RESPOND
VSSC

TITLES FOR RESPOND PROJECTS / RESEARCH AREA DOCUMENT

JUNE 2013
VSSC

A.	Area	**AEROSPACE**
A.1	Sub area	Interplanetary Missions
A1.1	**Estimation of Gaseous Radiation for Interplanetary Missions:** Gaseous radiation is significant in re-entry from interplanetary mission when entry velocity is greater than 1.5 km/s. Both equilibrium and non-equilibrium air radiation have to be modeled for the estimation of radiative heating. Number densities of various chemical species, translational, rotational and vibrational temperatures of heavy particles and electrons are to be evaluated for modeling emission and absorption characteristics of air under these conditions. The proposed study is for evaluating radiation heating under these conditions.	
A.2	Sub area	Thermal Analysis
A2.1	**Estimation of Heat Flux Distribution in the Vicinity of Protrusions on the Cone (Cylinder Body Under Varying Mach Number and Reynolds Number Conditions (Experimental &Theoretical):** There are established procedures to estimate heat flux at different regions of a launch vehicle, which are essentially axi-symmetric clean configurations. The presence of protuberances like DMRJ engine modules, wire tunnels, fins, etc . will enhance heat flux locally due to shock wave interference with boundary layer. Analysis using CFD methods and possible evolvement of engineering solution in terms of geometric and flow parameters will help in estimating the heart flux near proturberances. Results substantiated by carrying out experiments will give confidence in using the model for configurations with protrusions on cone cylinder body.	
A.3	Sub area	Thermal measurements
A3.1	**Heat Flux Measurements on RLV-TD:** TPS design of RLV-TD is based on heat flux data generated using engineering methods. Limited 2D CFD data generated for validation heat flux. Validation of heat flux data for the current configuration is important, especially for regions of shock-shock interaction, leeward region flow, base flow, fuselage wing	

	interaction. Flow enthalpy about 2 MJ.kg, M = 6.6, To = 1700 – 1800 K. Conditions corresponding to maximum heat flux and max dynamic pressure to be simulated. Diagnostic shall be (a) heat flux (b) liquid crystal thermography/IR thermography (c) Flow visualization. Models used for wind tunnel studies in VSSC/ATFD can be used after proper instrumentation. Generic data generated will be useful for further mission of RLV TD also.	
A.4	Sub area	Thermal simulation
A4.1	**Flow-thermal Simulation of Hypersonic Air Intake:** 3 D parametric geometry is to be created using VSSC supplied air intake configuration with identified variable geometric parameters. To predict complex flow field in the presence of shock-boundary layer interaction and heat transfer, 3 D numerical simulation is to be carried out using Computational fluid Dynamics (CFD) Software with wall friction & wall heat transfer. Based on air intake operation condition specified by VSSC for each simulation, boundary conditions and initial conditions are to be generated. Structured multi-block meshing is to be used for grid generation. Simulations are to be carried out converging o grid independence & interaction independence. Post processing includes (a) generation of Control plots & pallets for identified flow parameters at specified locations and (b) computation of specified parameters like mass flow rate, pressure recovery, mass capture ratio, skin friction, heat transfer etc.	
A.5	Sub area	Studies on re-entry
A5.1	**Wing body reentry vehicle optimization studies:** wing body reentry vehicle is a reusable launch vehicle concept to reduce the satellite launch vehicle cost drastically by safely returning the launch vehicle back to earth surface after the satellite/payload insertion is required orbit for re-launch. During reentry, the vehicle has to pass through low density atmosphere to high density atmosphere, High hypersonic Mach number to low subsonic mach number during touch down and it also encounter viscous flow regime and pass through laminar to turbulent flow regimes. The key aerodynamic and aero-thermodynamic design aspects are optimum heat flux, heat load, load factor, less than 4 g deceleration, sufficient payload bay, down range and cross range capability, good longitudinal and lateral – directional aerodynamic stability, adequate control	

	surface effectiveness, reduced TOPS cost. The optimum external aerodynamic design must fulfill the some of important objectives given above. Re-entry module is used for scientific mission, or to bring back astronauts from space back to earth. Re-entry module can be a ballistic/or semi ballistic concept with minimum control. The key aerodynamic and aero thermodynamic parameters are minimizing the maximum heat flux, heat load and 'g' force with optimum stable aerodynamic shape for the purpose. The module must be free from any dynamic stability issues, must have less dispersion in the down range and cross range, both soft landing on land and sea has to be considered within the design.	
A.6	Sub area	Eddy simulation studies
A6.1	Large Eddy Solver – for aerospace application: Large eddy simulations are presently the need of the hour with increased computing power and using parallel computing. LES resolves all the range of large eddies without the use of any turbulence model and it is been used for simple problems so far, but presently publication are available on the application of LES for launch vehicle with jet, aircraft etc… LES compressible solver is to be developed for a generalized grid with high order schemes for convective terms. It can have both full LES and wall modeled LES. The solution acceleration techniques like dual time stepping with multi-grid or other methods can be adopted. The LES is intended to get unsteady data over aerospace vehicle, jet interaction studies, and high angle of attack studies.	
A.6	Sub area	Vehicle analysis and design
A6.1	NS RANS solver development: Navier-stokes RANS solver is used for the design and analysis of aerospace vehicles. The code need to have both implicit and explicit solving capacity and must work in parallel mode using MPI and/or using GPU for faster turn around time. The code must perform comfortably well in both compressible and incompressible regime and must have various schemes like Roe, AUSM+, HLLC, SLAU for convective terms computations. The various established turbulence models like SA, SST, realizable k-epsilon, RNG model must be available for selection. The code must work on generalized grids. Acceleration techniques must be available like multi-grid, dual time stepping,	

	RK methods and accuracy must minimum second order. The solver must have further scope of introducing high temperature effects, combustion model.	
A.7	Sub area	Aerodynamics study
A7.1	Flow visualization Technique: Following flow visualization techniques are to be developed: 1) Qualitative Flowfield visualization: Qualitative flow visualization of nozzle jets interaction using Glow Discharge Method. 2) PIV and stereoscopic PIV: Qualitative and quantitative measurements of flowfield information such as velocity profile/vorticity associated with double delta wing, capturing of streamwise vorticity generation and its strength over RLV like geometries at angles of attack. Lift off jet impingement studies of launch vehicles using PIV. Studies of scramjet flame holding strategies such as cavity flow physics using PIV. Vortex enhanced mixing studies in a typical scramjet combustion chambers.	
A.8	Sub area	Multidisciplinary Study Options
A8.1	Development of a MDO Tool for Aerospace Applications: The aerospace problems are complex and often require interactions among different disciplines. Due to non-linear dependencies of various disciplines, conventional optimization procedures do not result in system optimum. As the name suggests, Multidisciplinary Design Optimization (MDO) involves optimization of the system by coupling two or more disciplines together. For example, structure design software could be NISA software and trajectory design software could be written in Fortran. The MDO tool has to suitably wrap these programs.	
A.9	Sub area	Trajectory design
A9.1	Re-entry Trajectory Design and Analysis of Two Closely Following Bodies with a Possibility of a Break ups: Re-entry trajectory design is complex as large amount of heat has to be dissipated and structural integrity of the body has to be ensured. Design becomes challenging when two bodies closely follow each other. This typically occurs in one of the missions where crew module and cryostage enters the Earth's atmosphere and are in close vicinity. In this TDP, possibility of cryostage breakup during the re-entry is to be analysed. Number of pieces during the break-up are to be evaluated based upon detailed structural analysis of the cryo stage components. The survivability of these pieces and the effect of impact of	

	these pieces on the ongoing crew module is to be assessed.	
A.10	**Sub area:**	**Aerodynamics studies**
A10.1	**Hybrid solution methodology with a combination of Cartesian grid and meshless method for high sped turbulent viscous flow solution from Cartesian mesh:** **Cartesian mesh has tremendous advantage in completed automated grid for complex geometries. However the near wall resolution to obtain skin friction and heat flux is not possible without some special near wall treatment. The solution proposed is to have a mesh less method for near wall solution and standard Cartesian mesh solution away from wall. The starting point is the Cartesian mesh over the geometry. The necessary code for near wall resolution with meshless method to obtain viscous solution is the key research work in this. It should be noted that there is a Cartesian mesh near the wall which can be used to generate points.**	
A.11	**Sub area**	**Aero Design**
A11.1	**Aerodynamic Design and Prediction Methodology of the Grid fins:** **A prediction method has to be developed for the estimation of aerodynamic characteristics of grid fin-body combinations at subsonic to supersonic Mach numbers regime. Aerodynamic effect of depth-to-height ratio, web thickness, web leading edge angle, cell width-to-height ration and various isolated cell shapes has to be studied.**	
A.12	**Sub area**	**Spacecraft trajectories**
A12.1	**Development of analytical tool for low thrust interplanetary mission trajectories:** **Spacecraft trajectories are obtained from the integration of the spacecraft's equations of motions, which contain terms for the external forces that are acting on the spacecraft and for the thrust force. The convergence behavior of trajectory optimization methods depends on an adequate initial guess of the solution, which is often hard to find. An efficient analytical tool can provide with good initial approximation which can reduce exhaustive numerical computation.**	
A13	**Sub Area**	**Space Debris**
A13.1	**Space debris consists of all defunct objects in orbit around earth. These objects are real threat for all space related activities**	

	especially in low earth orbit. This project aimed at setting up experimental set ups in ground lab level simulating space conditions.	
B	Area	**STRUCTURES**
B1	Sub Area	Structural Data Analysis
B1.1	Automated Acoustic Emission Data Analysis Through ANN: AE monitoring is being used for the integrity evaluation of various flight hardware during their proof pressure test for example Titanium Gas Bottles, Aluminium, Maraging steel and 15 CDV6 chambers etc. Implementation of an automated AE monitoring with Neural Network for the Real time integrity evaluation of the hardwares helps in minimizing the AE expertise and speed up analysis. AE criteria based on the values of various AE parameters like amplitude, duration, counts, energy etc. from the test results of similar hardware will be the input for the automated integrity evaluation.	
B.2	Sub area	Noise Filtering
B2.1	Filtering Out Noise From Genuine AE Signature Based on Spectral Content Analysis of Any Other Technique: In AE monitoring differentiating the genuine AE signals from external noises is a big problem for the real time AE monitoring of flight hardwares during pressure and structural tests. This is especially trouble some in case of pneumatic pressurisation. Due to the noise, the initiation of any defects like crack, yield etc. could not be identified during the loading phases. Since some of the noise signals are similar to genuine AE signals, identifying these noise signals in real time is a tedious job. Implementing a criterion for filtering these noises alone based on the combination of different AE parametric values is required for future tests.	
B.3	Sub area	Defects Analysis
B3.1	Monitoring and Assessment of EB Weld of Titanium, Spot Welding of Aluminium Inter-stages Through Acoustic Emission: Real time monitoring of Electron Beam Welding process by using AE Technique enables online detection of weld defects like porosity, lack of fusion in the weld etc. Corrective actions can be taken and weld quality can be maintained.	
B.4	Sub area	Strain Management

B4.1	**Development of Automated/Semi-Automated Method for Strain Measurement Using Photoelastic (Birefringent) coatings:** Photoelastic coating technique has good potential for wholefield strain measurement on prototypes. In a laboratory set up, the Photoelastic fringe orders are manually measured using a reflection polariscope and a digital compensator. In an industrial set up manual reading of fringe orders are not possible. Moreover, due to problems associated with glare and extraneous lighting, using a single circular polarizing sheet over the coating is beneficial. The work envisaged is the development of portable compact equipment based on computerised digital optics capable of whole field strain measurement from photoelastic coating fringe data.	
B.5	Sub area	Stress Measurement
B5.1	**Through Thickness Measurement of Non-Uniform Residual Stresses in Metallic Components:** The current technique of incremental hole drilling technique measures the residual stress to a depth of 2mm only. The development envisaged is the implementation of an accurate method for measuring residual stress through thickness for metallic materials for thickness more than 5 mm with a resolution better than 10 MPA.	
B.6	Sub area	Stress Measurement
B6.1	**Development of an algorithm and codes for Measurement of Non-Uniform Residual Stresses in Composite Components using the method of incremental hole drilling:** The current technique of incremental hole drilling technique measures the residual stress to a depth of 2mm only in metallic materials with analysis methods like integral method. The development envisaged is the implementation of an accurate algorithm including codes for measuring residual stress in composite materials for thickness up to 2 mm with a resolution better than 20 MPa .	
B.7	Sub area	Strain Measurement
B7.1	**Studies on the different aspects of Digital Image Correlation Technique for measurement of displacement and strain:** The state of the art technique of Digital Image Correlation Technique for measurement of displacement and strain makes use of a random pattern painted on the surface. The various aspects like the intensity maps of the pattern, illumination,	

	orientation, curvature of the surface etc affect the accuracy of measurement. The degrees to which these affect the results have to be studied and parameters bench marked. The calculations need to be carried out in polar or cylindrical coordinate systems and required codes developed. The development envisaged is better understanding of the various aspects when the technique is applied in an industrial scenario.	
B.8	**Sub area**	**Structural Analysis**
B8.1	**Development of Digital Holographic Microscope for MEMS Characterization, Deflection and Shape Measurement:** **To characterize the performance and reliability of Micro and Nano Electro Mechanical Systems like sensors, actuators and controls under static and dynamic conditions a robust non-destructive quantitative measurement tool has to be developed. Digital holographic interferometry technique presently used for testing of macro structures is to be adapted to the application in micro and nano structures. Digital holographic microscope, loading fixtures for micro sensors and phase map generator for deformation mapping, 3D profile measurement, micro material property measurement etc. are to be developed and validated by testing of MEMS and NEMS intended for the future ISRO programs.**	
B.9	**Sub area**	**Strain Measurement**
B9.1	**Strain Measurement at High Temperature (800^{O}C and Above) :** **Realisation of a suitable methodology including sensor system and data acquisition/analysis for measurement of strain on space structural components at temperatures higher than 800^{o}C.**	
B.10	**Sub area**	**Structural Analysis**
B10.1	**Semi- analytical approach for the evaluation of acoustic performance of CFRP skinned sandwich panel:** **Acoustic performance of CFRP skinned metallic honeycomb sandwich panels under low frequency were obtained through test using reverberation chamber. Honeycomb cells were embedded with semi-flexible PUF. Comparisons were made for the acoustic attenuation in terms of insertion loss for the rectangular panels with and without PUF. Based on say, LS DYANA obtain a semi analytical approach for the prediction of**	

	attenuation of sandwich panel for variables like skin thickness, core height, density of PUF etc .	
B.11	Sub area	Thermal Studies
B11.1	Thermal characteristics of PUF core sandwich for a temperature range of 600K.	
B.12	Sub area	Stress Measurement
B12.1	Inter laminar shear stress evaluation of bonded structures: To estimate accurately the stresses in the sandwich structures, in particular in the bond between the skin (metallic or FRP laminate skin) and honeycomb core higher order shear deformation theory is followed. Provide the software code that will be useful for studies in related areas.	
B.13	Sub area	Structural Characterization
B13.1	Evaluation of acoustic characteristics Polyamide foam for sandwich application: Honeycomb sandwich panels embedded with Polyimide foam inside the honeycomb cells have been tested for insertion loss (dB) over a range up to 1200 Hz. using reverberation chamber and air pulse tube. For analytical model for a theoretical prediction for insertion loss of the honeycomb sandwich panel, it is necessary to evaluate properties like porosity, sound flow resistivity etc. as per the standard apparatus.	
B.14	Sub area	Sandwich Structures
B14.1	Development of Sandwich Structures With Negative Poisson's Ratio Honeycomb Core: The core with negative Poisson's ratio improves the shear strength and resistance to piercing for the core and keeps inserts more intact in sandwich structures. The geometry of core and skin material/processing provides negative Poisson's effect for the sandwich structures as reported in literature. This will help to increase the load carrying capacity of the sandwich structure.	
B.15	Sub area	Structural Optimization
B15.1	Optimal Shaping of Cut out corners in non-linear range: Launch vehicle structures are optimized for the mass and hence are highly stressed. In this kind of highly stressed structures,	

	rectangular cut outs are commonly used. Hence very high stress concentrations are observed in the cut out corner which is very much local in nature. If not attended properly, this zone can be cause failure initiation and further propagate to a catastrophic failure of launch vehicle. Normally designers overcome this stress concentration problem by giving liberal fillet. Useful size of fillet to overcome the stress concentration blocks the free entry of large object and defeat the purpose for which the cut out is intended. There is no quantification of allowable or safe stress in this type of zones. AJ Durelli, K. Rajaiah etc. has done extensive research in shaping the cut out in the elastic stress range through photo elastic methods. As the material is stressed in the non-linear range in a launch vehicle structure, the shape proposed through this study is inapplicable. The stress in cut out corner is also very much local in nature which is also not considered in the study. Hence there is a need to shape the cut out including fillet considering the stress in the non-linear range and nature of the stress field at the cut out corner. Theoretical determination and experimental validation is expected. The study is expected to arrive at a parametric definition of minimum fillet radius based on geometry of cut out like r/w etc for using it in all sizes of cut outs of different width.	
B.16	**Sub area**	**Composite Structures**
B16.1	**Damage tolerant designs for laminated composite structures used in aerospace structures:** The initiation and propagation of manufacturing induced or service induced damage in the structural design of laminated composites are of primary concern for aerospace structures. The laminated composite wing and fuselage structure with low transverse strength, low inter-laminar shear strength and no plastic deformation are more susceptible to damage growth. A stress based criterion can determine the locations of potential damages followed by fracture analysis to predict the initiation of delamination. Based on suitable failure criterion, the failure is predicted. A thorough understanding is required to predict the multiple complex failure mechanisms in composite structures which are used especially in aerospace industry such as the wing structure. Virtual crack closure technique (VCCT), cohesive zone modelling (CZM) and progressive failure analysis (PFA) are the techniques to predict the failure followed by the experiments to validate the criterion. A series of aerospace materials ranging from the metals to composites has to be tested and predictions	

	through analytical and numerical method have to be carried out for the better understanding for future requirements.	
B.17	**Sub area**	**Inflatable Structures**
B17.1	**Development of Finite Element Software for Inflatable Structures** **For space applications, structural weight should be the minimum possible. At the same time it should serve the purpose for which it is meant. Inflatable structures have become increasingly popular in recent years for a wide range of space applications. An inflatable structure not only has lower weight but also can be folded when it is not in use giving it the advantage of minimum storage space. It can be unfolded to the required size and shape as and when required. Applications of such structures in space applications are solar sail boom, airship, antennas etc.** **The finite element to suit such applications needs special treatment in the formulations. Because the deformations of such structures depend on the applied load, inflation pressure and the constitutive law of fabrics. Beam element and shell elements are widely used finite elements for structural applications. This RESPOND project is proposed for the development of beam and shell finite elements, which can be used for inflatable structural applications.**	
B.18	**Sub area**	**3D Contact Element**
B18.1	**Development of 3-D Contact Element with Friction : The structures which are made for the launch vehicle and other space applications are made of several segments and joined together to give the required shape and size and also meet the design and functional requirements. Structures are made of segments having the flexibility to separate as and when its purpose is served. Two different segments made of same materials and /or of different materials are joined together with bolted/clip joints. When such structures are subjected to loadings the gap between the two bodies either open or close, depending on the nature of the loading. Load is transferred from one body to the other if the gap between the two bodies closes. To study such structures connected with joints contact elements are required.**	

	This RESPOND project is proposed for the development of 3-D contact element with friction for the application for both bodies deformable.	
B.19	**Sub area**	**Slosh Analysis**
B19.1	**Microgravity Slosh Analysis :** **Liquid sloshing dynamics under micro gravity field experiences different problems from those encountered under gravitational field. Gravitational potential has a stabilizing effect, wherein it brings the liquid volume towards the bottom of its container. When this body force diminishes, the liquid volume can assume any location inside its container in an unpredictable manner. This problem causes reorientation of the liquid in its container and pose difficulty in moving and handling, as the body forces are almost negligible. Analysis tools have to be developed for studying the liquid sloshing in low gravity environment.**	
B.20	**Sub area**	**Data Analysis**
B20.1	**Health Monitoring of Structures Using Vibration Data :** **Monitoring the health of a structure subjected to severe dynamic load condition is essential particularly for assessing the reusability of the structure. Health monitoring is a process aimed at providing accurate information concerning the structural condition and performance. It consists of continuous or periodic recording of representative parameters like vibration measurements over short or long duration. The measured responses can be used for assessing the damage of the structure, if any. Damage can be defined as changes introduced in the system that adversely affects its current or future performance. The damage will alter the stiffness, mass or energy dissipation properties of a system, which in turn alter the measured dynamic response of the system. From these vibration measurements, the health of the system can be assessed.** **Damage detection and health monitoring scheme have to be developed for aero- space structures using vibration data. The scheme includes data acquisition, feature extraction and information condensation and statistical discrimination of features for health monitoring of structures.**	

B.21	**Sub area**	**Simulation & Analysis**
B21.1	**Development of Analytical Techniques for the Design of Impact Resistant Structures :** **In the future missions of ISRO like reusable launch vehicles, human space flight, etc., the structural components will be subjected to impact loads during orbital and landing operations. These structures should be designed with highest probability of human, package and critical component survival. Design and analysis methodologies including structural, material and environment modelling needs to be established for effective design of impact resistant structures. Analytical methodologies to assess response of human body and critical packages to impact load needs to be developed.**	
B.22	**Sub area**	**Noise Control**
B22.1	**Active Noise Control for Composite Payload Fairings :** **Acoustic loads are one of the important environments for launch vehicles. The acoustic load transmission into the vehicle, particularly inside the heat shield needs to be attenuated for the proper functioning of satellite. The magnitude of acoustic loads transmitted to the payload is a function of external environment as well as design of payload fairing and its sound absorbing treatments. At present, passive acoustic blanket is used to reduce the internal acoustic field.** **The use of composite payload fairing has the advantage of reducing mass, but it has detrimental effect on acoustic levels inside the payload fairing especially at low frequencies. Passive approaches for acoustic attenuation are limited at low frequency because of sound absorption is limited in low frequencies. Active control offers an attractive approach for low frequency acoustic noise attenuation inside payload fairing.** **The proposed study is to develop structural actuators such as piezoelectric patches for noise control inside composite payload fairing.**	
B.23	**Sub area**	**Spaceflight environment**
B23.1	**Dynamic Modelling and Analysis of Human Body Exposed to**	

	Vibration Environment During Space Flight : **In manned mission, human body may be exposed to various severe environments for a long time. This may be detrimental to life or may cause illness/fatigue to the body. One of the major environments is vibration. Therefore, it is essential to study the influence of vibration on human body and necessary to find solutions to prevent such environment. To understand the effect of vibration on human body, it is required to generate three-dimensional dynamic model of the human body and carryout dynamic analysis for human biomechanical responses. The human body shall be idealized using beam, spring and mass elements to represent the various dynamics of the body. The model needs to be validated with the available literature / test results.**	
B.24	**Sub area**	**Vibration Isolators**
B24.1	**Development and Realization of Shock and Vibration Isolation System for Payloads:** **The payload experiences severe vibration loads during launch, which may result in its malfunctioning. To avoid this, an isolation system for shock and vibration has to be introduced for payloads. Reduction of vibration and shock loads on spacecraft during launch would significantly minimize the damage of the spacecraft and its instruments. It will also allow more sensitive equipment to be included in the missions. Moreover, as the launch environments are severe, it requires much of expertise in designing, qualifying and testing of spacecraft components. Introduction of an efficient isolation system would greatly reduce the cost for the development of the spacecraft. Thus an isolation system needs to be developed to isolate the spacecraft from the dynamic loads from the launch vehicle.**	
B.25	**Sub area**	**Vibration Noise**
B25.1	**Development of a Noise-cancelling Headphone Using Active Noise Control :** **Noise cancelling headphones reduce unwanted ambient sound or acoustic noise using active noise control (ANC). This involves using a microphone placed near the ear, a signal processing circuitry which generates antinoise so that the noise within the**	

	enclosed volume is cancelled. This is useful for an operator working in noisy environment such as vibration test facility, machine floor etc. The cancellation may be achieved using filtered X-LMS algorithm using some DSP processor. The minimum requirement of sampling is 12KHz with cut-off frequency of 5KHz. The required reduction is 40dB in the band of 100Hz to 2000Hz. The system should operate in battery and the electronics should be miniaturized and kept inside the headphone.	
B.26	Sub area	Vibration Testing
B26.1	Control Algorithm for Multi Axial Vibration Testing : Vibration testing is done to ensure that the flight structures and system will work satisfactorily in its service environment. In conventional vibration testing the vibration in each axis is separately simulated using single axis shakers using vibration controllers. But to simulate the actual vibration condition in flight, techniques to be developed to excite the structure in all the three axes simultaneously using three shakers in mutually perpendicular axes. For this a special vibration controller to control all the three shakers is required. The proposed work is to develop the control algorithms for sine and random multi shaker vibration testing. All the required algorithms have to be developed, implemented with suitable DSPs (Digital Signal Processor) and tested.	
B.27	Sub area	Data Compression Technique
B27.1	Data Compression Technique for Vibration Signals : The measured vibration signals from launch vehicle flights contain high frequency signals upto 2000 Hz. In order to telemeter these signals to ground during flight high bit rate is required. Typically for a measurement with 8 bit data resolution with a sampling rate of 6000 samples /second, it works out as 48 kbits/second per channel. In a typical launch vehicle flight around 10 channels of vibration measurements are made which requires a telemetry bit rate of 480 kbits /second. the bit rate for the typical launch vehicle is only 1 megabit/second. Hence suitable data compression techniques are required to reduce the telemetry bit rate.	

B.28	**Sub area**	**Structural Analysis**
B28.1	**Spectrum Analysis Technique Using Maximum Entropy Method :** **Formulation for the power spectral density estimation of vibration signals are measured during launch vehicle flight using maximum entropy method. This method overcomes the limitations of the FFT based methods for short length and time varying vibration signals measured during the atmospheric flight of launch vehicles and transient vibration signal measured during stage separation, ignition and shut-off of rocket engines.**	
B.29	**Sub area**	**Propellant Studies**
B29.1	**Visco-elastic Structural Analysis of Solid Propellant Grains in the Presence of Voids: Solid rocket systems are used extensively in situations where the total impulse is known in advance and restart is not required. Structurally, a rocket motor consists of the solid propellant grain, liner, insulation, motor case and the igniter. Solid propellant grains are strained / stressed due to thermal, gravitational, flight acceleration and ignition pressure loads. The structural response of the propellant grain in the presence of voids / porosity disrupt the stress/strain field.** **It is essential to examine the criticality of voids in solid propellant motor grains based on structural as well as ballistic and thermal considerations. A detailed viscoelastic solid propellant grain analysis in the presence of different void shapes and sizes is to be carried out for storage, thermal and ignition pressurization loading conditions for the development of an acceptance criterion. A methodology has to be established to model the void and examine its deformation criticality through finite element analysis**	
B.30	**Sub area**	**Fracture Studies**
B30.1	**Development of Constitutive Equations for Nano Composites :** **Constitutive equations have to be developed for composites containing both functionalised and non-functionalised nanotubes using continuum modelling technique. The elastic properties of both composite systems amorphous and crystalline polymer matrices with various nanotube lengths (continuous / short discontinuous), volume fractions and orientations are to be evaluated.**	
B.31	**Sub area**	**Structural Health Monitoring**

B31.1	**Fracture Studies on Textile Composites :** **Textile Composites are being used in the aerospace industries, specifically in the areas of impact resistant structures and hot structures. The increased use of these materials calls for the proper understanding of their fatigue behaviour. To ascertain the endurance of structural components made of Textile composites, fatigue and fracture studies on materials and structures are essential. A suitable method to perform the progressive fiber/matrix failure analysis has to be established in the presence/absence of defects useful for life estimation.**	
B.32	**Sub area**	**Structural Health Monitoring**
B32.1	**Structural Health Monitoring Through Classification of Strain Patterns Using Artificial Neural Network: Structural health monitoring technology has become an important approach to increase the safety and reduce the maintenance costs of high performance composite structures used in aircraft and re-entry vehicles.** **There is a requirement to develop the tools to detect damages such as fiber failure, matrix cracking, de-laminations, skin-stiffener de-bonds in composite structures. Neural network is one of the tools. Tool will be used to classify sensor malfunctioning and structural failure(s) based on the observed static strain patterns of the healthy and unhealthy structures. Analytical and experimental studies have to be made to validate the adopted methodology.**	
C	**Area**	**CONTROL,GUIDANCE & SIMULATON**
C.1	**Sub area**	**Control System**
C1.1	**Development of Control algorithms for autonomous mobile robotic manipulator** **The research proposal is for developing advanced control algorithms for an *autonomous mobile robotic manipulator* which consists of a six degree of freedom (6 DOF) robotic manipulator mounted over a four wheel mobile robot with the wheels having independent drive and steering control. Conventional control, and intelligent control shall be hybridized to develop a hierarchical control and vision-based control for robots.** **The control algorithm provides *dynamic coordination* of manipulator arm joints and mobile robot wheel drives to execute precision tasks in unstructured environments using multiple sensor feedback. With the development of *multilayered control***	

	***architecture*, the robot should be able to automatically compute its motions from the high level description of tasks. The proposed R&D also aims to develop algorithms for *Simultaneous Localization and Mapping* for the navigation and locomotion of mobile robot.**	
C2	**Sub area**	**Control & Guidance**
C2.1	**Rendezvous and docking** **To achieve docking during the final phase of the mission, the relative position and velocity of the target spacecraft and chaser spacecraft has to be brought to zero. To ensure proper alignment of the docking port, the relative angular orientation needs to be precisely aligned. Moreover, relative angular rate of the target and chaser are to be very close to zero for successful docking. Simultaneous control of the translational and rotational dynamics is required to achieve the docking conditions.**	
C3	**Sub area**	**Simulation**
C3.1	**Multi-body Dynamics Simulator** **Launch vehicle simulations require solving multi-body dynamics for addressing scenarios such as space transportation missions, crew module ejection, stage separation, booster/strap-on separation, satellite separation etc. All individual bodies having its own inertial systems and are bound to possess independent mass-inertia characteristics, propulsion systems, aerodynamic properties, guidance and control algorithms, control power plants etc. Simultaneous solving of translational and rotational dynamics for each body (during ascent and descent phase) is required with real-time plotting of trajectory parameters and other critical states. Software model can follow modular or component architecture where by system modules can be plugged in and used as required.**	
D	**Area**	**Materials and Mechanical Systems**
D.1	**Sub area**	**Materials Characterization**
D1.1	**Study of fracture under explosive conditions of 17-4 PH stainless steel in different heat treatment conditions:** **17-4 PH stainless steel is used for separation systems in which**	

	the steel has to get severed by use of an explosive. Heat treatment condition determines whether the material will get cut or not. Correlation of heat treatment to behaviour under explosive is to be done.	
D.2	Sub area	Cryogenic applications
D2.1	Development of solders for use in cryogenic applications Most of the conventional solders which are tin based become brittle at cryogenic temperatures. For cryogenic applications it is necessary to design alloys with good soldering characteristics and also having ductility at cryo temperatures.	
D.3	Sub area	Study of defects
D3.1	Defect formation in steel and aluminium welds – effect of process parameters. Identifying root cause for formation of defects during welding of high strength steels, stainless steels, aluminium alloys being used in ISRO.	
D.4	Sub area	Fibre Reinforced Composites
D4.1	Development of Process Technology to coat SiC chopped fibres with BN and Carbon: Sic fiber reinforced composites are suitable candidates for thermo-structural components of reusable launch vehicles and air breathing engines. In order to maintain the integrity of the composite for a longer duration under loading these fibres need to have suitable coating before incorporating intro the matrix. In addition reinforcing the coated fiber leads to proper adhension aids in stress release. Thus the proposed work serves a base to develop fiber reinforced composites for various thermo-structural applications.	
D.5	Sub area	Microstructure evaluation
D5.1	Microstructure and Micro texture evaluation in Age hardenable Aluminium Alloys: A variety of age hardenable aluminium alloys are used in the launch vehicles and satellites of Indian space programmes. These alloys are subjected to a number of thermo mechanical processes to get the final shape and put in service. This introduces varying textures and microstructures which influence the performance of these materials in service. Scope of the project is to study the microstructure and micro-texture as a function of the process parameters and to identify their influence on the performance of these alloys.	

D.6	**Sub area**	**Study on Al-Li alloy**
D6.1	**Inplane and Through thickness anisotropy in Li containing Aluminium Alloys:** **Al Li alloys are known to possess inplane and through thickness anisotropy which make it difficult for designers to effectively utilise them in structural applications. The scope of the study include inplane and through thickness anisotropy properties like tensile strength and fracture toughness and suggest measures to minimise it.**	
D.7	**Sub area**	**Characterisation of Al-Li alloys**
D7.1	**Submicrostructure characterisation of Al-Li alloys:** **Al Li alloys are being developed as a potential candidate for the future propellant tankages and structural material for the launch vehicles and satellites. These alloys are strengthened by T1 precipitates which need to be uniformly distributed throughout the matrix avoiding the sub grain boundaries for optimum cryogenic properties. The scope of the work is to evaluate the sub microstructures under different thermo mechanical treatments using TEM and EBSD to optimise mechanical properties.**	
D.8	**Sub area**	**Materials charecterisation**
D8.1	**Development of Processing Maps for High Temperature Aerospace alloys:** **High temperature materials are being developed or the futuristic launch vehicles like RLV, TSTO, SSTO, HSP missions of ISRO. High temperature deformation processing of these materials is complex and posses many challenges to manufacturers. The scope of the work include development of flow stress data as a function of strain, strain rate and temperature for these materials as well as processing maps useful for the identification of flow instabilities.**	
D.9	**Sub area**	**Analysis of weld bead**
D9.1	**Analysis of weld bead instability in the overlap zone of keyhole electron beam welds:** **Keyhole electron beam welding is being carried out for circumferential joints in the liner and gas bottle made out of Titanium alloy (Ti6Al4V). An underfill is found to occur in the run-out zone of the overlap region. In the run-out area, already**	

	formed root reinforcement will be ejected and replaced as long as transmitted power is capable to do so. A little consideration would show that ejection of root reinforcement will stop as a function of transmitted power and hence there present a zone of underfill, where due to power transition instability ejected root reinforcement will remain as it is. Localized bead depression often exceeds acceptance level as specified by AMS2680. The problem is due to thermal overloads. Variable parameters are beam current, focus current and travel speed and the fixed parameters are work distance and acceleration voltage. A study is proposed to analyze the thermal effects in the overlap area so as to predict the conditions that avoids the cited effects.	
D.10	**Sub area**	**Friction stir welding**
D10.1	**Development of coating/manufacturing technology for friction stir welding tool for welding of 3mm thick stainless steel sheets:** **Friction stir welding of Aluminium alloys is handy in terms of tool material and expected axial and feed forces. Vital part in this technology being tool development, for carrying out friction stir welding of materials like steel / titanium, appropriate tools are to be looked into. Hardened tool-steels with proper coating to withstand service temperatures up to 700^0C and also that will not form compounds / intermetallics with the material to be welded are to be developed and studied.**	
D.11	**Sub area**	**Ceramic matrix composites**
D11.1	**Evaluation of Ceramic matrix composites based on SiC and ZrB_2 for behaviour under water vapour containing environments at high temperatures and development of suitable coatings to improve the performance.**	
D.12	**Sub area**	**Ceramics for electromagnetic applications**
D12.1	**Simulation, Modelling and Design of UHF, L and S band Antenna in 2D EBG structures with high – permittivity (k>60) low-loss (<0.001) ceramics. Purpose:- Generally, low-k substrates are preferred for antenna applications due to less confinement and surface wave effects. However, for UHF, L and S bands, the size reduction is possible only with high-k substrates, which have surface wave effects that limits the Performance of antenna. EBG concept can be very effectively applied to design 2D periodic dielectric structures that at small in size as well as don't have surface wave.**	

D.13	**Sub area**	**Study on Al alloy**
D13.1	**Studies on delayed cracking phenomena on High strength Aluminium alloys using fracture mechanics:** **High strength aluminum alloys such as AA7075 and AA2219 are widely used in the aerospace industries due to its high strength, light weight, fabricability etc. However, they are prone to stress corrosion cracking (SCC) failures especially in marine environment containing chlorides. Although several studies were carried out and reported in the literature, understanding the variations in microstructure and its crack growth characteristics especially in the case of forgings is needed. The above topic envisages to understand the crack growth rate with respect to microstructure using fracture mechanics concept.**	
D.14	**Sub area**	**Oxidation behaviour of alloys**
D14.1	**Oxidation behaviour of advanced high temperature coatings for super alloys and Ti-based intermetallic alloys:** **Intermetallics such as Gamma TiAl and super alloys are considered as good candidate alloys for high temperature applications due to several advantages. However, these alloys can be used at high temperature with good coatings covering bond coat along with TBC ceramic coatings. Although several coatings were developed and published in the literature, still the coatings couldnot protect the base alloys especially at high temperature. Currently, application of coatings based on methods such as magnetron sputtering, EB-PVD and HVOF are reported to provide good bonding and oxidation resistance along with intermediate coatings using variations in surface preparation,anodizing etc. Hence the above topic involves developing a superior oxidation resistant coating and understanding the mechanism of oxidation and scale growth using TGA and extensive surface analysis studies.**	
D.15	**Sub area**	**Corrosion protection**
D15.1	**Development of nano composite coatings for corrosion protection of light alloys such as Aluminium and Magnesium:** **Aluminum and magnesium alloys are widely used in the aerospace industries due to light weight and other properties. However, they are prone to corrosion in the environment containing chlorides. Hence these alloys are mostly used in coated conditions covering single and multiple layered coatings of epoxy and polyurethane. Currently nano composite coatings**	

	are reported to show good barrier corrosion properties and hence show more advantages than the traditional coatings. Hence the above work is aimed to develop dispersion of nano particles in the above coatings and to study their performance using polarization, impedance and other surface characterization techniques to understand their prospective mechanisms against corrosion	
E.	**Area**	**COMPOSITES**
E.1	**Sub area**	**Structural health monitoring**
E1.1	**Structural Health Monitoring of Composite Structures using Optical fibres with Bragg Grating sensors:Optical fibres with Bragg Grating sensors are the leading candidate technology for Structural Health Monitoring (SHM) since they have minimal mass penalty for extremely large numbers of sensors. There are many advantages like compatibility with the composites, low Electro Magnetic Interference (EMI), multiple sensing capabilities with a single fibre etc. This sensor technology will be highly useful in present as well as our future launch vehicle applications.** **Scope:** · **Supply of optical fibres with Fibre Bragg Grating (FBG) *sensors* inscribed at required locations** · **Support for embedment/surface bonding of sensors for subsurface/surface strain monitoring of composite components** · **Demonstration of strain and temperature sensing with data recording in a computer on specimen and component levels** · **Development of interrogation techniques for multiple Fibre Bragg Grating sensors embedded in a single fibre**	
E.2	**Sub area**	**Piezoelectric actuators**
E2.1	**Piezoelectric actuators for position control applications:** **Piezoelectric materials produce voltage when stress is applied. This effect is also reversible in manner, i.e. a voltage across the sample will produce stress within the sample. Because of this reversible property, piezoelectric materials can act both as sensor as well as actuator.Piezoelectric actuation can be used in precision (small strain, fast response time) applications. One application envisaged is the precision position control of mirrors used in optical structures of satellites.**	

	Procurement and characterization of Piezoelectric actuation capability of piezo stack actuators and Macro Fibre Composite (MFC). MFC is a specific configuration of piezo electric patch where the patch is flexible and can be bonded over curved structures. Development and demonstration of closed loop control algorithm for precise position control of an object mounted over a tubular composite tripod structure.	
E.3	**Sub area**	**Development of Miniature Specimen**
E3.1	**Development of Miniature Specimen Test Techniques:** Miniature specimen test techniques enable the evaluation of mechanical properties using extremely small volume of the material. For characterization of C/C composites and CNT based composites this method is to be adopted considering the cost involved in the realization of specimens The reliability and accuracy of the parameters obtained by different miniature specimen test methods are established by modelling them. Finite Element analysis is used to convert the experimental load- deflection curves into stress-strain information, which in turn gives information on ductility, strength etc., (Data Inversion Technique). A complete simulation of these test techniques using finite-element modelling (FEM) helps to improve the accuracy and demonstrate the validity of these test methodologies.	
E.4	**Sub area**	**Charecterisation of C-C Composites**
E4.1	**An Inelastic Finite Element Model of Multidirectional Carbon-Carbon Composites to predict the material characteristics and behaviours.** Multidirectional C-C composites (3D, 4D) are composite material wherein the reinforcing fibres act as reinforcement at various directions. 4D C-C composites has found successful applications in solid rocket nozzles especially as ITE's. The material behaviour of nD C-C composites are highly anisotropic and shows nonlinear elastic behaviour. Most of the work carried to assess the behaviour of multidirectional C-C composites is evaluated through destructive testing, hence limited data is generated for the mechanical properties. In this context few works are carried (especially by SAFRAN group) to theoretically predict the mechanical behaviour of the material and corresponding material properties associated with this class of	

	material. Since at VSSC, nD C-C composites are envisaged to have application as SRM throat inserts and also as TPS material for certain applications, it is essential to initiate the micromechanical model studies to theoretically predict the material behaviour vis-a-vis the mechanical properties. An elastoplastic finite element model, including homogenised mono-axial stiffness can predict the material properties as has been referred in many literatures. Presently available tested material properties can further aid to verify the model if developed for such studies.	
E.5	**Sub area**	**Fabrication of thinner Carbon-Carbon composites**
E5.1	**Mathematical model of Interaction of gas phase with carbon preform during Isothermal CVI process.** **One of the most promising and common methods of fabrication of thinner Carbon-Carbon composites is through vapor phase densification of porous structure of carbon fibers acting as reinforcement. During CVI process, the vapors of the hydrocarbon namely methane, propane etc decomposes to produce the desired carbon matrix within the pores of the preform and thereby increases the density. The density aimed after the final densification is based on the targeted mechanical and thermal properties required for the specific use of application of the product. Practically, the major hindrance of realisation of C-C products through CVI process is the long processing duration required to achieve the desired density. Furthermore the process must be intermediately interrupted to permit surface machining or heat treatment at high temperature in order to open the pores for further densification. Under this consideration, a comprehensive numerical modelling is essential to optimise the processing parameters to achieve the required density and also to reduce the long process duration.**	
E.6	**Sub area**	**Modelling and study of large antenna**
E6.1	**Geometric, Kinematic and Finite Element Modelling of Large Deployable/ Inflatable/Unfurlable Structures in space :** **Large antenna reflectors and other structures are being used in increasing numbers for satellite applications. The sizes range from dia.5.0m and upwards to 20.0m.During Launch phase these reflectors will be stowed so that launch envelope interfaces requirements are not violated. In space these structures get deployed by suitable mechanism of energy release like inflatables, Unfurlable , Unfoldables etc.**	

	A suitable model need to be developed (a) To capture Geometry of these structures in space (0g condition) and in ground(1g condition) (b)To capture and model the kinematics of the members /linkages involved and (c)Finite element modeling of the structure to capture its dynamic, Static and Thermal distortion behaviour under space conditions.	
E.7	**Sub area**	**Composite process modeling**
E7.1	**Composite process modeling – to capture warpage, shrinkage ,spring back, and other moisture/curing induced deformations of Autoclave Cured - Prepreg based Fibre Reinforced Composites.** **Composite products for satellite structure applications are mostly realised by Autoclave curing Processes. The prepreg lay up is completed on a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of 175^{0}c.The product is cooled to room temperature before extracted. The high temperature curing and the cool down back to room temperature induces curing stresses in the composite part. After extraction from the tooling these stresses along with the inherent anisotropy of the composite manifest itself in the form of warpage/shrinkage ,spring back and other deformations of the composite part. A detailed model need to be worked out to capture and predict such behaviour - especially for regular geometries like Flat , Conical, Paraboloid , C shaped , L shaped & Tubular sections (round/square/ rectangular cross sections)- considering anisotorpy of the composite as well.**	
E.8	**Sub area**	**Study of defects in composites**
E8.1	**Study to parameterized the effect of defects (determinations ,de-bounce, voids, fiber separation etc.) and cut outs on strength and Stiffness properties of sandwich and laminate composites: Composite products are widely being used for satellite structural applications. The type of constructions range from laminate, stiffened laminate , Monocoque and sandwich. These products are autoclave cured and realized using prepregs. These composite parts are prone to defects during handling/movement between various work stations or due to processing. Also many a time cut outs are to be provided on these composite parts for various mechanical requirements. A study need to carried out to parameters(in terms of location , geometry and size) the effect of these defects/ cut outs on the stiffness and strength of sandwich and laminate composites.**	

E.9	**Sub area**	**Processing of composites**
E9.1	**Out of Autoclave Processing of Prepreg based fibres Reinforced Composites:** **Conventionally composite products for satellite structure applications are realised by Autoclave curing Processes. The prepreg layup is completed on a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of 175^{0}c.The inherent disadvantage of this process is the likely curing stresses induced in the composite part. A suitable process need to be developed in which curing can be done outside autoclave by Developing prepregs based on resins which can cure under UV light or using conventional prepregs but curing outside autoclaves using more energy efficient methods.**	
E.10	**Subarea**	**Characterisation of composites**
E10.1	**Effect of various curing parameters and procedures, tooling to composite interaction on the properties of sandwich and laminate composites:** **Composite products for satellite structure applications are mostly realised by Autoclave curing Processes. The prepreg lay up is completed on a tool/mould under room temperature conditions. The curing is completed under higher temperatures of the order of 175^{0}c.The product is cooled to room temperature before extracted. Various curing parameters like temperature, pressure, vacuum rate of heating/cooling ,various procedures being followed for monitoring and controlling these parameters .Tooling to composite interaction type of release medium used type of breather/bleeder material used , extent to resin bleed out etc. critically affects the properties of the realized composite part (sandwich and laminated composites). A study need to be carried out to characterise the influence of these factors on the properties of these composite parts.**	
E.11	**Sub area**	**Analysis on damages**
E11.1	**Damage tolerant analysis of composite structures especially with debond/delamination:**	
E.12	**Sub area**	**Structural response of CFRP**
E12.1	**Structural response on CFRP structures due to acoustic load in the low frequency domain:**	

E.13	**Sub area**	**Study for the impregnation**
E13.1	**Parametric study for the impregnation of 2D/3D preforms by RTM/RIM method:**	
E.14	**Sub area**	**Composite structures**
E14.1	**Fracture based design model of composite structures/pressure vessels:**	
E.15	**Sub area**	**Hot structures**
E15.1	**Stress free joints for hot structures:**	
E.16	**Sub area:**	**Nanometric assessment of composite structures**
E16.1	**Nano meter level measurement setup with all associated analytical software and hardware fully integrated, meant for specimen level as well as assembly level evaluation of the payload and camera structure:** **An increasing demand for high-quality, low cost Earth imagery has led to the requirement for improved structural stability of the satellite instruments providing the imagery. This translates into camera structures capable of maintaining very high levels of dimensional stability order of few micron (<10μ) for a length of 1m over their lifetime. CFRP[1] have emerged as one of the best materials for dimensionally stable space structures. The "theoretical" zero CTE[2] is only approximated as well as the manufacturing precision allows. So in ultra stable structure where micron level dimensional stability is required, there is an obvious need for quantitative assessment of the magnitude of change in dimensions. We are in need of a nano meter level measurement setup with all associated analytical software and hardware fully integrated, meant for specimen level as well as assembly level evaluation of the payload and camera structure.**	
F	**Area**	**PROPELLANTS, POLYMERS & CHEMICALS**
F.1	**Sub area**	**H2O2 based Propellants**
F1.1	**Development of Hydrogen Peroxide Based Propellant Systems:** **Hydrogen peroxide based propellant systems (monopropellant and bipropellant with RP1) have several advantages over conventional liquid propellants. However, this requires (i) development of 98% H_2O_2 (ii) development of method for safe storage of 98% H_2O_2 which involves development of suitable stabilizers (iii) development of suitable catalyst for**	

	decomposition of H_2O_2.	
F.2	Sub area	Thermoplastic Elastometers
F2.1	Development of Thermoplastic Elastometers for LCVG for Space Suit: Liquid Cooling & Ventilation Garment (LCVG) of space suit requires a "wicking material" which allows one-way water transport. Material usually used is a block copolymer based on polyethylene oxide (PEO) soft segment and Polyether-ester block amide (PEBA) hard segment. The polymer should have high tear strength, toughness and water vapour transmission.	
F.3	Sub area	Polymers for satellite application
F3.1	Development of Addition Curing Silicone Binder Resin Systems Along With Its Catalyst: These polymers are used for thermal paints for satellite components. The proposal involves indigenous development of silicone polymers with pendant hydrosilyl (-SiH) and vinyl groups and suitable platinum catalyst soluble in these silicone polymers.	
F.4	Sub area	Solid Rocket Propellants
F4.1	Development of Software for Modeling/Simulation of Mechanical/Ballistic Properties of Solid Rocket Propellants: Objective is to develop a code/software to accurately predict the mechanical properties and burn rate of HTPB-Al-AP based composite solid propellant. This may be effected in two phases:- Phase I: In this phase the concept and general framework of a modelling/simulation code for the propellant should be established. Phase II: In this phase a working code containing a full graphical user interface (GUI) and capable of running on a multi-processor platform should be provided. The code should predict the mechanical properties of the propellant and burn rate at a given pressure with a minimum of empirical correlations.	
F.5	Sub area	Fuel Cells for space applications
F5.1	Simulation & Analysis of Different Humidification Methods for Hydrogen and Oxygen Gases with Regard to Space Applications of Fuel Cells:	

	The proposal involves simulation & analysis of different humidification methods for hydrogen and oxygen gases with reference to flow rates, dew point, size, weight and power requirement in microgravity environment. Methods for using product heat and water for humidification are also to be analysed.	
F.6	Sub area	Fuel Cells for space applications
F6.1	Analysis of Different Gas-Water Separation Techniques for Oxygen and Hydrogen Gases with Regard to Space Applications of Fuel Cells: The proposal aims at analysis of different techniques for separation of liquid water from exhaust hydrogen and oxygen gases at variable flow rate in microgravity environment	
F.7	Sub area	PEM based fuel cells
F7.1	Study of Water Permeation Characteristics of Fuel Cell Proton Exchange Membrane Under Different Operating Conditions: Optimum water balance across PEM is crucial in getting required performance from PEM type fuel cells. Balancing of electro-osmotic drag and back-diffusion of water provides the required optimum water balance. The proposal aims at study of the influence of various parameters such as membrane type, membrane thickness, temperature, stack clamp force, saturation level, etc on the water balance of PEM fuel cells.	
F.8	Sub area	Fuel Cell modelling
F8.1	Developing a Model for Bipolar Plate to Optimise the Gas Flow Field with Regard to Water management and Current Distribution: Fuel cell performance is controlled mainly by bipolar plate flow field geometry. A reliable model enables faster design fine tuning and scale-up. The proposal aims at development of a reliable model.	
F.9	Sub area	Human Space Flight Programme
F9.1	Ceramic Supported Lithium Hydroxide (LiOH) For Human Space Flight Programme: Lithium hydroxide is useful for the removal of carbon dioxide produced by human metabolism in the crew cabin of a manned spacecraft. For efficient absorption of carbon dioxide, surface	

	area of LiOH particles should be maximum. This can be achieved by supporting LiOH particles on a highly porous ceramic material.	
F.10	**Sub area**	**High Energy High Density Propellant Fuel**
F10.1	**Development of Cubane and Substituted Cubanes for High Energy High Density Propellant Fuel for Rocket Applications:** **Positive heat of formation of cubane and substituted cubanes and their high density render them potential candidates for fuels for semi-cryo engines. Considerable improvement in specific impulse has been predicted for these fuels in comparison with RP-1 type hydrocarbon fuels. However, their syntheses in required quantities and propellant formulation are challenging tasks.**	
F.11	**Sub area**	**Mars exploration**
F11.1	**Development of Catalysts for Splitting of Carbon Dioxide:** **Atmosphere of Mars is reported to comprise mainly (95%) of carbon dioxide. It is suggested that oxygen for propulsion (for return flight to Earth) can be produced in Mars by catalytic splitting of carbon dioxide into carbon monoxide and oxygen. Another method is to reduce carbon dioxide using hydrogen (transported from Earth) to produce oxygen and methane. Development of catalysts for these reactions and optimisation of reaction conditions will go a long way in realizing Mars explorations.**	
F.12	**Sub area**	**Synthesis of solid propellant**
F12.1	**Synthesis and scale up of Energetic Nitrate Binders for Solid Propellants: Scope:** **Synthesis, characterization and scale up in 5 Kg batches for use at VSSC. Evaluation of the binders will be done at VSSC. Eg:- polyglycidyl nitrate(PGN) and Poly vinyl Nitrate(PVN).**	
F.13	**Sub area**	**Polymerisation**
F13.1	**Modelling of polymerization reactors:** **This is intended to develop mathematical models for polymerization reactions of polydimethylsiloxane, phenol formaldehyde and hydroxyterminated polybutadiene systems using advanced software programs.**	

F.14	**Sub area**	**Nano-ceramics**
F14.1	**Modelling of polymer derived nanoceramics:** **Most of the inorganic materials synthesized from polymer thermolysis retain amorphous structure upto 2000℃. Structural characterization of these materials at atomic level is required to achieve better understanding of their properties. Using structural modeling and computational studies details of atomic structure can be obtained which will further enable meaningful interpretation of experimental data. Generally Continuous random networks with well defined local coordination of all atoms are considered for molecular dynamics simulations to locate the minimum energy structures. These structures are further subjected to optimization and annealing scheme using DFT methods as implemented in Vienna ab initio Package (VASP) to get improved structural features.**	
F.15	**Sub area**	**Characterisation of Nano Ceramics**
F15.1	**Advanced characterization techniques for polymer derived nanoceramics:** **Scope: Preceramic polymers usually organometallic compounds are the precursors for the fabrication of advanced ceramics. They possess high temperature properties such as thermo-oxidative stability, radiation resistance, fire resistance, chemical inertness and resistance to free radical cleavage which make them suitable precursor materials for high temperature applications. Organometallic precursor molecules provide a novel path for controlling composition, homogeneity, atomic distribution and microstructure of the ceramic materials. Microstructural characterization of these ceramics require in depth understanding about the bonding of the constituent elements in the preceramic polymer. Advanced characterization techniques for polymer derived ceramics include High-resolution transmission electron microscopy (HRTEM), field emission scanning electron microscope (FESEM), high temperature TGA upto 2400℃ under inert atmosphere, electron**	

	energy loss spectroscopy (EELS), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, nanoindentation and high temperature XRD.	
G.1	Area	**AVIONICS**
G1.1	Sub area	Three phase motor driver
G1.2	Direct Approach of generation for three phase motor driver by multi level inverter with reduced computational complexity: This is a direct method for the generation of Space Vector Pulse Width Modulation (SVPWM) for any general *n-level* inverter. This method directly determines the switching states and coordinates of the switching vectors from the instantaneous amplitudes of the three phase reference signals. These direct relations emerge as a consequence of representing the reference vectors and switching vectors in the sixty degree coordinate framework. This also avoids fractional values as coordinates of the switching vectors. In this work a method is also proposed to compute the duration of the gating signals directly from the switching vectors without any mapping. The proposed method does not need any sector identification and can be used for any general *n-level* inverter.	
G.2	Sub area	ASIC Technology
G2.1	Custom ASIC design of asynchronous RISC processor: As the ASIC technology scaling continues, the effect of leakage and dynamic power consumption of the CMOS gets more consideration. Moreover the clock requirement for the new designs goes on increasing although the majority of the internal logic does not clock in the same speed. In such scenarios, the use of asynchronous circuit design gains importance.	
G.3	Sub area	Floating Point Unit
G3.1	Pipelined IEEE 754/ IEEE 854 compliant Floating Point Unit : The FPU should capable of handling Single precision, double precision and Quad precision floating point numbers. It should be complaint to both IEEE 754 and IEEE 854. The pipeline feature is intented for high throughput computations which eliminates the pipeline processor stalls. It should handle all the special numbers specified in the standard and also generate the specified exceptions.	

G.4	**Sub area**	**Mixed Signal ASIC**
G4.1	**Mixed signal ASIC:** **A mixed signal IC combines analog and digital circuits on a single die. The analog portion involves ADCs, amplifiers, voltage reference and multiplexers, which are used to receive signals from the real world and convert them for interfacing with the digital logic in the IC. The digital logic usually consists of a microcontroller, which operates on the digital inputs and provides control outputs. The control outputs are fed to a DAC to obtain analog signals which complete the feedback loop. The microcontroller has internal memories and standard serial interfaces.**	
G.5	**Sub area**	**Indigenous FPGA**
G5.1	**Indigenous FPGA:** **Due to the embargo issues it is required to design an Indigenous anti fuse FPGA in-house for the future ISRO missions. The design involves the following steps.** **Universal logic cell design** **Creating synthesis library** **Programmable interconnect design** **Modeling programmable interconnect** **Place and route software tool development** **FPGA fabrication** **FPGA programmer hardware and software development**	
G.6	**Sub area**	**On-board Computer**
G6.1	**Indigenous on-board computer VIKRAM1601 hardware accurate software model:** **A faster hardware accurate software models for VIKRAM1601 is required for plugging into checkout systems for doing software validation (SIP) of integrated flight software. This eliminates the requirement of hardware packages during software testing.**	
G.7	**Sub area**	**MEMS Acoustic Sensor**
G7.1	**Design, fabrication, testing and realization of a MEMS Acoustic Sensor:** **This project aims to realize a MEMS acoustic sensor. The**	

	deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are: • Structure : Bulk-micromachined • Sensing technology : Piezoelectric • Range : 100dB – 180dB Sound Pressure Level (SPL) • Frequency response : Within ±2dB over 20Hz to 8kHz • Linearity : ±1dB • Operating temperature: -55 to +125℃	
G.8	Sub area	MEMS Accelerometer
G8.1	Design, fabrication, testing and realization of a capacitive, MEMS Accelerometer: This project aims to realize a MEMS accelerometer. The deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are: • Structure : Surface-micromachined • Sensing technology : Capacitive • Range : 5g • Frequency response : DC-200Hz • Linearity : < ±1% • Control : Closed loop • Operating temperature: -55 to +125℃	
G.9	Sub area	MEMS Shock Sensor
G9.1	Design, fabrication, testing and realization of a MEMS Shock sensor: This project aims to realize a MEMS Shock sensor. The deliverables are realization of design, usage and optimization of processing technology, fabrication of functional devices, packaging and testing with requisite signal processing electronics. Specifications of the sensor are: • Structure : Bulk/Surface-micromachined	

	• Sensing technology : Piezoresistive • Range : 1000g • Frequency response : DC-8kHz • Linearity : 2% • Control : Open loop Operating temperature : -55 to +125°C	
G.10	Sub area	Programmable Power Supply
G10.1	Design, fabrication, testing and realization of Programmable High Voltage Power Supply (Programmable HVPS): The project aims at design and development of programmable High voltage power supply. The Programmable HVPS has 5V as input voltage. There is also a reference input which determines the output voltage. There must be multiple outputs and the voltages must be programmable from -5kV to 5kV and must vary proportionally with input reference voltage. Specifications of programmable HVPS are: Voltage input : 5 V Voltage output : -5kV to 5kV, multiple outputs but Proportional to input reference Voltage. Reference input : 0 to 5V range Power output : < 5W Card Size : 80mm x 80mm approximately Operating Temperature: -55°C to 125°C	
G.11	Sub area	On-board Flight Software
G11.1	Formal Methods for Flight Software Specification and Verification: Formal methods for software specification and verification are based on mathematical methods and offer a more rigorous approach for software development and verification. In order to ensure consistency of requirements and provide proof of correctness, formal methods are to be used to supplement the traditional techniques followed for specification and verification of flight software for launch vehicles.	

G.12	**Sub area**	**Modelling of On-board Software**
G12.1	**Model-based Software Development for Safety-critical systems:** **Model-based approach to Software Development involves a mathematical and visual method of addressing problems associated with designing complex systems. It provides a common design environment for all development agencies, facilitates rapid proto-typing and early detection of errors as well as design re-use. One of the safety-critical elements of flight software is to be developed using the model-based software development paradigm, as a pilot project.**	
G13	**Sub Area**	**Electro-mechanical Actuators**
G13.1	**Design and analysis (static & dynamic) of a planetary rollerscrew** **Planetary rollerscrews having double nut configuration are used in high power electromechanical actuators for converting the rotary motion to linear. The scope of project includes** **(i) Mechanical design of the rollerscrew based on input requirement which includes detailed specification and outer dimensions of Rollerscrew.** **(ii) Generation of 3D CAD model** **(iii) Kinematic analysis and estimation of slip** **(iv) Static analysis (Finite Element Analysis), stiffness and efficiency** **(v) Dynamic analysis (Using solvers like ADAMS)** (vi) **Fabrication drawing of all components**	
G14	**Sub Area**	**Robotic manipulator**
G14.1	**Modeling, simulation, analysis and design of a controller for a robotic manipulator having five degree of freedom for lunar mission** **Robotic manipulator having five degree of freedom forms part of a lunar exploration rover.** **The scope of project includes,** **(i) Generation of a mathematical model and its analysis which includes forward and inverse**	

	kinematics, work space analysis, trajectory planning, static and dynamic analysis (ii) Design of a controller and simulation of certain predefined tasks (iii) Hardware realization of the controller (control electronics to drive the manipulator) (iv) Experimental demonstration of the predefined tasks (Robotic manipulator will be provided for this purpose)	
G15	**Sub Area**	**Robotics**
G15.1	**Design, analysis and experimental verification of a force and slip controller for the object grasp by an underactuated three fingered robotic hand.** (i) Design of force and slip controller (including selection and procurement of appropriate sensor / sensors) (ii) Simulation of grasp (Spherical, Cylindrical & Planar) with objects of various sizes and shapes (iii) Experimental demonstration of grasp (Spherical, Cylindrical & Planar) with objects of various sizes and shapes (Underactuated robotic hand will be provided for this purpose)	
G16	**Sub Area**	**Actuators**
G16.1	**Design and analysis of harmonic drive** Harmonic drive replaces the conventional gear train of the rotary actuator. The scope includes (i) Mechanical design of the harmonic drive for the input requirements (ii) Modeling and quasi-static analysis using finite element analysis for the tooth mesh conditions [for stress, strain and stiffness] (iii) Kinematic and kinetic analyses using ADAMS like software (iv) Tooth profile optimization for maximizing performance	

	(v) Generation of fabrication drawings (vi) Procurement of components (like elliptical bearings, circlip, etc, needed for the assembly) (vii) Realisation, assembly and testing	
G17	**Sub Area**	**BLDC Motor**
G17.1	**Design and development of 25kW quadruplex BLDC motor with quadruplex hall sensor sets** **25kW quadruplex BLDC motor with quadruplex hallsensor sets is planned as a driver for linear electro-mechanical actuators generating high actuation forces. The scope includes** **(i) Design of motor and controller for the input requirements** **(ii) Modeling and analysis using finite element analysis software to validate the motor performance** **(iii) Generation of fabrication drawings and PCB layout** **(iv) Procurement of components needed for the motor and controller** **(v) Realisation, assembly and testing of motor and controller**	
G18	**Sub Area**	**Stepper motor**
G18.1	**Design and development of Dual redundant 22.5^o stepper motor** **22.5^o stepper motor with is planned as a driver for the rotary actuator. The scope includes** **(i) Design of motor for the input requirements** **(ii) Modeling and analysis using finite element analysis software to validate the motor performance** **(iii) Generation of fabrication drawings** **(iv) Procurement of components** **(v) Realisation, assembly and testing of motor**	