ANNEXURE-2

1. SCOPE OF WORK

The Propulsion Research Group in the PRS entity has the following laboratories/facilities.

a) Semi-cryogenic engine injector calibration lab.
b) Automated injector calibration facility
c) Back Pressure testing lab for injectors and other elements
d) Satellite thrusters calibration lab
e) Back Pressure test facility for semi-cryogenic engine elements
f) Throttleable flow control component test facility
g) Thermal lab
h) Acoustic lab
i) Igniter studies laboratory
j) Combustion research laboratory
k) Small vacuum chamber facility for SPT and RF plasma engine testing.
l) High Performance Computing lab

The major activities expected in these laboratories /facilities are as given below.

1.1. ***Calibration of earth storable engine elements (LAM,100N,800N&RCS injectors)***

1.1.1. Run tank cleaning
1.1.2. DM water plant operation
1.1.3. Run tank filling
1.1.4. Filter cleaning
1.1.5. Pressure cylinder connections and regulator operations
1.1.6. Injector assembly and disassembly in the test bay
1.1.7. manual valve operations
1.1.8. Spray image capturing using imaging system
1.1.9. Maintenance of the log book and test request/report register
1.1.10. Pressure cylinder transportation and connections for filling
1.1.11. Maintenance of tools and instruments

1.2. ***Operation and maintenance of automated injector calibration facility***

1.2.1. Leak check operations using dummy element
1.2.2. Operation and maintenance of compressor, DM water plant and pump panel
1.2.3. Operation of HMI panel
1.2.4. Assembly/ disassembly of injectors.
1.2.5. Operation of the facility to calibrate the injector elements.

1.2.6. Monitoring of SCADA operation
1.2.7. Data logging in register.
1.2.8. Reference hardware calibration
1.2.9. Maintenance of log book/ test request/report register
1.2.10. Purging and vacuum drying of injectors
1.2.11. Packaging of injectors
1.2.12. Maintenance of tools and instruments
1.2.13. Periodic cleaning of line filters and tank
1.2.14. Preparation of test report

1.3. ***Calibration of semi cryogenic injectors***

1.3.1. Leak check operations using dummy element
1.3.2. Operation and maintenance of compressor, DM water plant and pump panel
1.3.3. Power supply management for mass flow meters and pressure transmitters.
1.3.4. Operation of manual and EP valves.
1.3.5. Operation of proportional control valves.
1.3.6. Reference hardware calibration
1.3.7. Assembly and disassembly of injectors on fixtures and on the facility
1.3.8. Operation of the facility to carry out actual calibration of elements
1.3.9. Processing of acquired data
1.3.10. Maintenance of log book/ test request/report register
1.3.11. Purging and vacuum cleaning of injectors
1.3.12. Packaging of injectors
1.3.13. Maintenance of tools and instruments
1.3.14. Periodic cleaning of line filters

1.4. ***Operation and maintenance of back pressure test facility and GN2 plant***

1.4.1. Operation and maintenance of LN2 pump
1.4.2. Operation of GN2 plant for producing Nitrogen gas from LN2.
1.4.3. Operation of manual and EP valves.
1.4.4. Operation of proportional control valves.
1.4.5. Filling of DM water in the run tank
1.4.6. Setting of pressure regulator and maintenance pressure regulator.
1.4.7. Assembly and disassembly of test hardware.
1.4.8. Leak check of the test hardware.
1.4.9. Operation of pressurization circuit to pressure the back pressure chamber
1.4.10. Operation of the facility to carry out testing of injector element under back pressure.
1.4.11. Processing of acquired data
1.4.12. Maintenance of log book/ test request/report register
1.4.13. Packaging of injectors
1.4.14. Maintenance of tools and instruments
1.4.15. Periodic cleaning of line filters

1.5. ***Testing of throttleable flow control components***

1.5.1. Run tank cleaning

1.5.2. DM water plant operation
1.5.3. Run tank filling
1.5.4. Filter cleaning
1.5.5. Actual testing which involves the operation of valves and acquisition of flow data
1.5.6. Pressure cylinder connections and regulator operation
1.5.7. Assembly and disassembly of the valve in test bay
1.5.8. Connections of measuring instruments
1.5.9. Operation of manual valves during test
1.5.10. Maintenance of log book
1.5.11. Maintenance of tools and instruments

1.6. ***Characterization of Anode Gas Distributer (AGD) for SPT***

1.6.1. Cleaning of test setup with IPA
1.6.2. Filling IPA for bubble test
1.6.3. Filling operation of nitrogen
1.6.4. Assembly and disassembly of AGD in test bay
1.6.5. Operation of pressure regulators
1.6.6. Leak check procedure in feed line
1.6.7. Fixture assembly for bubble and uniformity test
1.6.8. Purging and vacuum cleaning of AGD
1.6.9. Safe packing of the hardware
1.6.10. Maintenance of tools and instruments

1.7. ***Testing, operation and maintenance of combustion research lab***

1.7.1. Minor cutting, drilling, welding and tubing work during the development of various test rigs
1.7.2. Raw material sizing for fabrication of test articles
1.7.3. Arrangements for DP test of each weld joints of the test articles
1.7.4. Arrangements for hydraulic / Pneumatic proof test of test articles.
1.7.5. Assembly and dismantling of test articles to test rigs
1.7.6. Refilling of high-pressure and low pressure water tanks prior to test
1.7.7. Refilling of nitrogen cylinders and air receiver for tests.
1.7.8. Assembly and dismantling of propellant cylinders to propellant header
1.7.9. Setting up the pressures by opening the various cylinder valves, manual valves of feed lines, and operating the pressure regulators
1.7.10. Maintenance of air compressors, EP valves, control valves, pressure regulators, flow meters, filters, relief valves of various propellant feed lines
1.7.11. Maintain log for tools and equipment's used for the assembly and dismantling

1.8. ***Igniter development and thermo acoustic experiments***

1.8.1. Filling and maintenance of propellant cylinders
1.8.2. Augmentation of test setup
1.8.3. Operation of manual and EP valves during test
1.8.4. Minor fabrication of facility components
1.8.5. Conduction of various hot and cold flow tests related to igniter development

1.8.6. Maintenance of test register
1.8.7. Maintenance of test setup
1.8.8. Maintenance of tools and instruments

1.9. ***Evaluation of thermal properties of materials using transient plane source technique (Thermal lab)***
1.9.1. Preparation and Installation of test samples in the sample holder.
1.9.2. Operation of Cryostat/Furnace for measurement at different temperature.
1.9.3. Handling of liquid nitrogen for measurement at low temperature.
1.9.4. Conducting measurement and recording the data for analysis.

1.10. ***Operation and maintenance of liquid nitrogen Generator(Thermal lab)***
1.10.1. Operation and maintenance of the generator unit consisting of helium compressor, air compressor and chiller unit.
1.10.2. Level monitoring and filling of water in the chiller unit as per requirement.
1.10.3. Replacement of parts such as filter, O-rings etc.

1.11. ***Operation and maintenance of axial heat flow apparatus(Thermal lab)***
1.11.1. Installation of test specimen with temperature sensors inside the vacuum chamber
1.11.2. Setting up of Liquid nitrogen and gaseous nitrogen supply for temperature and load cycles
1.11.3. Operation of the apparatus for carrying out the measurement

1.12. ***Establishment of test setup for cryogenic geysering experiment (Thermal lab)***
1.12.1. Preparation of fabrication drawings and follow up of internal fabrication process
1.12.2. Installation of LN_2 run tank, transfer feed lines, pressure sensor lines, flow meters and valves.
1.12.3. Filling of LN_2 and GN_2 cylinders and conducting experiments.

1.13. ***Operation and maintenance of hot disk thermal constants analyzer (Thermal lab)***
1.13.1. Preparation of samples and accessories for thermal properties measurement.
1.13.2. Preparation and setting up of tubular furnace (evacuation/purging) for measurement at high temperature.
1.13.3. Operation of cryostat for measurement at low temperature.

1.14. ***Direct Contact Condensation experiments (Thermal lab)***
1.14.1. Preparation of fabrication drawings and follow up of internal fabrication process
1.14.2. Assembly of double walled test section for experiments using liquid nitrogen.
1.14.3. Installation of vacuum pumping station and its operation.
1.14.4. Filling and movement of liquid nitrogen Dewar and gaseous nitrogen cylinders for experiments.
1.14.5. Conduct the test as per the plan.

1.15. ***Establishment of cryogenic fluid void fraction measurement (Thermal lab)***
1.15.1. Follow up and monitoring of component fabrication and assembly process.
1.15.2. Assist in the assembly of two phase flow meter with the cryostat.
1.15.3. Conduct trials and check for any leak or improper operation.

1.15.4. Conducting chill down studies, two phase injector studies using void fraction measurement.

1.16. ***Small vacuum chamber facility for plasma thruster testing***

1.16.1. Mounting of thruster, Xenon feed circuit connection to thruster and spot welding of thermocouple on thruster

1.16.2. Conduct minor maintenance and checks to ensure smooth working of various pumping systems.

1.16.3. If requirement arises, conduct periodic maintenance of various systems.

1.16.4. Schedule the various test activities in the facility

1.16.5. Carryout minor electrical and mechanical repair works as and when required.

1.16.6. Electrical connection to thruster and electrical checking

1.16.7. Leak check of thruster gas feed connections and closing of vacuum chamber

1.16.8. Operation of roughing pumps, turbo pumps, cryo pumps, xenon heads, chiller units, air-compressors to reach and maintain Ultra-High Vacuum level for vacuum chamber during various tests and checks.

1.16.9. Voltage injection checking of thruster electrical connection

1.16.10. Setting the regulators, mass flow controller, opening of valves for xenon feed to thruster

1.16.11. Cathode and anode feed circuit flow trial

1.16.12. Power supply setting and cathode activation

1.16.13. Thruster operation

1.16.14. Tuning and construction of RF circuits for RF plasma engine

1.16.15. Operation of high power RF amplifiers and transmission systems

1.16.16. System assembly and integration of RF plasma engine

1.16.17. Connection of GH_2 feed circuit for gas feed in RF engine

1.16.18. Leak check of GH_2 feed circuit.

1.16.19. Regulator setting for GH_2 pressure regulator.

1.16.20. Compression-decompression cycles for conditioning of feed circuit.

1.16.21. Operation of superconducting magnet system and integrated cryo-systems

1.16.22. Verification of auto-sequence and abort sequence.

1.16.23. Chiller operation for magnet system and RF amplifiers.

1.16.24. Mounting of diagnostic probes.

1.16.25. Test data plotting.

1.16.26. Maintenance of operation log

1.17. ***Cleaning activities of vacuum facility and clean room***

1.17.1. Cleaning of vacuum chamber and pumping system

1.17.2. Cleaning and mopping of clean room

1.17.3. Laundry management for clean room garments

1.17.4. Movement of files and test requests

1.18. ***High performance computing lab***

1.18.1. Semi-Cryogenic engine Turbo-Machinery

1.18.1.1. Geometrypreparation and fluid volume extraction

1.18.1.2. Geometry cleaning for CFD simulation

1.18.1.3. Turbo-grid generation for MRF meshes

1.18.2. Semi-Cryogenic & Cryogenic engine test facilities
- 1.18.2.1. Preparation of geometrical model
- 1.18.2.2. Grid generation for CFD analysis

1.18.3. Injector Head for Semicryogenic thrust chamber and preburner
- 1.18.3.1. Geometry modeling/preparation of thrust chamber and preburner injector heads
- 1.18.3.2. Structured/Hybrid mesh generation for CFD simulations.

1.18.4. Gaganyaan crew and service modules
- 1.18.4.1. Geometry preparation and fluid volume extraction from three-dimensional models of crew and service module propulsion system
- 1.18.4.2. Generation of structured and unstructured mesh with appropriate boundary layer for CFD simulations

1.18.5. C25 propellant tank for Gaganyaan mission
- 1.18.5.1. Geometry preparation of tank for two-phase CFD simulations.
- 1.18.5.2. Structured/Unstructured grid generation for CFD simulation of pressure evolution during propellant sloshing.

1.18.6. Chandrayaan 3
- 1.18.6.1. Geometry cleaning and fluid volume extraction from lander propulsion model
- 1.18.6.2. Generation of structured and unstructured mesh with appropriate boundary layer for CFD simulations

1.18.7. Satellite Propulsion- Existing & Upcoming
- 1.18.7.1. Geometry modification and modeling for thrusters in large domain.
- 1.18.7.2. Domain & grid generation for multiple-engine thruster firing.
- 1.18.7.3. Structured/hybrid grid generation
- 1.18.7.4. Appropriate boundary layer formation

1.18.8. Combustion Modeling& Dynamics-Semi-cryogenic engine
- 1.18.8.1. Geometry modeling for multi-element thrust chamber
- 1.18.8.2. Structured/hybrid grid generation with regenerative channels
- 1.18.8.3. Appropriate boundary layer formation for LES, DES & DNS simulations

1.18.9. Combustion Modeling- LOX-Methane
- 1.18.9.1. Geometry modeling for multi-element thrust chamber
- 1.18.9.2. Structured/hybrid grid generation with regenerative channels
- 1.18.9.3. Appropriate boundary layer formation for LES, DES & DNS simulations

1.18.10. Aero-Thermal modeling for new launch vehicles
- 1.18.10.1. Geometry modeling
- 1.18.10.2. Structured/hybrid grid generation
- 1.18.10.3. Appropriate near wall mesh formation for drag simulation

1.18.11. Hybrid Propulsion
- 1.18.11.1. Geometry modeling/cleaning for LOX tank

1.18.11.2. Structured/hybrid grid generation, mesh generation with required boundary layers for CFD simulation of vortex formation in LOX tank with baffles

2. WORK UNITS REQUIRED FOR EACH ACTIVITY

The approximate requirement of work units per annum for each major activity is given in the table below.

Sl No	Activity	Work units for two year			
		Technician (ITI)	Supervisor (Diploma)	Engineer (B.E/B.Tech/ Equivalent)	Unskilled worker (SSLC)
1.	Calibration of earth storable engine elements (AOCS,LAM, 100N, 800N, RCS injectors)	4992	0	0	0
2.	Testing of throttleable flow control components				
3.	Operation and maintenance of automated injector calibration facility	4992	4992	0	0
4.	Calibration of semi cryogenic injectors				
5.	Characterization of Anode Gas Distributer (AGD) for SPT				
6.	Operation and maintenance of Back pressure test facility and GN_2 plant	4992	4992	0	0
7.	Operation and maintenance of test rigs for pulse detonation engine and spray characterization				
8.	Testing, operation and maintenance of Combustion Research lab	4992	0	0	0
9.	Igniter development and thermo acoustic experiments				
10.	Evaluation of thermal properties of materials,	4992	0	0	0
11.	Operation and maintenance of LN_2 generator				
12.	Operation and maintenance of axial heat flow apparatus				
13.	Establishment of test setup for cryogenic geysering experiment				
14.	Operation and maintenance of hot disk thermal constants analyzer				
15.	Direct Contact Condensation experiments				
16.	Establishment of cryogenic fluid void fraction measurement				
17.	Small vacuum chamber facility for plasma thruster testing	4992	4992	0	0

18.	High performance computing lab	0	0	4992	0
19.	Cleaning activities of vacuum facilities and clean room	0	0	0	4992
		29952	**14976**	**4992**	**4992**
	Split up of manpower requirement based on trade				
	Technician-ITI(Fitter)	29952	0	0	0
	Supervisor-Diploma(Mechanical)	0	14976	0	0
	Engineer-B.E/B.Tech(Mechanical)	0	0	4992	0
	Unskilled worker-SSLC	0	0	0	4492

WORK UNITS AND COMPUTATION

One work unit is defined as one hour duration of work per person and the total quantum of work carried out will be computed on monthly basis based on the completed work unit. The Service provider shall be available for work not only during office hours but also during late office hours and on holidays if needed.

3. MANPOWER/QUALIFICATION/EXPERIENCE

Sl.No	Category	Qualification	Experience	Number of workforce
1	Graduate Engineer	B.E/B.Tech in Mechanical Engineering	Minimum 1 year experience in modeling and simulation (CFD)	1
2	Supervisor (Mechanical)	Diploma in Mechanical Engineering	Minimum 1 years of experience in operation and maintenance of similar facilities/ chemical plants.	3
3	Technician	ITI –Fitter	Minimum 1 years of experience in operation and maintenance of similar facilities/ chemical plants.	6
4	Unskilled worker	SSLC	No experience is required	1