Suggested topics for research proposals

In order to ensure that the research work carried out under JRP scheme is meaningful and relevant to ISRO programme, detailed discussions were held with ISRO Scientists/Engineers to identify the research topics where academic institutions like University of Pune, can make positive contribution. As a result of this effort, following list of suggested research topics has emerged. The listed topics may be taken as guideline in making research proposals under ISRO-UoP Joint Research Programme by the prospective Investigators from Pune University.

Research area	Outline of suggested research topic
Space radiation	1. Equilibrium as well as non-equilibrium air radiation modeling for estimation of radiative heating in re-entry from interplanetary mission when entry velocity is greater than 15 km/s
Wind measurements & modeling	1. Dynamic modeling for real time weather forecast 2. Assimilation of satellite data in numerical weather and ocean prediction models improving the initial condition in models 3. Global and regional numerical dynamic models for ocean state forecast 4. Diagnostic study using satellite data to understand atmospheric and oceanic process near ocean surface 5. Empirical and dynamic modeling and assimilation techniques for predicting movement and intensity of a cyclone 6. Algorithms/models for generating 5-daily and 10-daily snow cover products, snow melt run-off, features of glaciers to understand Himalayan cryosphere 7. Modeling marine lithosphere using satellite altimetry over marine regions 8. Studies related to: ▪ Aerosols and their impact on climate ▪ ARFI : Aerosol Radiative Forcing over India (National Network with 40 Universities and Institutions) ▪ IGBP : ISRO Geosphere Biosphere Programme ▪ Physics and dynamics of atmospheric boundary layer (0-1km) ▪ Cloud studies using satellite data ▪ Atmospheric dynamics – winds, waves and structure ▪ Ionospheric (100-1000 km) modeling characteristics, features, dynamics, electron content ▪ GAGAN – Aircraft navigation ▪ Planetary atmosphere

Suggested topics for research proposals

- Inner and outer planets
- Temperature and humidity profile from atmospheric sounders
- Wind vectors from satellite observations
- Rainfall estimates from infrared and microwave radiometers
- Land parameters from microwave radiometers
- Application of atmospheric parameters in monsoon related activities
- Retrieval of ocean surface wind vector from first principle
- Retrieval of ocean wave spectra and ocean winds from Synthetic Aperture Radar
- Retrieval of coastal Bathymetry using SAR
- Simulation of altimeter signals from ocean surface and retrieval of basic ocean parameters
- Simulation of coastal wave and circulation through Numerical Model
- Merging open ocean and coastal models for waves and circulations
- Sensitivity studies on forecast winds, waves, mixed layer depth for their application in physical and biological oceanography
- Propagation studies for ionospheric correction making use of satcom technology
- Atmospheric modeling for radiometric correction

Optical coatings & sensors

1. Piezoelectric films on Zn-cut Al_20_3, NCD substrates for Surface Acoustic Wave (SAW) devices with low propagation loss, high performance and high frequency characteristics
2. Langasite single crystal (LGS) for high performance, low loss narrow band SAW filters
3. Nanostructured magnetostrictive thin films for SAW device applications
4. Ferroelectric thin films for electronically tunable filters used in wireless communication system
5. Investigating compaction, focusing, alignment techniques and swath improvement in Hyper spectral system
6. Mathematical modeling and optical domain processing in multipurpose large area array detectors
7. Sensor/detectors related studies:
   - Developing complete sensor system for CO, CO_2, N_2, O_2, N_2O, SO_2 and other Greenhouse gases

Suggested topics for research proposals

- Testing, calibration and evaluation of sensor systems
- Life/failure mechanism in photo detectors using InGaAs, InSb and Si-PIN technologies and modeling to estimate life of such detectors

Rural development & developmental communication

1. Socio-economic research/evaluation of satellite-based societal applications
2. Demonstration projects for new applications of space and related technologies for end-users of socio-technical system
3. Study of social, economic and cultural impact of new technologies and production of software as models/examples
4. Content generation in terms of multi-media programs and evaluation study at national and regional levels for Edusat utilization
5. Interactive programs for applications like Training, Education, e-Governance, Disaster Management, Tele-conferencing, Urban/Rural Development under Gramsat programme
6. ISRO's Village Resource Centres into multi-service centres and integration with existing VRCs
7. Innovative applications for Education, Health and rural welfare using satcom technology

Geo-informatics

1. Algorithms and techniques for processing terrestrial imagery acquired in stereo/mono
2. Study of planetary geodesy for optimization in calculating surface measurements (coordinates, distances, areas) on spheres or spheroids
3. Methods to analyze multisensor satellite data and to detect guides for mineral exploration
4. Three dimensional models of urban area using GIS techniques
5. Continuous simulation model using high resolution satellite data embedded with GIS technique to represent the entire hydrological system on computer
6. Multi facet model for assessing the impact of a geo-hazard on human settlement and simulating the damage scenario
7. Spatial decision support system (SDSS) for flood management, using Geoinformatics (mathematical and statistical modeling techniques)

Suggested topics for research proposals

Remote sensing applications

1. Investigation in geocorrection models namely (a) Model based on ephemeris platform and sensor information (b) Model relating ground control points or features and (c) Hybrid model
2. Sensor calibration on ground based test sites
3. Signal processing and Tracker algorithms for altimeter sensor, correlation algorithm for synthetic aperture radiometer and performance analysis, feature extraction algorithm for microwave data
4. Partitioning land surface temperature into components using angular thermal remote sensing
5. Quantifying variability of green-house gases (GHG) using space borne sensors
6. Estimating aerosols over land and ocean using multiangular and polarization measurements
7. Agro-ecosystem models to study long term sustainability
8. Developing land data assimilation system to optimally merge remote sensing observations with hydrological model
9. Earthquake precursors using satellite data such as land surface temperature and gravity anomalies
10. Modeling the dynamics of change of land use cover for future projection
11. Modeling hydrological cycle of natural wetlands in relation to change in land use/cover
12. Differential SAR interferometry and its applications for geohazards monitoring
13. Agriculture resources related studies:
    - Classification of hyperspectral remote sensing data to discriminate between crop condition, variety and stage
    - Inversion of radiative transfer model for estimation of crop parameters from hyperspectral data
14. Marine resources related studies:
    - Calibration and validation
    - Mixed layer physics
    - Algal-bloom specific algorithm for chlorophyll retrieval from ocean colour data
    - Identification of phytoplankton functional type (PFT) and time series measurements on inherent optical properties to develop bio optical algorithm

Suggested topics for research proposals

- Assessment of fate of carbon during algal bloom
- Impact of climate change on ocean productivity

15. Environment related studies:
    - Eco-casting of environmental parameters
    - Quantitative modeling of wind erosion
    - Decertification vulnerability analysis
    - Quantitative estimation of gas emission from biomass burning
    - Urban hazard model
    - Microwave scattering and emissivity models from natural surfaces
    - Retrieval and modeling of atmospheric pollutants
    - Hyper spectral data evaluation for forest condition assessment
    - Early warning/forecasting models for land slides
    - Forewarning and damage assessment for natural disasters
    - Development of indices for urban transportation geometry
    - Development of semi automated procedures for urban structural planning
    - Evaluating impact of watershed treatment
    - Web based solution for multi resolution image fusion
    - Methodology to derive digital terrain model
    - Development of web based services
    - Development of data mining tools
16. Disaster related studies:
    - Early warning for cyclone prediction of track and probable landfall point
    - Areas likely to be inundated and estimation of population affected in case of floods
    - Short range and medium range forecast for local severe weather conditions
    - Earth-quake precursors with satellite based observations and ground experiments
    - System study on services for rural centers, fishing community etc

Material Sciences

1. Making H_2O_2 of 98% purity, stabilizers for its safe storage and catalyst for its decomposition
2. Synthesizing cubane and substituted cubanes in industrial scale
3. Aqueous solution of Hydroxylammonium nitrate (HAN) (minimum concentration of 60%) and catalyst to initiate decomposition at lower temperatures
4. Indigenize lubricants FLUOR-06 and FLUOR-60 for use in liquid

Suggested topics for research proposals

rocket engines

5. Development of silicone polymers for thermal paints on satellite components
6. Code/software for prediction of mechanical & ballistic properties of composite solid propellants
7. Catalytic splitting of carbon dioxide into carbon monoxide and oxygen
8. Graphite fiber reinforced aluminum for material housings in components like DC-DC converters
9. Electric propulsion systems related studies:
   - 18 mN & 75 mN stationary plasma thruster (SPT)
   - Pulsed plasma thruster
   - Power processing & control systems for SPT
   - Xenon flow controllers

10. Studies related to fuel cells:
    - Simulation & analysis of humidification methods in microgravity environment
    - Techniques for using product heat and water for humidification
    - Techniques for separation of liquid water from exhaust hydrogen and oxygen gases
    - Influence of membrane thickness, temperature, saturation level on water balance of proton exchange membrane (PEM)
    - Modeling bipolar plate flow field geometry

11. Studies related to Human Space Flight Programme:
    - System supporting LiOH particles on porous ceramic material to absorb carbon dioxide produced by human metabolism
    - Block copolymer based on polyethylene oxide (PEO) soft segment and polyether-ester block amide (PEBA) hard segment to make liquid cooling & ventilation garment (LCVG) for space suit
    - High pressure Oxygen compatible materials
    - Fluid circuit for thermal control system inside crew module
    - Suit circuit system
    - Dynamic modeling and analysis of human body exposed to vibration environment during space flight

12. Studies related to mechanical and materials:
    - Modeling guided wave propagation in (i) circumferential direction of tubes (ii) sheets with defects
    - Experimental analysis and evaluation of formability limit diagram

for Inconel-718

- Thermal analysis of resistance spot welds
- Analysis of weld bead instability in the overlap zone of keyhole electron beam welds
- Thermal analysis of partial penetration and full penetration seam welds by laser
- Testing/screening of metallic materials at high temperatures and in high oxygen environment

13. Studies related to composites:
    - Structural health monitoring of composite structures using optical fibers with Bragg Grating sensors
    - Miniature specimen test techniques

14. Studies related to Aeronautics/Aerodynamics/Aerothermal areas:
    - Thermal response of sandwich honeycomb panels under transient heating condition
    - Heat flux distribution in the vicinity of protrusions on the cone cylinder body under varying mach number and Reynolds number

15. Studies related to rocket motors:
    - Carbon – carbon liner with transpiration cooling
    - Vacuum plasma sprayed CuCrNb liner
    - Thermal barrier coating for improving life cycle
    - Thermal protection system for liquid He storage vessel and feed lines
    - Nickel electroplating on Copper
    - Seals and bearings for turbo pump
    - Kerosene refinement - using catalysts
    - Nano particles and nano fluids for augmentation of heat transfer in thrust chamber
    - Pulse mode combustion studies
    - Hydrostatic bearings
    - Micro-gravity slosh analysis

16. Studies related to design and manufacturing:
    - Assessment of EB weld of Titanium, spot welding of Aluminum inter-stages through acoustic emission
    - Strain measurement using bi-refrigerant coatings
    - 3d strain mapping using stereovision and digital image correlation

Suggested topics for research proposals

- Digital holographic microscope for mems characterization, deflection and shape measurement
- Experimental investigation of delamination fracture toughness of sandwich panels
- Sandwich structures with negative Poisson's Ratio
- Finite element software for inflatable structures
- Development of 3-d contact element with friction
- Health monitoring of structures using vibration data
- Control algorithm for multi-axial vibration testing
- Vibration isolation system for payloads
- Visco-elastic structural analysis of solid propellant grains
- Fracture studies in textile composites

Biodiversity

1. Modeling sediment transport in coastal and marine environment using satellite retrieved parameters.
2. Study identifying source to sink path ways, impact on habitats, mapping shoreline changes, coastal erosion, predicting shoreline changes and quantifying coastal vulnerability to predicted sea level rise
3. Ecosystem models to assess the condition of marine ecosystems like coral reef, sea grass bed etc.

Instrumentation / Electronics

1. Fiber optic sensor based measuring system with multiplexing capability for simultaneous measurement of strain, temperature, pressure, and displacement
2. Portable and compact equipment based on computerized digital optics and capable of whole field strain measurement from photoelastic coating fringe data
3. Development of an algorithm and integrated computer based optical system capable of non-contact whole field strain mapping with minimum resolution of 50 micro strains using the principles of stereovision and Digital Image Correlation (DIC)
4. Sensor system and data acquisition/analysis for measurement of strain on space structural components at temperatures higher than $800^{o}C$
5. Characterize performance and reliability of micro and nano electro mechanical systems like sensors, actuators and controls under static and dynamic conditions
6. Non-linear stability analysis for MMIC design
7. Extending exact synthesis method to non-linear microwave circuit designs like mixer, modulator, frequency multiplier to get the best results

Suggested topics for research proposals

8. Design of an input filter with low mass and volume by inductor and capacitor values enhancement techniques
9. Design of an input filter by hybrid of Equivalent and EM technique combining accuracy of EM solver and the speed of Equivalent
10. Studies related to acoustic emission:
    - In-flight health monitoring of launch vehicle structures using acoustic emission
    - Automated AE monitoring with Neural Network for the real time integrity evaluation
    - Differentiating genuine AE signals from external noise in the real time AE monitoring
11. Studies related to piezoelectric material:
    - Application of piezoelectric material in precision position control of mirrors used in optical structures of satellites
    - Characterize piezo stack actuators and Macro Fiber Composite (MFC)
12. Transducers and sensors related studies:
    - MEMS based transducers and sensors
    - Cryo temperature sensor

Image processing

1. A generic model based on Rational Polynomial Coefficient (RPC) is a common approach in satellite data processing in encapsulating the interior and exterior orientation of image acquisition, geometric correction and derivation of digital elevation models (DEM). Investigation related to various orders of polynomials, functional representations, bundle adjustment of s block of images using such representations, DEM generation for a block of imagery and extension of this methodology to planetary data processing to be carried out.
2. Currently satellite images have resolution ranging from 25 m to 0.8 m and likely to improve to 0.25 m. Study to be carried out to generate images with better than 0.25 m resolution using available multi-resolution images. This involves development of concepts like super resolution, image registration, sub-pixel processing and multi-resolution.
3. With the availability of high resolution stereo imagery, there is a need to develop new techniques for a dense set of match point pairs from such data to derive the DEM. In view of large volume of data involved, optimization aspect is to be investigated. New algorithms should remove the short comings of cross-correlation techniques using FFTs.

Suggested topics for research proposals

4. Urban DEM poses a different challenge due to singular nature of the underlying DEM surface which is to be detected. It should cater to identification of buildings and steep landscapes and determination of their heights through space intersection by other means. Special techniques based on morphological features and AI paradigms to be developed for solving this problem. Generation of relative DEM also to be investigated.
5. Developing robust techniques using image cues for interpolation from DEMs and considering constraints such as break points, break lines and exclusion masks
6. Combining DEMs from various sources into a single DEM considering slope, aspect and other terrain properties for better DEMs
7. Antenna related studies:
   - Antenna design for very large apertures
   - Development of feed elements
   - Milli-Meter (MM) wave reflector antenna and feeds
   - Thinned array antenna
8. Data processing related studies:
   - Hyperspectral data processing for theme specific application leading to optimization of spectral bands
   - Automatic registration of images of different sensor, resolution and acquisition modes
   - Automated feature extraction using multiple data sets from multiple sources
   - Multi-source data fusion and integration
   - Automatic 2D/3D feature extraction, object recognition from high resolution data
   - Automatic DSM/DTM generation from different data sources (satellite, Aerial, Lidar) in different terrains (urban, forest, coastal)
   - Advanced quantitative, physical based retrieval of biophysical and biochemical parameters