can be directly obtained using optimal filtering technique, which will make a realization of self-compensation for the single MEMS sensor possiblewithout needing other sensor's information in a dynamic condition. This Algorithm should be suitable for static and dynamic condition of the MEMS sensors.

This optimal filtering algorithm should have possibility to tune the Bandwidth. Relationship of the filter parameters and Bandwidth to be explored The proposed research to be done in two phases. In the first phase theoptimal filtering Simulation Algorithm to be developed in and it has to run with the sensor datas in offline In the second phase Processor based optimal filtering to be implemented and to be integrated with the Sensor in real time and performance to be evaluated in detail

Scope of the Work:

- Algorithm can be applied to reduce the Noise and enhance performance of the iCRG and MEMS accelerometers for Navigation application in Launch vehicle and Spacecraft.

Deliverables:

- Denoising Algorithm for Realtime application in Processor/FPGA with specified update rate.

RES-IISU-2022-008

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

High-Fidelity Sinusoidal Synthesiser for HRG Whole Angle Tracking.

Name of Co PI from ISRO Centre/Unit

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Shri. Rajesh George P

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Area of Research

Digital Signal Processing and Embedded Hardware Design

Summary of the proposed research and expected deliverables

Hemispherical Resonating Gyro (HRG) is a class of Vibratory Gyroscopes with very high Q factor (≈ 5 million) and thus very low resonance bandwidth (≈ 1.5 milli-Hz). To operate this sensor at its resonance, high fidelity sinusoidal excitation is essential so that the frequency spectrum is comparable to the resonance bandwidth.Hence, a waveform synthesiser which can generate pure tone sinusoids with less than 1 milli-Hz frequency standard deviation is to be designed.For precise tracking of HRG resonant frequency during temperature variations, frequency resolution of the synthesiser must be much smaller than resonance bandwidth as well. Further, to be suitable for HRG Whole Angle Tracking (WAT), the synthesiser has to generate two simultaneous excitation signals which are made up of two orthogonal pure tone sinusoids; amplitude and frequency of the individual sinusoids has to be continuously updated at regular intervals according to the vibration orientation and frequency tracking information provided by an external controller. The proposed research envisages an FPGA which shall enable development of an ASIC based hardware which can synthesise spectrally pure sinusoids suitable for HRG WAT and can be easily interfaced with an external controller.

Scope of the Work:

- The spectrum of the excitation signal is influenced by both the hardware and oscillator algorithm used. Hence, the proposed research involves
  - Hardware development - Must employ the most precise clocking scheme and instruction execution cycles, low noise DAC, wave shaping and EMI rejection filters.
  - Software development –Oscillator algorithm should be capable of generating pure tone sinusoids and must be validated by realistic simulations. The start-up and running parameters of the oscillatoris to be loaded from the controller.
- The detailed requirements are as follows.
  - Frequency range of interest is from 1 KHz to 10 KHz.
  - Frequency and phase resolution of the oscillator must be less than0.1 milli-Hz and 1 milli-degree respectively.
  - The output frequency must be highly stable and repeatability to be less than 1 milli-Hz with minimum warm-up time.
  - Amplitude range 10V peak, resolution must be at least 1 ppm of the operating full range.
  - Controller interfacing should be SPI with clock speeds of 35 MHz or more and must be programmable.
  - Current values of the orthogonal pure tonesinusoids has to be passed to the external controller without any latency.
  - The synthesiser must have the provision to window itsoutput while the oscillator is kept running even during window off period. Window duration and duty cycle must be programmable by the controller.
- To aid start-up of the sensor during initial power on, synthesiser output must be the sum of Pseudo Random Noise (bandwidth <5Hz and amplitude programmable) and pure tone sinusoids for a short period of time.

Deliverables:

- ASIC based prototype hardwarewith schematic, layout, test codes and demonstration.
- Simulation results and testbenches.
- Electrical Interface document with communication protocol.
- Comprehensive software document and simulations.
- ASIC details and software code along with software life cycle documentation.

RES-IISU-2022-009

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

System-on-chipfrequencyand amplitudestabilized laser source.

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Area of Research

Physics, Opto-electronics, MEMS

Summary of the proposed research and expected deliverables

Stabilized laser source locked to Rb or Cs vapour cell has many quantum technological applications including atomic magnetometer & atomic clocks. To develop robust portable instruments/sensors based on stabilized laser sources, orders of magnitude reduction in size, weight & power is required compared to a laboratory setup. In addition, reliable operation under vibration, shock & temperature conditions in a launch vehicle/satellite is also essential. Towards this, a 795nm stabilized laser with narrow line width (<100kHz)is to be realized using suitable frequency locking setup, as a system-on-chip with laser source, stabilization setup& integrated electronics. Electronics may include a lock-in-amplifier, a current/temperature/piezo based frequency feedback mechanism and a controller, or any other equivalent scheme required for stabilization. In addition, the scheme should support remote operations like switch on/off,operation mode selection like free running or locked mode, as well as self health assessment.

Scope of the Work:

- Scope includes identification of a suitable diode laser configuration amenable for miniaturization, as well as controllable and providing output power of >100mW, robust chip level integration for diode laser, reference, and sensing & feedback mechanism. Scope also includes electronics design for sensing & feedback control system.

Deliverables:

- Stabilized laser source with integrated electronics, as a system-on-chip, providing output power of >100mWand should be stand-alone device and directly integrable to any sensing element.

RES-IISU-2022-010

Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal
Fabrication of Spatial Light Modulators.

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Area of Research
Optical signal processing

Summary of the proposed research and expected deliverables
Optical signal processing is proposed for high speed vision based navigation systems. A spatial light modulator SLM is an integral element of an optical signal processing system. An SLM is used to encode a 2D image into an optical field. Acquiring technical knowledge on SLM fabrication is essential to develop indigenous vision based navigation systems.

Scope of the Work:

- Optical signal processing is proposed for high speed vision based navigation systems. A spatial light modulator SLM is an integral element of an optical signal processing system. An SLM is used to encode a 2D image into an optical field. Acquiring technical knowledge on SLM fabrication is essential to develop indigenous vision based navigation systems.

Deliverables:

- Fabricated phase only SLM, Fabrication technical knowhow, documentation
- Fabricated complex SLM, Fabrication technical knowhow, documentation

RES-IISU-2022-011

Name of ISRO Centre/Unit
ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal
Design of IP core and front-end system for Camera Interface.

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Area of Research

Camera Interface, FPGA, GigE, USB 3.0, IP Core development

Summary of the proposed research and expected deliverables

A modern imaging system requires high speed, high performance, long distance and low power interface for camera. Also, ease and cost of implementation, timing and international standardization are other needs that drives the camera front-end processing.

This research aims to

- Design and deploy an IP core for advanced camera interface standards, viz., 10GigE and USB3.0 (both) for high speed applications. Specifically, IP core to be deployed in Xilinx Zynq, Ultrascale+ or later FPGA series.
- Front-end hardware to interface camera and FPGA in minimum form factor. 2 such systems independently for 10GigE and USB 3.0
- Verification and demonstration of portability of IP core in other FPGAs.
- Supporting software/hardware tools

Scope of the Work:

- **Phase 1:** Front end interface system for 10GigE and USB3.0 in small form factor
- **Phase 2:** Development of 10GigE and USB3.0 IP core for Xilinx series FPGAs
- **Phase 3:** Demonstration with sample application

Deliverables:

- Front-end hardware interface card
- IP core along with HDL, RTL, netlist etc. (Few Necessary RTL guidelines to be followed will be supplied by IISU)
- Detailed documentation.
- Software/ tools for programming, sample application demonstration

RES-IISU-2022-012

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Modelling and Control design of a Quadruped Robot in microgravity.

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Area of Research

Control Design for Microgravity

Summary of the proposed research and expected deliverables

- Gait generation: Design of quadruped with energy efficient online gait generation (dynamic walking/trotting/rolling) suitable for microgravity environment for a given nominal configuration. The environment may have obstacles nearly the same length as the robot leg.
- Control design: Foot placement strategy should consider terrain with debris and sand, and slopes in the range of 2-5 degree. One of the legs should be multi-purposed as a manipulator for sample collection tasks. Task controller design for the manipulator should ensure stability of overall system. The control design must ensure complaint walking and disturbance rejection on rough terrain. Conventionally PD control is being used However in the presence of rough and undulating terrain, an online adaptive control strategy shall be explored. At each stance of the gait cycle, the controller must be able to address the two main aspects of (i)instability detection and recovery (ii) body stabilization (iii) recovery after fall. The control design must be supported by Stability analysis via appropriate stability criteria.

Deep learning methods amenable to real time implementation can be explored to address the above mentioned problems

Scope of the Work:

- This is necessary for the upcoming proposal of a quadruped legged robot for interplanetary exploration.

Deliverables:

- Algorithm for online gait trajectory generation
- Controller performance demonstration in simulation and stability analysis results
- Controller implementation as ROS2 package.

RES-IISU-2022-013

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Formal Analysis of Redundancy Management Logic for Navigation Processor used in Man-rated Launch Vehicle.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Theoretical Computer Science, Logic, Algorithms ,Verification

Summary of the proposed research and expected deliverables

The strap down inertial navigation system (INS) for launch vehicle missions is a real time embedded system that acquires 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 is a mission critical system that processes the sensor data and transforms it to a given reference frame and integrates, to generate the navigation states of the launch vehicle. For man rated mission, the INS is a safety critical system that plays a crucial role in the success of the mission during the ascent phase of the launch vehicle. The required failure detection and error handling is managed by increasing the redundancy in the system.

The INS states shall be computed in quadruple redundancy by the quad processor electronics resident in the system. The states are generated using data from independent sensor channels after proper redundancy management by failure detection and isolation (FDI) logics.

Traditionally, a detailed Failure Modes and Criticality Effects Analysis (FMECA) is carried out on the system and, FDI is designed to detect and isolate all possible failure modes. However, validation of the FDI logic is done based on simulated sensor failures, which may not capture all the worst-case combinations on sensor failures and other error conditions. 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 and testing. The proposal is to apply formal methods for software safety analysis of the failure detection and voting logic of navigation software for man –rated mission to ensure the correctness of the logic in the initial phase of the design.

Scope of the Work:

- Formal analysis of redundancy management algorithm and data selection logic of Inertial Navigation System for man rated mission
- A formal model shall be developed (open source tools preferred).
- The natural language requirement specifications of the algorithms are to be translated to formal specifications and verified for functional requirements and safety critical properties.

Deliverables:

- Formal model of fault detection and isolation logic used for redundancy management.
- Formal model of data selection and voting logic for quadruple redundant navigation solutions.
- Identification of functional and safety properties of item 1&2 from requirements specifications in natural language and translation to formal language.
- Formal Analysis providing proof of compliance to the properties.
- Identification of non-compliance situations for the properties.
- All source codes and relevant documentation.

RES-IISU-2022-014

Name of ISRO Centre/Unit

ISRO Inertial Systems Unit, Trivandrum

Title of the research proposal

Design and Realization of direct RF sampling based NavIC Receiver front end.

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Area of Research

GNSS RF circuits, High frequency FPGA design

Summary of the proposed research and expected deliverables

The conventional NavIC receivers converts the RF signals to the intermediate band signals and then to the base band before correlation. So, the correlator has to work at low frequency only. In the proposed design, the RF sampling to be done and the correlator has to work with the RF sampled digital signals. No mixer will be used in the circuit. The NavIC L1 (1176.45MHz) signal is to be directly sampled to the digital domain using fast ADC. It uses digital processing after sampling, and thus can flexibly process signals in a number of bands using software. The converted digital samples to be correlated to the expected signal suing at very high frequency correlator. The correlation peak to be identified and to be recorded in the PC.

The correlation peak shall be at least 4 times higher than the noise band (peak to peak).

Scope of the Work:

- Design of advanced NavIC Receivers for future applications

Deliverables:

- Electronic circuit schematic, layout and Gerber file for RF front end, FPGA sections and bill of materials
- Engineering model hardware including the RF and FPGA circuits
- User manual of the hardware
- FPGA code (in VHDL) for correlator functions.

INDIAN INSTITUTE OF REMOTE SENSING
DEHRADUN

RES-IIRS-2022-001

Name of ISRO Centre/Unit
Indian Institute of Remote Sensing, Dehradun

Title of the research proposal
AI (Artificial Intelligence) and Remote Sensing Applications in Soil & Crop Management.

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Area of Research
AI (Artificial Intelligence) in Agriculture / Digital Agriculture

Summary of the proposed research and expected deliverables
AI-driven technologies are emerging to help in improving the efficiency with respect to crop and soil management, weather forecasting, forecasting of crop disease and pest infestation and predictive agricultural analytics.

The geospatial database of natural resources with focus on soil need to be created using satellite images of LISS-IV/Sentinel/drone etc. and using GIS software The geodatabase of different soil properties will be created by taking soil samples and analyzing them in the field using portable soil testing kit / laboratory. High resolution Remote-sensing data (including drone) will be used to monitor the crop condition to determine crop stresses.

Crop diversification is one of the most cost-effective way of reducing uncertainties in farmer's income, especially among poor smallholder farmers. Diversification of agriculture will enhance the resilience of agriculture to sustain biotic and abiotic stresses.

A comprehensive relevant database of Progressive Farmers / Research Institutes data of the area will be generated for various crops of the agroclimatic region. To link between farmer's field data related to soil, terrain and climate and farming expenditure (Cost/ Benefit) and research / progressive farmers data by developing Decision Support System / Machine Learning Techniques to suggest suitable agricultural crops to enable farmers for adopting diversified cropping system to enhance their profit of cultivation. Recommendation for crop diversification will be undertaken based on soil potential and recommendation of research studies carried out by ICAR Institutions and progressive farmers of the districts.

Scope of the Work:

- The project indents to develop methodology / procedure on digital platform in developing large data base of agricultural fields and farming systems including cost/benefit as well as soil constrains to analyse their suitability for various crops. Software's need to be developed for allocation of

field of suitable crops to optimize yield for diversification of agriculture. Temporal UAV images will be obtained to identify soil fertility constrains and to recommend nutrients applications to maximize crop yield. Different AI/ML algorithms can be used to develop module to analyse suitability of different crops/cropping system and to suggest crop selection for optimizing crop yield with cost benefit ratio.

Deliverables:

- To develop a geo-farm database for site-specific soil nutrient management.
- To develop a system of site specific crop management by assessing biotic and abiotic stress.
- To develop Geo-Crop Diversification Module for analysing suitable crops/cropping system for optimizing crop yield and profitability.

RES-IIRS-2022-002

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Crop growth monitoring, crop yield estimation, crop biophysical parameters retrieval and soil moisture estimation using Synthetic Aperture Radar (SAR) data.

Name of Co PI from ISRO Centre/Unit

Dr. Hari Shanker Srivastava
Scientist / Engineer - 'SG'

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PPEG,
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Area of Research

Radar Remote Sensing (SAR), Integration of SAR with other sensor data, Agriculture, Soil moisture, Machine Learning Techniques, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, PolInSAR etc., & also multi-parametric SAR and multi-sensor data.

Summary of the proposed research and expected deliverables

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 penetration capability of SAR make it a better choice for crop growth monitoring, crop yield estimation and crop biophysical parameters retrieval for various crops. Use of multi-parametric SAR and advance SAR techniques like SAR Interferometry (InSAR), SAR Polarimetry (PolSAR) & PolInSAR allow to 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. 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 cover and soil texture. These parameters act as noise while retrieving soil moisture using microwave remote sensing data. Therefore, it is necessary and also challenging to retrieve soil moisture with high accuracy by incorporating the effects of noise parameters in the soil moisture retrieval model. Use of multi-parametric SAR along with advance SAR techniques like Interferometric coherence, Hybrid polarimetry, fully polarimetry, PolInSAR can successfully retrieve soil moisture under variety of agricultural heterogeneities. Use of advance Machine Learning Techniques are expected to further improve the soil moisture retrieval accuracy. Passive microwave remote sensing data can also be used for very large area soil moisture estimation but due to very poor spatial resolution, soil moisture retrieval accuracy is relatively lower than SAR data and it's also difficult to apply it on farmers' fields. However, advantage of fine temporal resolution of passive microwave RS data and advantage of fine spatial resolution of SAR RS data can be combined to generate daily soil moisture maps at relatively finer spatial resolution.

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 crops including few kharif crops are either unexplored or under-explored. Therefore, there is huge potential to exploit unique sensitivity of SAR towards shape, size, orientation, structure and moisture content of various components of crop plant along with penetration capability of SAR 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 advance satellite data sets like multi-parametric, PolSAR, InSAR, PolInSAR along with advance algorithms are expected to significantly improve the soil moisture retrieval accuracy.

Deliverables:

- **AGRICULTURE:** Detailed methodology and/or methods/models to exploit SAR data or integration of SAR and optical/hyperspectral 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/models for soil moisture estimation using active and/or passive microwave remote sensing under variety of agricultural heterogeneities. Methodology should be applicable to large area soil moisture estimation.

RES-IIRS-2022-003

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Use of multi-parametric Synthetic Aperture Radar (SAR) and/or SAR Polarimetry, SAR Tomography & SAR Interferometry in Forestry & Ecology with special emphasis on following themes:

FORESTRY: Forest species discrimination in mixed forest scenario & forest biophysical parameters retrieval.

WETLAND ECOSYSTEM: Assessment, Habitat mapping & modeling, Monitoring and Management of Wetland Ecosystem & biophysical parameters retrieval of various types of vegetation including aquatic vegetation.

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Area of Research

Radar Remote Sensing (SAR), Wetland Ecosystem, Forestry, Species discrimination, biophysical parameters retrieval, Modeling, Machine Learning Techniques, Multi-parametric SAR, Advance Microwave Remote Sensing Techniques e.g. InSAR, PolSAR, Hybrid Polarimetry, SAR Tomography, PolInSAR etc., & also multi-sensor data.

Summary of the proposed research and expected deliverables

FORESTRY: Unique sensitivity of SAR data towards physical, geometrical and dielectrical properties of forest trees and plantations of various shapes, sizes and structures along with all-weather & penetration capabilities of SAR can successfully be used to retrieve various biophysical parameters of forest like forest above ground biomass, tree height etc. along with detailed species discrimination in mixed forest type scenario. Availability of multi-parametric SAR along with advance SAR techniques like SAR Interferometry, Hybrid polarimetry, fully polarimetry, PolInSAR, SAR tomography etc. can be used successfully for various other forestry applications along with detailed forest type discrimination in mixed forest type scenario.

WETLAND ECOSYSTEM: Wetland ecosystems have received little recognition on the vital role that they play for human wellbeing. As a result of this, there is an alarming loss of wetlands. It is required to arrest the losses and to achieve optimal resource use with balanced priorities of biodiversity conservation. This calls for meaningful and timely information and data on wetland ecosystem like various wetland habitats, its fauna, flora and socioeconomic variables of relevance. Traditionally, the source of the spatial information that captures dynamics of a wetland ecosystem has been that of optical remote sensing data. Although optical remote sensing data is found to be very useful for wetland monitoring, cloud cover restricts the availability of satellite data during rainy season, which

is the main source of water for most of the inland wetlands. Moreover, delineation of several classes of importance for wetland ecosystem is also not clearly differentiable on optical remote sensing data. Synthetic Aperture Radar (SAR) due to its unique sensitivity towards physical, geometrical and dielectrical properties of various components of a wetland ecosystem along with all-weather & penetration capabilities of SAR can play an important role to achieve above goals. Capability of Radar signals to penetrate vegetation cover and to sense the moisture content of the earth materials, allows microwaves to monitor the wetland ecosystem more accurately as compared to optical remote sensing tools alone. However, it has been established beyond doubt that synergic use of optical and SAR data provides the best results.

Scope of the Work:

- **Forestry:** Use of SAR remote sensing in forestry is grossly under explored in Indian sub-continent and most of the times it is used as supplementary data with optical remote sensing data. Therefore, there is huge potential to exploit unique sensitivity of SAR towards shape, size, orientation, structure and moisture content of various components of trees along with penetration capability of SAR signals to develop full-fledged methodologies and/or models for forestry applications using SAR data.
- **Wetland:** Use of Radar remote sensing in assessment, monitoring and management of wetland ecosystem is grossly under explored and under reported in Indian sub-continent. Therefore there is a huge potential of research in the proposed research area.

Deliverables:

- **Forestry:** Development & validation of Methods/ Methodology/ Models for biophysical parameters retrieval of forests using advance SAR techniques along with Machine learning techniques. Species discrimination in mixed forest scenario & efficient monitoring of Natural forests or large plantation areas.
- **Wetland:** Development & validation of Methods/ Methodology/Models for efficient monitoring/ discrimination of various wetland habitats along with assessment & management of a wetland ecosystem. Biophysical parameters retrieval of various types of vegetation including aquatic vegetation.

RES-IIRS-2022-004

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Detailed analysis of olivine-rich areas of the Mars based in their morphology and associated mineralogy using high resolution datasets from recent Mars mission.

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Area of Research

Planetary data analysis and their geological interpretation

Summary of the proposed research and expected deliverables

Primary crust of planets are formed after accretion, melting and differentiation, and record evidences of the last stages of their formation, which are later on modified by subsequent volcanism, cratering and alteration. Their mineralogy, composition and morphology are direct products of the processes that produced or altered them during and after their formation. Hence, they are the most powerful tools available for unravelling the petrologic history of a planet. Mars provides a valuable analogue for the conditions of ancient terrestrial crusts that would have preserved primitive crustal materials due to lack of plate tectonics. Therefore, detailed mineralogical and morphological appraisal of the primary crust of Mars can provide significant information about its interior structure as well as its geological evolution through time.

Scope of the Work:

- At present significant work exists on the global distribution of olivine on Mars but it remains limited to areas of basaltic nature or their altered lithology. Detailed work regarding the nature of occurrence, associated mineralogy and morphological characteristics of primitive mafic exposures is also limited and has not been fully investigated. More investigations are needed that can help in better constraining their geological history.

Deliverables:

- These exposures serve as distinct records of the physio-chemistry and formation condition of a planetary body. The results will be utilized to explore the origin and evolution of early crustal development of the Mars keeping in mind the significance of the area from astro-biological perspective.

RES-IIRS-2022-005

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Search for new occurrences of kimberlite from Indian cratons using hyperspectral and high-resolution imaging method along with their detailed field study.

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Area of Research

Integrated study using Lab, field and High-resolution Satellite data for Igneous Petro-genesis; Hyperspectral remote Sensing

Summary of the proposed research and expected deliverables

Project aims to identify new occurrences of kimberlite from various cratons of India using hyperspectral and multispectral imageries. Detailed field study will be carried out of the selected study areas assisted by spectroscopic and geochemical analysis of selected samples for correlating and validation of the results. Kimberlites are a rare group of ultramafic igneous rock that represent a clan of volatile-rich potassic ultrabasic rocks. These petro-graphically complex and diamond bearing rock will be explored using high-resolution remote sensing technique that could prove to be promising and cost effective tool for kimberlite exploration suite/megcryst suite and primary phases. The study aims to utilize high-resolution multispectral and hyperspectral datasets (Hyperion, ASTER, AVIRIS-NG, Landsat TM, PRISMA etc.) along with lab based spectral-compositional study of and geochemical analysis for deducing their petrology and petro-genesis.

Scope of the Work:

- Most of the studies for identification of kimberlites have been carried out involving analytical techniques. Remote sensing based on spectroscopy using multispectral and hyperspectral sensors provide a more cost effective way to put the minerals into their global perspective and enables identification of broad lithologies present.
- There is a great scope to look for new occurrence of this diamond bearing rock using high-resolution remote sensing technique that could prove to be promising and cost effective tool for kimberlite exploration.

Deliverables:

- This work in conjunction with their analysed geochemistry and petrographic study could improve the existing spectral calibrations as well as to develop new calibration equations to estimate their mineral chemistry. This study could provide specific inputs for future Moon and Mars Missions spectrometers. Therefore, providing means of obtaining a better insight into the nature and evolution of planetary bodies from remote sensing studies.

RES-IIRS-2022-006

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Advanced methods and algorithms for automatic information extraction for (online/offline) processing and analysis of images/data from various multi-source data.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Automating Information Extraction; Image Processing & Analysis

Summary of the proposed research and expected deliverables

Extraction of important information from a satellite image or a set of satellite images (such as 2D & 3D building parameters and individual tree boundaries, number, height, canopy shape etc., water bodies, roads and their width, road types, tree plantations, parks, play grounds, built up area, in a habituated (urban or rural) area, in-land water bodies, information on cultural heritage and tourism sites, etc.) is important for various purposes (inventorisation, planning, management and decision making) at various levels. Availability of multi & hyper spectral (optical/microwave), multiresolution/ sensor, multi-temporal from multiple platforms (space based aerial/ ground based/ UAV/ LiDAR) coupled with appropriate automated methods could fulfil the requirement of information extraction from satellite images. Several potential methods such as neural networks & deep learning, natural intelligence based methods, object based methods considering spatial spectral classification analysis, contextual methods, appropriate fusion (at pixel/ feature level) of multi-source data, need to be explored for effective utilization of the huge amount of multi-source data available from remote sensing satellites.

Scope of the Work:

- Conception, development and implementation of model for feature extraction, data collection and pre-processing for above and demonstration of working of the model with set and appropriate outcomes.

Deliverables:

- Working model on important information extracted from satellite images or a set of satellite images such as 2D & 3D building parameters and tree canopy boundaries, number, height, canopy shape etc., water bodies, roads and their width, road types, tree plantations, parks, play grounds, built up area, in a habituated (urban or rural) area, in-land water bodies, information on cultural heritage tourism sites, etc.)

RES-IIRS-2022-007

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Development of models and algorithms for geospatial modelling of various geographical phenomena.

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Area of Research

Geostatistics, Geospatial Analysis & Modelling

Summary of the proposed research and expected deliverables

Various algorithms for mapping and modelling of geographic phenomena have been/ are being

developed. Their application potential needs to be evaluated on specific case/ scenario basis, with the constrained availability of input information.

Purpose of Research:

Investigating & evaluating methods for mapping, modelling of spatial phenomena is the final goal of this research. This requires development of models and algorithms for geospatialmodelling of various geographic phenomena for understanding and describing underlying processes and studyingdistribution and spatial structures, relation with associated variables (various parameters of soil, water, land such as distribution of ground water level, variation of pollution levels in a region, study of electrical conductivity and PH of water/soil etc.), dispersion/spread models and point spread.

Details:

For analysis & modelling of Geospatial phenomena such as pollution dispersion, disease spread, spatial networks of utilities, population distribution, land-use growth and change, exploring, developing and evaluating advanced methods of geospatial modelling (such as advancedmethods of spatial modelling, geostatistical modelling, multi-dimensional modelling (surface modelling, time-series analysis and modelling), network modelling, etc.) is the need of time for utilizing huge information being derived from available repositories of satellite data and geospatial datacubes. Proposals addressing investigation of models for modelling of such phenomena will enable appropriate and efficient use of the available space based, aerial and ground based data repositories. Geostatistics with its strong mathematical foundation, is a potential tool for studying spatiotemporal distribution, spatial properties such as spatial structure of geographic phenomena.

Exploring advanced methods of Geostatistics for modelling of geographic phenomena and their performance evaluation in real world situations which will lead to more precise, accurate as well as spatially informed mapping and modelling of such phenomena.

Development of models and algorithms for geospatial modelling of various geographic phenomena (various parameters of soil, water, land such as distribution of ground water level, variation of pollution levels in a region, study of electrical conductivity and PH of water/soil, etc., dispersion/ spread models) would lead to better understanding of underlying processes and distribution and spatial structures, scales and range, their relation with associated variables.

Scope of the Work:

- Development of models and algorithms for geospatial modelling of specific geographic phenomena (such as various parameters of soil, water, land such as distribution of ground water level, variation of pollution levels in a region, study of electrical conductivity and PH of water/soil, etc., dispersion/spread models).

Deliverables:

- Models/ algorithms for geospatial modelling of specific geographic phenomena as per description provided in the proposal.

RES-IIRS-2022-008

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Climate Induced and Urbanisation Impact on Urban Flood Hazard and Risk Modelling.

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Area of Research
Geospatial Technology for Urban Studies
Sub-area: Climate change, Urban flood risk modelling

Summary of the proposed research and expected deliverables
Reliable and timely prediction of flood extent in an urban environment is a challenging task. Various modelling approaches are available ranging from data driven to physically based, from conceptual to detailed 1D - 2D modelling. These approaches are then ensembled in wider context of flood risk assessment and disaster management. An integrated model that simulates the sewerage-network, river-network and 2D mesh-network are desirable to obtain flood extents in urban areas so that whenever overflows occur due to insufficient drainage capacity, the resultant surface flooding and/or levee break could be predicted.

As the cities generally are co-located along river/ water bodies, studies are required to interlink space based observation driven hydrological and hydro-dynamic properties of SWD network and of entire catchment for integrated flood risk modelling. GIS coupled Storm Water Management Models are useful to estimate the runoff depth, extent, peak flow and intensity of flooding while taking into consideration the remote sensing data derived elevation, slope, land use/land cover (LULC), rainfall conditions and the designed storm water drain (SWD) infrastructure of the city.

Scope of the Work:

- Urban hazard and risk modelling using hydrologic, and 1D and 2D hydrodynamic models; vulnerability analysis using multi-criteria decision models.

Deliverables:

- Urban hazard and risk maps, and scenario generation for varying events.

RES-IIRS-2022-009

Name of ISRO Centre/Unit
Indian Institute of Remote Sensing, Dehradun

Title of the research proposal
Urban Micro- and Meso-Scale Climate Modelling and Urban Canopy Parameters Estimation.

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Area of Research

Geospatial Technology for Urban Studies

Sub-area: Urban micro-climate modelling

Summary of the proposed research and expected deliverables

Study of urban climate is important at local and global scale, which is influenced by several factors such as urban morphology and density, properties of urban surfaces, vegetation cover, etc. The urban built-form due to its dense development and high-rise character, and the increase in impervious and absorptive surfaces are responsible for the trapping of heat and reduction in evaporative cooling due to decrease in vegetated, soft, pervious surfaces in urban areas. The study of urban climate is also gaining further importance in the scenario of climate change. Technology development is desirable for the generation of 3D urban database, urban parameterization in numerical weather models, urban canopy parameters estimation and understanding the micro- and meso-scale urban climate phenomena using space based observations. Such studies shall be helpful formicro-climate zonation of urban areas for climate oriented planning guidelines.

Scope of the Work:

- The study will focus on geospatial driven methods and approaches for urban canopy parameter estimation and their integration in high-resolution urban climate models for improved weather and climatological modelling in urban areas.

Deliverables:

- Spatially variable urban canopy parameters for urban areas.
- Model outputs and approaches for various urban climate applications.

RES-IIRS-2022-010

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Synergistic Study and Modeling of Urban Heating, Urban Fluxes and Landscape Pattern in an Urban Purlieu.

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Area of Research

Geospatial Technology for Urban Studies

Sub-area: Urban Environment, Thermal Remote Sensing, Hyperspectral Remote Sensing, Urban Air Pollution

Summary of the proposed research and expected deliverables

Assessment of energy fluxes and surfaceatmosphere energy balance is considered an important study for urban environment. The arrangement of manmade impervious surfaces (building and roads), their geometry and orientation, material composition, albedo/emissivity, topography, natural and delineated spaces of vegetation, and the concurrent atmospheric profiles together play a pivotal role in defining the urban morphological thermal environment at micro-scale. All the above parameters together help in determining the surface temperature and related boundary layer parameters. Scale and spatial resolution can also alter the scenario of conclusive recommendations based on the interrelationships between urban landscape structure and urban heating through their respective indicators.

Scope of the Work:

- The analysis would primarily depend on satellite derived data products for urban areas.

Deliverables:

- Deterministic models such as building energy models (BEM) developed based on the interactions of building volume with the surrounding environment and other computational fluid dynamics (CFD) based models (like ENVIMET) can be efficiently used for modelling heat flux and urban heating phenomenon holistically.
- These models can simulate the micro-scale thermal interactions to investigate the effects of urban form and landscaping efficiently as suggested by variousstudies. Also, the model can help in exploring the relationship between Near Surface Urban Pollution (NSUP) and Surface Urban Heating (SUH) using high resolution drone data.

RES-IIRS-2022-011

Name of ISRO Centre/Unit

Indian Institute of Remote Sensing, Dehradun

Title of the research proposal

Hydrological Parameters Retrieval using Remote Sensing (Evapotranspiration ET, Soil Moisture SM, Surface Runoff SR, Snow Physical Parameters, Glacier Facies, Glacier Velocity, Snow/glacier melt, River/Lake Water level, River discharge and change in Terrestrial Water Storage ΔTWS) and Data Assimilation in Hydrological Models.

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Area of Research

Hydrological Modelling

Summary of the proposed research and expected deliverables

The hydrological parameters such as Precipitation, Evapotranspiration (ET), Soil Moisture (SM), Surface Runoff (SR), Snow Physical Parameters, Glacier Facies, Glacier Velocity, Snow/glacier melt,

inland water level, river discharge change in Terrestrial Water Storage (ΔTWS) are essential for water balance and hydrological quantification of any river basin or watershed. The traditional ground based methods of hydrological parameters estimation are mostly point based, and very good temporal resolution, but lack spatial coverage. The large spatial variation in hydrological parameters such as rainfall, SM, ET, Snow Water Equivalent (SWE), Water level (WL) and (ΔTWS) can be easily overcome by remote sensing based hydrological parameters retrieval methods. The temporal variation of some of these parameters can be at sub-daily to hourly time scale, and some of the remote sensing satellites working in constellation mode can easily address such issues.

The projects under this theme should be able to develop, calibrate and validate the hydrological parameters retrieval techniques using existing and future remote sensing sensors such as, active/passive imaging microwave, altimeters/Lidar, thermal, hyperspectral, GNSS, and gravity based satellite sensors, with ground truth from existing and future planned set of ground instruments/observations for Indian conditions. The derived hydrological parameters can be used in data assimilation mode for improving the prediction and assessment capability of hydrological and hydrodynamic models.

The main deliverable from this project will be time series of hydrological parameters derived from various remote sensing based satellites, sensors and validated with ground-based observations, along with DA in hydrological models.

Scope of the Work:

- The project will be aimed at retrieval of individual or group of hydrological parameters using remote sensing data. The parameterization of existing algorithms, development of new algorithms, calibration and validation of existing algorithms/datasets. The derived hydrological will be assimilated in hydrological/HD models to improve their modelling accuracy.

Deliverables:

- Operational/Semi-operational algorithms/techniques for retrieval of hydrological parameters OR long-term database of validated hydrological parameters.

RES-IIRS-2022-012

Name of ISRO Centre/Unit
Indian Institute of Remote Sensing, Dehradun

Title of the research proposal
Flood Prone Area Mapping, Modelling/Forecasting & Risk Assessment using Geospatial Tools (SAR, Optical, Satellite Altimetry, Topographic Indices) and geospatial data cube.

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Area of Research
Flood Studies and Geospatial Data Cube

Summary of the proposed research and expected deliverables

Flooding during the monsoon season is a recurring problem in many parts of India. Different Indian states, especially North West Himalayan (NWH) states and downstream Indo-Gangetic floodplains states (J&K, HP, UK, UP and Bihar) have experienced large number of hydro-meteorological disasters such as high intensity precipitation and subsequent flooding in these areas in the last few years. Few major flood disasters associated with high intensity rainfall are Bihar 2019, Manali flood 2018, Leh flood 2010, Manali and Uttarkashi flash floods of 2012, Ukhimath flash floods and mudslides of 2012. The floods in entire Uttarakhand, part of Himachal and GLOF at Kedarnath during 15-17 June 2013 are worst ever for NWH region. Flood events leads to extensive socio-economic damages, as happened in Kedarnath area during 15-17 June 2013.

Therefore, scientific study of such flood prone areas (in the, but not limited to, Ganga and Indus basin) will help to reduce vulnerability form such hazards and also enhance the disaster management capacity of various disaster management agencies of this region. Expected deliverables and theme of proposed research will be:

- Investigation of topography based indices (Ex. HAND, TWI, SP) and geomorphological information for floodplain mapping in hilly and plain terrains
- Creation of geospatial data cube a selected flood prone area for improved flood information retrieval
- Assimilation of satellite altimetry in hydrodynamic modelling for high flow monitoring

Innovation in hydrological-hydrodynamic modelling input data preparation using integration of in-situ and satellite data Innovation in glacial/landslide lake outburst flood (GLOF/LLOF) modelling parametrisation approach.

Scope of the Work:

- The projects will be aimed at development of innovative ways of using remote sensing data for mapping flood affected area and estimation of flood damage using space based inputs. Use of high-resolution (spatial and temporal) remote sensing data in improving reliability flood modelling outcomes to element footprint level.

Deliverables:

- Tools and/or techniques for operational flood mapping using multi-sensors remote sensing data. Historical flood maps. Flood hazard zones. Flood hazard and risk maps suitable for planning and insurance purpose. Operational flood forecasting systems for critical stretches.

NATIONAL ATMOSPHERIC RESEARCH LABORATORY

GADANKI

RES-NARL-2022-001

Name of ISRO Centre/Unit
National Atmospheric Research Laboratory, Andhra Pradesh

Title of the research proposal
Scattering simulations of electromagnetic radiation by raindrops.

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Area of Research
Radar meteorology

Summary of the proposed research and expected deliverables
Interaction of electromagnetic radiation with raindrops is quite complex and depends on several factors, phase and shape of hydrometeor, frequency of EM radiation, temperature, etc. These simulations are highly essential for variety of applications, including accurate quantitative precipitation estimation with polarimetric Doppler weather radars. Traditionally, T-matrix scattering simulations are being used to estimate polarimetric products from measured raindrop size distributions. Other scattering simulations, like lattice Boltzmann code, can be developed to better understand the dependence of scattering on size and shape of raindrops, which improves quantification of rainfall.

Scope of the Work:

- In addition to advancing scientific understanding of EM wave scattering by raindrops, the work will help improve QPE by Doppler Weather radars and space-borne radars.

Deliverables:

- Lattice Boltzmann code
- Relations between polarimetric products for improved estimations of rainfall, raindrop size distribution, etc.

RES-NARL-2022-002

Name of ISRO Centre/Unit
National Atmospheric Research Laboratory, Andhra Pradesh

Title of the research proposal
Modeling of atmospheric tides: Generation, vertical propagation interactions and their influence.

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Area of Research

Atmospheric dynamics, energetics and coupling

Summary of the proposed research and expected deliverables

Atmospheric tides dominate the spectrum of wind and temperature fields in the upper mesosphere and lower thermosphere. There are migrating and nonmigrating tides. Though solar tides dominate, lunar tides also sometimes can have comparable influence. They provide the largest westward momentum source for background mesospheric wind field. Besides, their influence in the E region dynamo electric field, their vertical advection to modify atomic oxygen, the wavenumber 4 longitudinal structure, E-Valley and F region irregularities have been well recognized.

Scope of the Work:

- Though there are many observational based studies on atmospheric tides, theoretical modeling studies are limited particularly from India.

Deliverables:

- The model is expected to simulate four dimensional atmospheric migrating and non-migrating tides in the MLTI parameters under variable generating sources; propagating conditions.

RES-NARL-2022-003

Name of ISRO Centre/Unit

National Atmospheric Research Laboratory, Andhra Pradesh

Title of the research proposal

Influence of lateral wave forcing and middle atmospheric processes on tropical weather and climate.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Atmospheric dynamics, energetics and coupling

Summary of the proposed research and expected deliverables

The stratosphere will affect climate through radiative processes and the subsequent variations in the temperature gradients can influence atmospheric dynamics. Stratospheric forcings in relationship

with ozone depletion, water vapour, volcanic aerosols, or the quasi-biennial oscillation exhibit a signature in surface climate. Understanding such a coupling is important for more realistic simulations of anthropogenic climate change. QBO-induced high-latitude wind anomalies penetrating downward into the troposphere can also influence tropical monsoon. Stratospheric aerosols have a direct radiative impact that decreases the surface temperature, since more shortwave radiation is reflected. Enhanced intrusion of ozone to the troposphere may accelerate global warming.

Scope of the Work:

- The stratospheric effects on tropospheric weather and climate are thus found to have significant implications for many aspects of intraseasonal and interannual variability and systematic change in the tropospheric circulation. However, the mechanism is poorly understood

Deliverables:

- Publications in peer reviewed journals and increase in the understanding of how middle atmospheric processes and lateral forcing can influence tropospheric weather and climate.

RES-NARL-2022-004

Name of ISRO Centre/Unit

National Atmospheric Research Laboratory, Andhra Pradesh

Title of the research proposal

Development of Multi-Satellite Assimilation System to improve the short-range rainfall forecasts using machine learning techniques and numerical models.

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Area of Research

Numerical Weather Prediction, Satellite Data Assimilation Machine Learning

Summary of the proposed research and expected deliverables

The prediction skill of numerical weather and climate models is mainly dependent on accurate model's initial conditions (ICs). The generation of model ICs is tightly relay on weather observations from Automated Weather Stations (AWS), ground weather radar network, and weather satellites. This research aims to assimilate the rainfall measurements estimated from multi-satellite (polar orbiting like GPM, CUBSAT and geostationary like INSAT-3D and 3DR) and rain-gauge blend product into the Weather Research and Forecasting (WRF) model using the advanced variational assimilation techniques to improve the model initial condition for prediction of severe convective systems over south-east coast of India. The first part of the research proposal will be focused on developing a hybrid machine learning tool such as Deep Neural Network (DNN) models to estimate the surface rainfall from available satellite radiances. Here, two DNN models run consistently: the first one will be building the relationship between the ground rain gauge network and weather radar Dual-pol variables and other one would make the relationship between radar estimated surface rainfall from the first DNN model and the satellite radiances. The final part of this research proposal will be

focused on assimilating the estimated surface rainfall rate from a hybrid machine learning system into the WRF model through the assimilation techniques to improve the prediction skill of short-term rainfall prediction at short-range time scales.

Scope of the Work:

- Improve the satellite rain rate retrieval and enhance the WRF model rain fall prediction skill.

Deliverables:

- Development of machine learning based satellite rain rate retrieval model using in-house prepared algorithms.
- Optimal short-range forecasting systems using WRF, WRF-DA model setup to predict accurate surface rain fall.
- Note: It is expected to utilize commercially available tools, need to utilize tailed made in-house open source python based algorithms and state-of-the-art Artificial Intelligence methods for optimizing the rainfall prediction.

NORTH EASTERN SPACE APPLICATIONS CENTRE

SHILLONG

RES-NESAC-2022-001

Name of ISRO Centre/Unit

North Eastern Space Applications Centre, Meghalaya

Title of the research proposal

Assessment of edaphic factors to combat Citrus Decline in Assam using Geospatial technology.

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Area of Research

Agriculture and Soil

Summary of the proposed research and expected deliverables

Due to consistent nutrient mining and poor fertility management, the quality of soils under citrus orchard has been deteriorating which has led to citrus decline in Assam. The condition is further aggravated by soil and nutrient erosion due to heavy rainfall. Citrus orchards, often located at sloppy hills invite management problem and, hence newer plantations in plains are also on demand. Considering all these aspects, the present research programme entitled "Assessment of edaphic factors to combat Citrus Decline in Assam using Geospatial technology" has been formulated. In this study GPS based surface and sub-surface soil samples, both in bulk and core, will be obtained from citrus orchards of Brahmaputra Valley and Hill zones of Assam. The collected soil samples will be processed and analyzed for various physical, chemical and fertility related parameters like sand, silt, clay content, particle density, pH, electrical conductivity, organic carbon, cation exchange capacity, exchangeable Ca^{++}, Mg^{++}, Na^{+}, K^{+}, macronutrients like nitrogen, phosphorous, potassium and micronutrients like Zn, Cu, Fe and Mn. The collected core samples will be used to analyze physical parameters like bulk density, hydraulic conductivity and porosity. Soil aggregate status will be assessed by estimating macro aggregate, micro aggregate and mean weight diameter. The water retention characters of the soils will be evaluated by estimating field capacity, permanent wilting point and available water content. The soil loss of the studied area will be estimated using the derivative equation of Universal Soil Loss Equation: A = RKLSCP. The activities of soil dehydrogenase, phosphatase, catalase and invertase will also be determined to get a stock about microbial behaviors in the soils. Soil fertility capability classification will be carried out to identify the major soil fertility limitations in the studied soils. Soil samples will also be collected from prospective plain areas and land suitability will be assessed for area expansion of citriculture. Various thematic maps of the soil quality parameters will be generated by using geoinformatics tools.

The study will help in assessing macro cum micronutrient stock and enzymatic activities in the citrus growing areas of Assam which eventually will assist in formulating site specific nutrient management plan to mitigate citrus decline. The estimation of soil and nutrient loss will guide in formulating conservation measures in the citrus orchards in order to prevent erosion. The land evaluation study based on soil and climatic suitability will guide the planners to advise farmers to expand area under mandarin plantation. The GIS based mappings prepared through geostatistics will help in assessing the spatial variability of the soil parameters in the studied areas.

Scope of the Work:

- Study on spatial variability of soil quality including macro cum micronutrient stock and enzymatic activities in the declined Khasi mandarin orchards of the Brahmaputra Valley and the Hill Zones of Assam has not been conducted till now.
- The knowledge on soil quality helps in formulating site specific nutrient management plan and prospective sites for area expansion under Citriculture, therefore the present study has been proposed to find out the edaphic factors because of which the citrus orchards are declining and suggest proper orchards management plan which will benefit the citrus growers.

Deliverables:

- Site specific nutrient management plan based on GIS based soil quality maps will help to mitigate citrus decline in the study area.
- The estimation of soil and nutrient loss will guide in formulating conservation measures in the citrus orchards in order to prevent erosion.
- The land evaluation based on soil and climatic parameters will guide the planners to advise farmers to expand area under khasi mandarin plantation.

RES-NESAC-2022-002

Name of ISRO Centre/Unit
North Eastern Space Applications Centre, Meghalaya

Title of the research proposal
Rainfall-Induced Landslide Susceptibility Evaluation by Accounting the Influence of Vegetation.

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Area of Research
DMS/Landslide

Summary of the proposed research and expected deliverables
Vegetation plays a significant role in controlling the mechanical and hydrological characteristics of the soil slopes by controlling soil moisture and suction of the slope and thus influences its stability.

Hence, there is a need to understand the influence of vegetation and unsaturated characteristics in the physics-based approach to improve the success rate of existing Rainfall triggered landslide Early Warning System (EWS).

The present study thus focuses on the development of landslide EWS by considering the unsaturated soil characteristics and vegetation. The physics-based model will consider the moisture variations, evapotranspiration, leaf area index, hydraulic properties, and unsaturated shear strength. The changes in hydraulic and shear strength characteristics due to vegetation will be estimated by instrumenting the natural, vegetated slopes to develop physics-based EWS.

Scope of the Work:

- Identifying and quantifying the vegetation, root characteristics, subsurface profiles, and the initial soil moisture at chosen sites where the EWS were already developed based on the rainfall characteristics by NRSC/ISRO. EO data will be collected for evaluating these data further.
- Quantifying the influence of vegetation on evapotranspiration and infiltration characteristics of the instrumented slope for different rainfall events.
- Evaluating the influence of plants and trees roots on the unsaturated hydraulic characteristics by field infiltration tests and laboratory tests on SWCC and HCF. Evaluation of tensile strength of roots and mechanical strength based on the root characteristics for identified plant species.
- Evaluation of factor of safety (vulnerability) using limit equilibrium approach by considering the influence of vegetation and comparison with present EWS model.

Deliverables:

- Successful completion of the project will help to improve the accuracy of landslide prediction and the success rate of the EWS.

RES-NESAC-2022-003

Name of ISRO Centre/Unit
North Eastern Space Applications Centre, Meghalaya

Title of the research proposal
Geospatial study on ecology and conservation status of Feral Horses (Equus ferus) of Assam.

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Area of Research
Biodiversity, Ecosystem

Summary of the proposed research and expected deliverables

Feral horses (Equus ferus) are semi wild or wild horse species adapted to survive under a wide range of ecological conditions (Beever, 2003). These horses are enlisted as Endangered according to IUCN. In India, these horses are reported from two places so far viz. Dibru Saikhowa in Assam and Point Calimere in Tamil Nadu. The ecological facts about these horses are less known and yet to be explored for scientific documentation. Feral horses in Dibru Saikhowa are the offspring of the army horses left after the World War II (North East News, 2020). After the massive earthquake of 1950, these animals remain trapped in the floodplain island of Dibru Saikhowa (Bhuyan, 2011). In recent past there have been reports of severe habitat destruction and illegal smuggling of these horses in Dibru Saikhowa. Geospatial technology can be used to understand how their natural habitats has changed over time with possible future prediction. It can be used for modelling of suitable habitats as well as restoration of degraded habitats. Population status and spatial distribution of these horses can be assessed using various GIS tools. The outcome of the study will lay a baseline database that will be helpful in conservation and habitat management of this endangered animal.

Scope of the Work:

- The proposed research will give detailed insight to the ecological status of the endangered Feral Horses trapped inside the River island of mighty Brahmaputra River last 80 years.
- The study will help in understanding the present suitable habitat if Feral horses including their zone of distribution, need for recreation of additional habitat etc.
- The study will help the management in developing wildlife tourism.

Deliverables:

- Successful completion of the project will deliver a detailed & updated database of the Feral horses and their habitat status for taking up appropriate development and conservation measures.

ISRO TELEMETRY TRACKING AND COMMAND NETWORK

BENGALURU

RES-ISTRAC-2022-001

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of Controlled Radiation Pattern antenna for interference mitigation & anti-jamming of NavIC satellite system receivers.

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Area of Research

Navigation Satellite System Antennas

Summary of the proposed research and expected deliverables

The main purpose of a Navigation Satellite System is to provide reliable and accurate position and time information to the user. Under normal scenarios the objective is fulfilled and easily achievable. However, the Navigation Satellite system signals are vulnerable to either unintentional or intentional interference signals. The interference signals can degrade the Navigation Satellite Systems signals, which will result in reduced signal availability. Therefore, additional measures are taken to enhance the low power signals against high power interference signals.

Since the antenna is the first element in the Navigation receiver chain, it has a major impact on the system performance. This project aims for the development of an indigenous controlled radiation pattern antenna (CRPA) for the interference mitigation of NavIC Satellite system receivers.

In literature, many CRPAs have been studied and realized. The many types of CRPA to be explored in this project are :

1. Adaptive CRPA for beam forming and Null steering
2. Space-Time Adaptive Processing & Space-Frequency Adaptive Processing
3. Advanced classes of Navigation Satellite system antennas:

3.1 All-in-view Adaptive CRPA

3.2 Vector Tracking Adaptive CRPA

The antenna design proposed in this project is a miniature antenna element for multi-frequency Navigation Satellite system coverage for S (2.492 GHz ± 8.25 MHz), L1 (1.575 GHz ± 16 MHz) and L5 (1.176 GHz ± 16 MHz). The CRPA antenna element should consist of antenna elements that are more effective against broadband and narrowband interference signals. An effective array approach is proposed to employ and design a compact CRPA with the space adaptive processing to take care of each jamming signal regardless of its type. The radiation pattern properties that enables a good accuracy of the navigation solution are to be achieved.

Scope of the Work:

- To design and realize an indigenous CRPA to ensure good accuracy for the NavIC multi-band Navigation Satellite system with interference & anti-jamming mitigation properties.

Deliverables:

- CRPA with interference and anti-jamming mitigation properties for NavIC multi-band Navigation Satellite system.

RES-ISTRAC-2022-002

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Multisensor data fusion and Orbit determination with nonlinear estimation for space debris RADAR.

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Area of Research

Radar Signal Processing

Summary of the proposed research and expected deliverables

Multi-sensor networks can alleviate the need for high-cost, high-accuracy, single sensor tracking in favour of an abundance of lower-cost and lower-accuracy sensors to perform multi sensor tracking. The use of a multi-sensor network gives rise to the need for a fusion step that combines the outputs of all sensor nodes into a single probabilistic state description. Information regarding the state of a space object is typically inferred via the processing of measurement data acquired from optical telescopes or radars in a Bayesian framework.

The measurement data from a single sensor tends to be scarce and focused on a limited portion of the space object's orbit, which leads to the use of a network of sensors to extend the observed portion of the orbit as well as to provide redundancy in the tracking of objects. In the situation

where multiple sensors can observe the same object, the observation geometry of each sensor within the network should be exploited to increase the amount of information regarding the state of the object.

Moreover, recent advances in space object tracking have led to Bayesian strategies using full probability density function (pdf) representations of the state of an object instead of the more traditional mean and covariance.

Scope of the Work:

- Determining the trajectory of debris and debris cluster to avoid collision with active missions.
- Exploring of the technical details of high-risk large space debris to avoid or remove them.
- Measurement with multiple tracking radars/sensors and fusion of data to make dynamic model of debris.
- Deploying an active method to retrieve the most likely future debris sources to prevent future spacecraft operators due to collision.

Deliverables:

- Develop a set of information-theoretic cost functions for determining for each sensor's opinion, such that multi-sensor data fusion methods.
- Details of the filtering techniques developed along with the simulation results and test cases which would improve the space object detection and tracking performance.

RES-ISTRAC-2022-003

Name of ISRO Centre/Unit
ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal
MIMO based Signal processing algorithms for Space Debris tracking radar.

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Area of Research
Radar Signal Processing

Summary of the proposed research and expected deliverables
MIMO technique for Space Debris Tracking radar is based on transmitting different orthogonal signals from different antenna elements, where the signals can be separated on receiver with matched filters and processed independently. With MIMO technique, using a number of orthogonal

waveforms transmitted from the antenna array in different directions can be used to illuminate the whole Field of Regard (FOR). This brings new possibilities in signal processing as compared to a classical solution, where a narrow illumination beam scans the FOR. This makes possible a setup where the transmit beam covers the whole area of interest at once where field of view (FOV) is equal to field of regard (FOR).

Then, multiple narrow receive beams are synthesized to cover the illuminated area with high angular resolution. With continuous illumination the integration time can be chosen arbitrarily. As the angular velocities of targets depend mainly on the orbit altitude, the integration time can be made range-dependent. This makes the power budget for far targets significantly better than it would be with fixed integration time.

To summarize, benefits of using MIMO technique in a surveillance radar are the result of continuous illumination of the whole area – so the FOV and FOR is the same.

Scope of the Work:

- Study and simulation of MIMO Signal processing algorithms and strategy for Space Debris Tracking.
- Computation complexity analysis and optimization of signal processing algorithms

Deliverables:

- Details of different MIMO based Signal processing algorithms for Space Debris tracking radar including mathematical description
- Simulation results and comparison results of various algorithms

RES-ISTRAC-2022-004

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Prediction, Detection, and Correction of Faraday Rotation effect particularly during Near solar maxima or ionospheric storms for Space Debris tracking and surveillance.

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Area of Research

Radar Signal Processing

Summary of the proposed research and expected deliverables

Faraday Rotation (FR) is a rotation of the polarization vector of radio waves that propagated through the ionosphere. Anisotropy in the ionosphere due to charged particles in the presence of a persistent magnetic field causes this rotation. Linearly polarized data quality can be significantly impacted if the effect is not corrected. FR is frequency dependent and is expected to be much more severe for L-band than for C-band under the same ionospheric conditions.

At L-band, Faraday rotation (FR) can reach significant values, degrading the quality of the received space debris detection radar data, which will significantly reduce the accuracy of parameter recovery if uncorrected. Therefore, the estimation and correction of FR effects is a prerequisite for data quality and continuity.

One of the potential limitations to use this data set is the difficulty in detecting and correcting for FR, particularly for dual- and single-polarization data.

Scope of the Work:

- Methods for estimating FR and analysis.
- FR prediction method and validation.
- Approaches to correct for the estimated FR effects and their effectiveness

Deliverables:

- Details of Algorithms, Simulations, Analysis, Comparisons and Validation of various Algorithms and Techniques for Prediction, Detection, and Correction of Faraday Rotation particularly during Near solar maxima or ionospheric storms

RES-ISTRAC-2022-005

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Investigation of Doppler Keystone transform (DKT) for Range migration correction (RMC) of a moving space debris target at LEO orbit.

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Area of Research

Radar Signal Processing

Summary of the proposed research and expected deliverables

Pulse coherent tracking radar determines the range to a target using the pulse timing techniques and uses the Doppler effect of the returned signal to determine the target object's velocity.

In Range-Doppler processing, the target is assumed to stay in the same range bin during the coherent processing interval (CPI) and a Fourier transform along the slow-time dimension is used to focus the target signature. Range migration occurs when the target passes into multiple bins over the CPI. As a result, the Doppler signature of a target smears in both range and Doppler domains.

Combined with the wide bandwidth, the long CPI, and the high radial velocity between the target and the radar, this combination of factors causes significant linear range migration over the CPI. With range migration accumulated from profile to profile, range profile alignment is destroyed which results in the degradation of the coherent integration gain. Therefore, migration compensation must be considered.

Keystone Transformation proposed to correct the range walk(the linear component of the range migration) and it is combined with the Doppler phase compensation to image the moving target.

Keystone transform in Pulsed Doppler radar to remove the range migration effect and improve the performance of detection.

Scope of the Work:

- Simulation of keystone Transformations or equivalent techniques for Low and High SNR range migration
- Comparison of various techniques for mitigation of range migration effect.
- Performance evaluation of various techniques for range migration correction and Doppler ambiguity resolution for a moving space debris target at LEO orbit

Deliverables:

- Simulated results of keystone Transformations or any technique for a moving space debris target at LEO Orbit for High and low SNR.
- Details of techniques, simulations and report for range migration correction and Doppler ambiguity resolution

RES-ISTRAC-2022-006

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of software package for conformal array analysis.

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Area of Research

Antennas and Radomes

Summary of the proposed research and expected deliverables

Spherical phased array antennas are useful for hemispherical coverage requirements in radar. But it has the disadvantages of manufacturing and alignment in a spherical surface with higher accuracy. For ease of realization, the geodesic dome phased array antenna is preferred which has the same advantage of hemispherical coverage with planar subarrays. This is technically and economically viable because the design avoids fabrication complexity associated with conformal array because the subarray fabrication is based on well-developed easily manufacturable planar array technology.

Scope of the Work:

- Development of GUI as per user requirement
- Various array geometry generation
- Importing the data file for single element antenna pattern from 3rd party software in standard formats
- Selection of active elements, beam steering inputs and computation for the radiation patterns accordingly

Deliverables:

- Software coding with GUI as per user requirement.
- Integrated Software Tool with Visualization

RES-ISTRAC-2022-007

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

MMIC receiver chips design for cryo-cooled Temperature.

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Area of Research

Cryo-cooled MMIC

Summary of the proposed research and expected deliverables

Extremely low noise Front end Receivers are the key component to improve the system sensitivity requiring state-of-the-art performance, such as Space debris tracking, deep space missions and radio astronomy.

Low noise figure with high gain MMIC Receiver chip Design ,simulation and performance Evaluation for both cryo temperature and room temperature at L,S,X and Ka band frequencies

Designed MMIC chip shall be capable to operating at temperature 4k and 15 K & 77K.

Scope of the Work:

- Design and simulation of MMIC Receiver chip for both cryo temperature and room temperature at L,S,X and Ka band frequencies.

Deliverables:

- Design and Simulation results of MMIC Receiver chip design for cryo cooled temperature.

RES-ISTRAC-2022-008

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design of Micro cryogenic coolers for phased array receiver.

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Area of Research

Thermal Engineering

Summary of the proposed research and expected deliverables

In the fields of advanced tracking systems, electronic components should be cooled to 4K level to improve its sensitivity and reduce the background noise. The cryogenic receiver is mounted onto a cryo cooler. However, compactness and energy efficiency of the whole system are seldom a major requirement. Two-stage coolers are thus widely used as they provide both low temperature and significant cooling power, necessary to cool down a low-loss input line in order to minimize the receiver noise temperature.

Joule-Thomson cryo coolers have been used in many applications including cooling of infrared detectors and high-electron-mobility transistor-based devices in space, low-noise amplifiers for radio telescopes, among others due to their special features such as compact geometry and absence of moving parts. The geometrical parameters and the operating conditions of the heat exchanger drastically affect the cryo cooler performance in terms of cool down time and cooling effect.

A JT cooler has two basic components: a counter flow heat exchanger and an orifice. Due to the fact that the cooler has no moving parts and contains relatively simple components it is a great candidate for miniaturization, and realization with the new additive manufacturing technologies.

Micro cryogenic coolers with different operating conditions and working fluids like nitrogen and helium should be explored and evaluated for performance as part of this proposal with an emphasis on JT cryogenic coolers.

Scope of the Work:

- Design and development of micro cryogenic cooler for cryogenic Receiver with nitrogen and helium as working fluids.

Deliverables:

- Design and Simulation results of Micro cryogenic cooler capable of maintaining the cryogenic operating conditions for phased array receiver.

RES-ISTRAC-2022-009

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Distributed Beams Technique and the analysis of the radar-variable, Motion-Compensated Steering (MCS) technique and Impact on Signal Power and Copolar Correlation Coefficient Estimates in Phased Array Weather Radar.

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Area of Research

Weather radar signal processing

Summary of the proposed research and expected deliverables

In Weather radars, observation of short-lived atmospheric phenomena with high temporal resolution is particularly important when observing severe weather. Parabolic dish radars suffer from the need to scan mechanically. It constrains the speed at which scanning occurs as well as the spatial pattern of a scan.

In Phased Array Radar, Electronic scanning allows a near instantaneous change in beam position to an arbitrary angle, making possible very rapid scanning unconstrained by any particular spatial pattern, as well as a constant beam position during each dwell time.

Distributed Beams (DB) technique reduces the scan time and/or reduces the variance of radar-variable estimates. It exploits unique PAR beam forming by synthesizing a wide transmit beam and receiving multiple beams simultaneously.

The DB technique consists in coherently combining receive beams coming from the same location to effectively produce a longer dwell (increased by number of simultaneous beams received).

The Phased Array Radar systems' beam agility can be exploited to reduce beam-smearing effects by electronically steering the beam on a pulse-to-pulse basis within the coherent processing interval. That is, the motion of the antenna can be compensated to maintain the beam pointed at the center of resolution volume being sampled. This motion-compensated steering (MCS) could reduce the effects of antenna motion and lead to a reduction in the effective beamwidth.

It is required to provide a formulation for the MCS technique, simulations to quantify its performance in mitigating beam smearing effects, its impacts on the quality of dual-polarization radar-variable estimates, and a practical implementation on simulated XPAR system.

Scope of the Work:

- Performance evaluation of Distributed beam technique and MCS technique for phased array radar system
- Simulation Results of Distributed Beams (DB) technique for reduction in scan time and radar-variable estimates.
- Scan Time reduction under the different Scanning strategies
- Impact of Distributed beam techniques on phased array radar system performance like side lobes, sensitivity, rotation speed etc.
- Algorithm implementation and performance of MCS for the mitigation of beam-smearing effects impacts on the quality of dual-polarization measurements

Deliverables:

- Simulation results of DB technique for phased array radar System
- Design document, simulation framework and test results to quantify the performance of the MCS technique
- Signal processing algorithms of the MCS technique for a dual-polarization Phased Array Weather radar system.

RES-ISTRAC-2022-010

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Advanced Signal Processing techniques like Intra-pulse orthogonal phase coding, opposing frequency chirp and Quasi-Simultaneous H/V for Cross-polar bias Mitigation in Phased Array Weather Radar.

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Area of Research

Radar Signal Processing

Summary of the proposed research and expected deliverables

To Obtain accurate polarimetric measurements from a phased array weather radar, matching of the copolar H and V radiation patterns of the radar has to be carried out, as these patterns can differ in both the shape and amplitude. When electronically steering the transmitted beam away from the principal planes of the array, they can reach levels capable of severe interference with meteorological measurements.

One technique for the mitigation of cross-polar biases is a pulse-to-pulse Phase Coded Simultaneous H & V (PCSHV) transmit mode. The basic principal is that the H and V excitations emitted by the transmitter are modulated through multiplication by a pair of orthogonal phase codes ch(n) and cv(n), where n is the index of the transmitted pulse. On receive, the V signal is decoded through multiplication by the conjugate phase code c(n).

Quasi-simultaneous horizontal and vertical transmission operates by transmitting a separate H and V pulse in near immediate succession on every PRT. Because the reflections from distributed weather targets are a zero-mean random process and the gates contributing the two cross-polar signals are independent from the copolar gate, the cross-polar contamination should sum incoherently when the measured signal from a gate is integrated over many pulses.

Another potential method for obtaining polarization isolation is the use of orthogonal waveforms. This can be achieved through a number of design techniques, such as intra-pulse orthogonal phase coding or opposing frequency chirp directions between the two waveforms.

Scope of the Work:

- Design, simulation and comparisons of Advanced Signal Processing techniques for Cross-polar bias Mitigation in Phased Array Weather Radar like
  - Intra-pulse orthogonal phase coding
  - Opposing frequency chirp
  - Quasi-Simultaneous H/V
- Can be proposed with better algorithms to mitigate cross polar bias

Deliverables:

- Design document, simulation framework and test results to quantify the performance of signal processing algorithms to mitigate cross polar for a dual-polarization Phased Array Weather radar system.

RES-ISTRAC-2022-011

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Distributed Beamforming and Beampattern Design using Drone Swarm Network.

Name of Co PI from ISRO Centre/Unit

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Area of Research

Signal Processing and Control System on FPGA

Summary of the proposed research and expected deliverables

Because of the complexity of UAV systems and the highly specific nature of UAV applications, there is a need for novel algorithms that could be deployed to turn clean sensor data into actionable information on board the UAV.

UAVs should be into groups using swarm coordination algorithms to perform tasks in a scalable, reliable and robust manner. The dynamic uncertain environment and complex tasks determine that the unmanned aerial vehicle (UAV) system is bound to develop towards clustering, autonomy, and intelligence.

Some types of algorithms that have been proposed are formal logic machine learning or neural network, and graph theory.

The classic algorithms include particle swarm optimization algorithm, ant colony algorithm, which are often used in cluster collaborative control scenarios such as path planning and task allocation. For some emerging algorithms, the wolf swarm algorithm, bee colony algorithm, and firefly algorithm are widely applied in distributed UAV swarm cooperative control. Perhaps the most common algorithm proposed for UAV swarm control and planning revolves around variations and adaptions of particle swarm optimization.

Scope of the Work:

- Study of distributed beamforming and opportunistic array concepts be applied to UAV swarms
- Transmission equations for Swarm UAVs
- Usage of UAV-borne array elements within a UAV swarm collectively and utilize the digitally formed beam for operational purposes
- Technical challenges in implementing collective beamforming, and what are possible solutions to these challenges like Geolocation Problems, Synchronization Problem, Transmission Losses and Range Limitations

Deliverables:

- Design and Simulations of Control system and algorithms for Distributed Beamforming and Beampattern for Drone Swarm Network to make phased array radar.

RES-ISTRAC-2022-012

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Design and simulation of Luneburg Lens and Hemispherical Dielectric Lens Focal Planar array for simultaneous multiple beams.

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Area of Research

Radar Antenna Design

Summary of the proposed research and expected deliverables

Emerging space and military applications such as collision avoidance and tracking at millimeter-wave frequencies typically require beam-steering antenna systems. Due to the higher attenuation at millimeter-wave frequencies highly directive antenna systems are demanded.

Lens antennas increase the effective aperture and consequently enhance antenna directivity; and can achieve wide angle scanning with simple beamforming. Hence they are good candidates for high-gain microwave and millimeter-wave applications.

Lens arrays have lower cost, complexity as compared to a phased array at the expense of total volume and complete beam continuity. For ground station applications, both of these trade-off parameters are not important and can thus be exploited in order to lower the cost of the ground station.

Spherical Luneburg lenses (gradient refractive index) are often considered for beam scanning since they can produce nearly identical beams in various directions over a wideband operational range.3-D printing, has offered a new way to implement complex 3-D Luneberg Lens array structures at low costs.

Hemispherical Dielectric Lens Focal planar Array with the convenience of fabrication, high efficiency and low costs would also be a promising solution to realize the analog beamforming for mm-wave applications. Though inferior in performance to spherical luneberg lens array, fabrication of Hemispherical Dielectric Lens is less complex.

Scope of the Work:

- Design and Simulation of 3D printable Luneberg Lens Antenna array, Hemispherical Dielectric Lens Focal Planar array for simultaneous multiple beams

Deliverables:

- Design and Simulation results of 3D printable Luneberg Lens Antenna array, Hemispherical Dielectric Lens Focal Planar array for simultaneous multiple beams.

RES-ISTRAC-2022-013

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

EM analysis Software to design, analyse & tune radome.

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Area of Research

Antennas and Radomes

Summary of the proposed research and expected deliverables

It is proposed to develop full wave simulation software that would be useful to design radome panel, joint and tuning the same. The software should be able to assess the scattering of the fields by the radome and then combine this with the antenna's radiation characteristics to predict the overall radiation performance of the antenna-radome system.

Scope of the Work:

- Development of software coding for radome panel & joint analysis
- Development of software coding for analysing seam in user defined orientation for tuning the radome
- Development of software coding for performance evaluation of antenna enclosed with tuned radome

Deliverables:

- Software coding with GUI as per user requirement
- Integrated Software Tool with Visualization

RES-ISTRAC-2022-014

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Spacecraft Health analysis using AI techniques.

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Area of Research

Artificial Intelligence, Reinforcement Learning, Expert Systems, Neural Networks, Genetic Algorithms

Summary of the proposed research and expected deliverables

1 Introduction:

Spacecraft operations broadly classify into following categories namely-

- Health Monitoring & Anomaly Management
- Planning and Execution of routine planned activities

Multiple missions with different on-board configurations and payloads have to be maintained in optimum operating conditions for the duration of their useful mission lifetimes. Management of this large fleet of satellite demands a high degree of automation of ground operations. The use of techniques from artificial intelligence for spacecraft health monitoring and anomaly handling will enhance the operation handling capability. The applications of AI include expert systems, Neural Networks (NN), Reinforcement learning, Natural Language Processing (NLP), Genetic Algorithms, and machine learning.

2. Mission Operations automation at ISTRAC – Presently OOL based system is being utilized for health monitoring and development of automated planning of routine operation is in progress.

Also, To enhance the health monitoring and anomaly management, AI based system development is started.

Scope of the Work:

- Spacecraft health monitoring and anomaly management

Deliverables:

- AI based Expert system module for Spacecraft health monitoring and anomaly management with following features :
  - Should have capability to detect the anomaly or change in the subsystem behaviour
  - Should have the capability to predict the anomaly based on current trend of data

- This system should have the individual Expert model for each subsystem, which can simulate their behaviour in different dynamic condition
- System should be modular and generic

RES-ISTRAC-2022-015

Name of ISRO Centre/Unit

ISRO Telemetry Tracking and Command Network, Bengaluru

Title of the research proposal

Development of Algorithm for Optimal schedule generation for MEO Search and Rescue system (MEOSAR) ground segment at ISTRAC, Bengaluru.

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Area of Research

Optimization techniques for MEOSAR Scheduler

Summary of the proposed research and expected deliverables

COSPAS-SARSAT is a satellite system designed to provide distress alert. It is an international initiative for satellite-aided search and rescue. It is dedicated to detect and locate radio beacon activated by persons, aircraft or vessels in distress, and forward this alert information to authorities that can take action for rescue. India is a member of the COSPAS-SARSAT program for providing distress alert and position location service. The Indian Mission Control Centre (INMCC) located at ISTRAC has developed MEOSAR ground segment that typically tracks MEO satellites designated for search and rescue, capture any beacon alert, process the alert message and disseminate to respective destinations to carry out rescue operations on time.

With 7 conventional antennae deployed for MEOLUT operations, it becomes necessary to allocate satellites for these antennae to track out of all visible satellites for a given time slot from the constellations GPS, GLONASS & GALILEO, so as to cover service area pertaining to INMCC.

There exists software in place which uses heuristics for selection and allocation of resources. The proposal is to have a suitable optimization algorithm that will have a better performance for the MEOSAR system that shall go for operational certification in the international COSPAS-SARSAT system.

Scope of the Work:

- To develop algorithm for optimal allocation of satellites to MEOSAR ground segment.

Deliverables:

- Algorithm for MEOSAR scheduler

MASTER CONTROL FACILITY

HASSAN

RES-MCF-2022-001

Name of ISRO Centre/Unit
Master Control Facility, Hassan

Title of the research proposal
FFT based Spectrum Analyzer

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Area of Research
Digital Signal Processing and Radio Frequency Communication

Summary of the proposed research and expected deliverables
FFT based spectrum Analyzer will be used Monitoring RF signals by all RF Enginners in Earth Stations of Satellite Operators (TTC Support), Teleport and VSAT users

Scope of the Work:

- As a part of the project a FFT based Spectrum analyzer is to be developed for monitoring IF and RF signals from 10MHz to 18 GHz
- All standard Provisions of spectrum Analyzer like Frq, Span, RBW, VBW, Attenuator, Ref Level etc to be provided.
- Instantaneous Band width of 80MHz required
- Sensitivity - 150dBm
- Aging and Phase Noise- suitable for required operations

Deliverables:

- Hardware Design with Proto
- Software with Source Code
- Other Necessary elements required for Independent Operation as Spectrum Analyzer

RES-MCF-2022-002

Name of ISRO Centre/Unit
Master Control Facility, Hassan

Title of the research proposal
SDR(Software Defined Radio) based Modem for Spacecraft Telemetry reception, Telecommanding and Ranging Operations.

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Area of Research
SDR based Communication devices

Summary of the proposed research and expected deliverables
Integrated Based Devices are used in spacecraft ground segment for the reception of telemetry signals, command transmission. Ranging units are used to determine the precise orbit of the spacecraft.

Scope of the Work:

- As a part of the project an integrated device has to be designed for following activity.
- Telemetry reception – Various demodulation techniques, Bit and frame synchronization, Decoding techniques.
- Telecommand unit and modulator- CCSDS standard implementation, Coding and encryption methods.
- Range processing unit.

Deliverables:

- Detailed simulation results and simulation files.
- Design document along with details of the algorithms implemented.
- Source Code of the firmware developed.

RES-MCF-2022-003

Name of ISRO Centre/Unit
Master Control Facility, Hassan

Title of the research proposal
IF Switch Matrix (Combining and Distributive) -32x32 matrix

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Area of Research

Solid state relay circuit design and simulation

Summary of the proposed research and expected deliverables

In Satellite ground segment, in order to utilize the baseband resources effectively combining/ distributive switch matrixes are utilized for the routing of baseband signal from various ground terminals to baseband equipment and vice-versa

Scope of the Work:

- As a part of the project a combining and a distributive switch matrix has to be developed.
- Prototype development.
- Remote interface features.

Deliverables:

- Circuit schematic, design files and simulation files/results.
- Prototype design and test results. Source Code of the firmware developed.

RES-MCF-2022-004

Name of ISRO Centre/Unit

Master Control Facility, Hassan

Title of the research proposal

DVB-S2/S2X Satellite Modem

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Area of Research

Satellite data reception and handling

Summary of the proposed research and expected deliverables

Satellite Modems are used world wide for the establishment of VSAT link connectivity. In the VSAT link establishment, satellite modem is one of critical element in data handling area.

Scope of the Work:

- As a part of the project a satellite modem prototype has to be developed with following features
- Standard Compatible- DVB-S2/DVB-S2X Data handling capcity – Upto 10 Mbps.
- Implementation of various encoding/decoding techniques like Viterbi, Turbo etc.

- Interface standards – V.35, IP etc.
- Carrier in Carrier implementation.
- Different Modulation/ demodulation Techniques – QPSK, 8PSK, 16APSK, QAM etc.

Deliverables:

- Detailed simulation results and simulation files.
- Design document along with details of the algorithms implemented.
- Source Code of the firmware developed.

RES-MCF-2022-005

Name of ISRO Centre/Unit
Master Control Facility, Hassan

Title of the research proposal
Design and development of RF synthesizer

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Mr. Manish Kumar

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Area of Research
Enabling Ground system operationfor Satellite operation based upon indigenous RF system.

Summary of the proposed research and expected deliverables
The proposed RF synthesizer shall be used as a tuned local oscillator input to Indoor and Hub mounted frequency converters. The synthesizer can also be utilized for developing hand held signal generator.

Scope of the Work:

- Currently, various types of RF converters such as up-converter, down-converter and test loop translators are in use at MCF. RF synthesizer is the main components of these frequency converters. With the help of Indigenously developed RF synthesizer, we would be able to develop our own frequency –converters and signal generators. The synthesizer shall have LAN as well as Wi-fi controllability. Wi-fi controlled frequency synthesizer and converters shall be very useful and convenient in operating these units in Outdoor and hub reflector antenna.

Deliverables:

- RF frequency synthesizer hardware unit with firmware and GUI.

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		

Annexure-2

List of Respond Coordinator of ISRO/DOS Centre

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2.	SAC	Dr. (Smt.) Parul Patel Respond Coordinator Space Applications Centre Ambavadi Vistar PO Ahmedabad: 380 015	Tel: 079-26913338 e-mail: research_sac@sac.isro.gov.in
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RESPOND & AI

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