भारत सरकार/**GOVERNMENT OF INDIA**
अंतरिक्ष विभाग/**DEPARTMENT OF SPACE**
विक्रम साराभाई अंतरिक्ष केंद्र/VIKRAM SARABHAI SPACE CENTRE
तिरुवनंतपुरम/**THIRUVANANTHAPURAM – 695 022**

EXPRESSION OF INTEREST / अभिरुचि की अभिव्यक्ति

Ref. No. VSSC/STR/SDTG/ISDTF **Date: 29.03.2023**

"290 kN प्रकंपित्र प्रणाली के विकास, अभिकल्पना, प्रापण, एकीकरण, संस्थापन एवं कमीशनिंग के लिए अभिरुचि की अभिव्यक्ति"

"EXPRESSION OF INTEREST FOR DEVELOPMENT, DESIGN, REALIZATION, INTEGRATION, INSTALLATION AND COMMISSIONING OF 290 kN SHAKER SYSTEM"

Interested parties may furnish their **Expression of Interest in Sealed Envelope** quoting our **Reference No. VSSC/STR/SDTG/ISDTF on or before 26.04.2023 [16:00 Hrs.]** to the following address :-

वरि. क्रय एवं भंडार अधिकारी / Sr. Purchase & Stores Officer,
क्रय यूनिट I, मुख्य क्रय / Purchase Unit- I, Main Purchase
आर एफ एफ क्षेत्र, इसरो पीओ/ RFF Area, ISRO PO,
तिरुवनंतपुरम/ Thiruvananthapuram- 695022
फोन/Ph: 0471-256 3139 / 3522

नोट/Note :- मेक इन इंडिया नीति के अनुसार केवल श्रेणी-I तथा श्रेणी-II के स्थानीय आपूर्तिकार इस बोली में भाग लेने हेतु पात्र हैं। / **Only Class-I and Class-II Local suppliers as per Make in India policy are eligible to participate in the bid.**

पूछताछ / सहायता के लिए कृपया संपर्क करें : 0471 2563139/3522, ई-मेल : : spso_psd@vssc.gov.in / pso1_main_pur@vssc.gov.in

For any queries / assistance, please Contact : 0471 2563139 / 2563522. E-mail : spso_psd@vssc.gov.in / pso1_main_pur@vssc.gov.in

हस्ताक्षरित/Sd/-
वरि.प्रधान, क्रय एवं भंडार/ Sr. Head, Purchase & Stores

Request for

Expression of Interest

For

Design, Realization, Integration, Installation and Commissioning of 290 kN Shaker System

Contents

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1. Introduction

Launch vehicles and satellites are subjected to vibration environment during their operation. In order to ensure reliability, structural integrity and performance of major systems, sub-assemblies need to be verified/validated under vibration environment. In this regard, electrodynamic shakers are used to generate controlled vibration. These shakers are available in different force ratings as per the system requirements.

Considering vibration testing requirements of future vehicle sub-assemblies and satellites, ISRO has a requirement for **three 290kN force capacity shakers**. ISRO is planning for Indigenous design, development, realization, testing, supply, installation and commissioning of high capacity shaker system through Indian industries on turnkey basis. EOI is invited from technically competent parties with previous experience in development of multidiscipline engineering systems, preferably of high capacity electrodynamic shaker systems (force rating greater than 10Tons).

2. Background of EOI

VSSC/ISRO had indigenously developed a 250kN force capacity electrodynamic shaker with slip table for testing of 4m dia. class sub-assemblies. This EOI is invited for enabling Indian industries to develop world class high capacity electrodynamic shaker systems and compete in international market having very few suppliers.

Interested parties have to submit a brief introduction on their capabilities related to the proposed work. In addition, all the documents/details as requested in section 8 has to be attached.

All the received EOI will be scrutinized and Request for Proposal (RFP) will be sent only to the selected vendors. The received proposals thereafter will be reviewed on a case by case manner for final selection.

3. Scope of work

The scope of work includes, design, development, realization, testing, supply, installation &commissioning of a 290kN force capacity electrodynamic shaker, power amplifier for driving the shaker, field power supply, output transformer, Load Bearing Platform (LBP), slip table system for lateral axis tests, electrical controls and sensors as interlocks for

safety, and other auxiliary systems like the hydraulic power packs, cooling systems, power cables, hoses etc. At present, requirement is for THREE such systems, one at VSSC, Trivandrum and other two at URSC & LPSC, Bangalore.

4. Brief system description

Electrodynamic vibration shakers derive its name from the method of force generation. Force that causes motion of the table is produced electrodynamically by the interaction between current flow in the armature coil and the intense DC magnetic field which passes through the field coil. Armature coil along with armature structure on top constitutes armature assembly. Vibration is generated on top of the armature structure. The armature coil is concentrically located (with radial clearances) in the annular air gap of the dc magnet circuit.

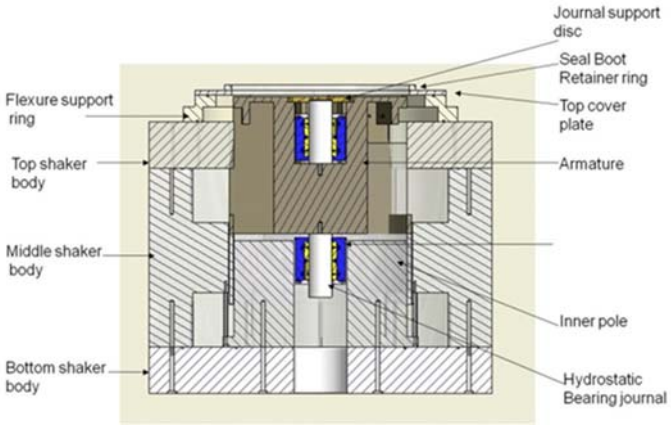

Figure 1. Cross-section view of electrodynamic shaker

The magnetic circuit is made from soft iron which forms Inner pole and body of the shaker. The body is magnetically energized, using two field coils as shown in. These coils generate radial magnetic field in the air gap, which is perpendicular to the direction of current flow in the armature coil. Generated force in the armature coil is in the direction of the axis of the coil, perpendicular to the table surface. The direction of the force is also perpendicular to the armature current direction and to the air-gap field direction.

The table and armature coil assembly is supported by air suspension that permits rectilinear motion of the table, in perpendicular direction to the axis of the armature coil. Motion of the table in all other directions is resisted by armature guidance system that

consists of a pair of hydrostatic journal bearings and other guidance mechanisms. Table motion results when an ac current passes through the armature coil. Body of the shaker is supported to ground by shaker suspension system with a trunnion shaft centerline passing horizontally through the center of gravity of the body assembly. This configuration permits the body to be rotated about its center, thereby giving a vertical or horizontal orientation to the machine table. The shaker suspension system also includes an elastic support to the body that provides vibration isolation between the body and the supporting floor. Being a high power system, copper and iron losses in the electrodynamic shaker unit is large. Separate chilled water cooling system is designed to carry off the dissipated heat.

5. Brief Specifications of the system

1.	**Shaker**	
1.1.	Type	Water cooled
1.2.	Sine Force Rating (Peak)	290 kN
1.3.	Random Force Rating (RMS)	290 kN
1.4.	Static Load capacity	≥5000 kg
1.5.	Useful frequency range	i. With Full Force rating:5 Hz to 1700Hz. with multi-point control.
		ii. Without Full Force rating: 5Hz to 2000 Hz
1.6.	Body Suspension Frequency	≤3 Hz
1.7.	Sine Acceleration	≥75g
	Random Acceleration	≥60gRMS (20-100Hz:6dB/Oct, 100-2000Hz: flat PSD to obtain the 60gRMS acceleration)

1.8.	Half Sine Shock	≥100 g, 10 milliseconds
1.9.	Velocity (Sine)	≥ 1.8 m/sec
1.10.	Displacement (Peak-Peak-Sine) (continuous)	≥ 50 mm
1.11	Offset Moment	≥10.5kNm
1.12.	Bare table acceleration noise on armature tabletop with the rated power amplifier.	≤0.05grms (Power amplifier at 100% gain and input shorted)
1.13.	Minimum possible test level	0.1 g peak swept sine test from 5 Hz to 2000 Hz with control channel in Broad Band RMS (BBRMS) measurement mode with 2 kHz bandwidth, With power amplifier 100% gain
1.14.	Armature mass	< 280 kg
1.15.	Fundamental Armature Resonance	> 1250Hz
1.16.	Armature cross axis response (Measured on 22 inch or higher PCD of the armature without load.)	5 Hz – 500 Hz:< 12%, except sub-harmonic peaks 500 Hz – 1000 Hz:< 15%, except sub-harmonic peaks
2.	**SLIP-TABLE Configurations**	

2.1	Slip Table dimensions	Configuration 1: Length (L): 2000 mm, Width (W): 2000 mm, Thickness (T): 70mm Configuration 2:Length (L): 4900 mm, Width (W): 4200 mm, Thickness (T): 50mm Configuration 3 (URSC Preferred): Length (L): 3000 mm, Width (W): 3000 mm, Thickness (T): 70mm
2.2	Slip plate material	Magnesium Alloy (AZ31B) Tool plate
2.3	Cross axis responses	5Hz – 200Hz <5%; except sub-harmonic peaks
		200Hz – 400Hz <10%; except sub-harmonic peaks
2.4	Combined useful frequency range of shaker with Slip-table	5 to 2,000Hz
2.5	Displacement	≥50mm peak to peak (bare table)
2.6	Minimum static payload capacity	15,000 Kg
3	**Power Amplifier**	
3.1	Capacity	Suitable to the rated Capacity of the shaker with a Minimum of 320kVA.
3.2	Type	PWM based, switching type, class D, Modular, Air Cooled
3.3	Frequency Response	+3 dB, 5 Hz to 3000 Hz.

3.4	Overall efficiency	> 90%
3.5	Amplifier shaker distance	25-45 meters approx. depending upon the location
3.6	Minimum numbers of modules	20
3.7	Total Harmonic distortion	< 0.2% when measured with matched resistive load at rated output.
3.8	Peak current handling capacity	Approximately three times or more than that of continuous Sine Current Rating for a period of 100 m seconds
3.9	Amplifier Remote control panel	Remote control panel with all monitoring and control switches be provided with a cable length of 20 meters via PC interface.
3.10	Amplifier, Soft start/Shut down	Shall be available
3.11	System noise	0.05Vrms or Less, with Input shorted and full gain.
3.12	Switching frequency	> 150 kHz
3.13	Signal to noise ratio	>65 dB
3.14	Input impedance	High input Impedance, > 10 KΩ
3.15	Input Sensitivity	1 Vrms for 100 Vrms output. Differential input compatible with all standard controller. Should accept maximum 10 V peak input.

3.16	Safety Interlocks, Indicators: The power amplifier and shaker system must be protected with following system interlocks with appropriately located Indicators. This has to be indicated on remote panel and also on power amplifier	
3.17	Electrical wiring & mains power	Wiring suitable for 415 VAC +/- 10%, 50 Hz 3 phase. Lower tapings for operation at 380 VAC to be provided
3.18	Power module	The power module should have independent cooling and RFI Filters.
3.19	Power Loss Protection	The amplifier should have synchronised loss protection facility to have a smooth shut down in the event of power failure.
3.20	System Interface	The amplifier should have Microprocessor / PC based user interfaces which improves reliability and fault diagnosis of the system
3.21	Isolation and Redundancy	Power modules shall be distributed across multiple bays for the purpose of isolation in case of failure. Redundancy shall be provided in terms of individual bay control processor.
4	Guided Load Bearing Platform	
4.1	LBP dimensions	Configuration 1 (LBP-1): 1500 mm Dia.

		Configuration 2 (LBP-2) : 3000 mm Dia. *(URSC requires both the above configuration)*
4.2	LBP material	Magnesium Alloy (AZ31B) Tool plate
4.3	Cross axis responses	5Hz – 200Hz <5%; except sub-harmonic peaks
		200Hz – 400Hz <10%; except sub-harmonic peaks
4.4	Combined useful frequency range of shaker with Head Expander	5 to 2,000Hz
4.5	Displacement	≥50mm peak to peak (bare table)
4.6	Minimum static payload capacity	LBP -1: 8,000 Kg LBP-2: 15,000 Kg
4.7	Minimum Offset Load Capability	40kNm

6 Major elements of the system

VSSC has developed a 250kN Electro Dynamic shaker. The configuration details are outlined in this section. The provided information is only indicative and design, development, realization, testing, supply, installation, and commissioning of the proposed 290kN shaker system will be the responsibility of vendor. The major elements of electrodynamic shaker system consist of:

6.1 Shaker

6.1.1 Shaker body elements: The shaker body is made of pure iron/low carbon steel, with good magnetic properties. The overall mass is around 15 Tons.

6.1.2 Armature: Consists of the armature structure and the armature coil. Armature structure is machined out from AA2014 forging of Dia 860 mm x 720 mm. Armature coil is AA1050 Hollow rectangular tube 18 mm x 14 mm x 3 mm thick, bonded with armour plates using Redux 319A adhesive. The diameter is around 840 mm. It is cooled with chilled DM water. The variable current from the power amplifier is passed through the armature coil.

Figure 2. Armature Assembly

6.1.3. Field coils: Shakers have a pair of field coils. These are made from OFHC Copper square tubes, (8 mm x 8 mm, 2 mm thick), and cooled with chilled DM water. It is having 240 turns, 24 layers, 10 turns / layer, electrically single, and cooled parallel through 12 independent water circuits. Field coils are shown in fig. 1.

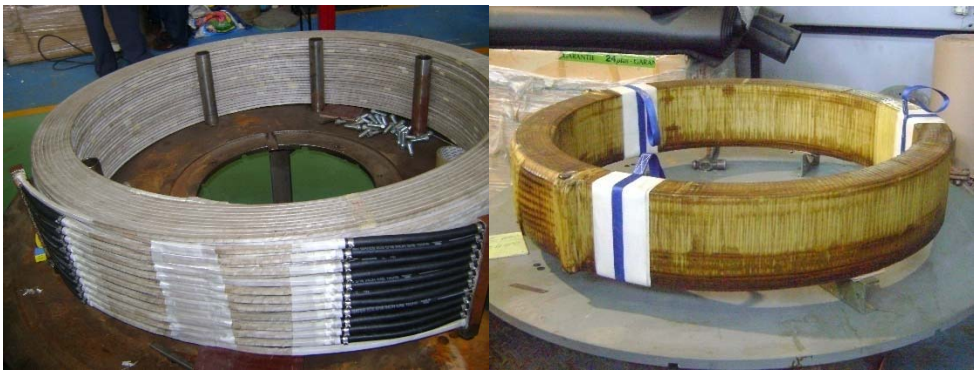

Figure 3. Field Coil

6.1.4. Suspension System and Tilting mechanism: This body suspension and Tilting mechanism is required for supporting and tilting the shaker 90 degrees for attaching it to the slip plate for lateral axis tests. It also isolates the shaker from ground. The structure is made using MS Plates, 15CDV6 Forgings. The isolation is through double convoluted air bellows. Movement of the body is guided using linear ball bush bearings. Rotation of the shaker is motorized with suitable gear system.

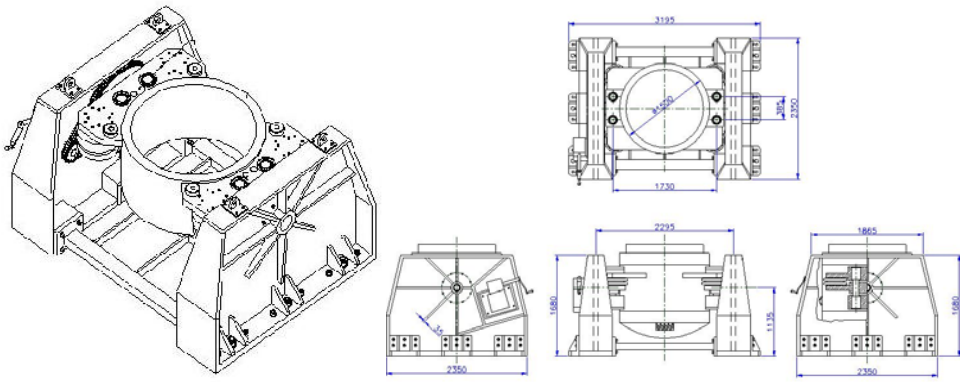

Figure 4. Shaker Suspension System

6.1.5. Hydrostatic bearings: Guidance of the armature is critical to avoid rubbing of the armature against the shaker body and also to control its cross axis movement. Two hydrostatic journal bearings are provided to balance the overturning moments acting on the armature and for guidance. The journals are attached to the armature, while housings are attached to the inner pole piece (shaker body).

6.1.6. Armature suspension system: In addition to the guidance provided by the hydrostatic bearings. Suitable mechanism in the form of flexures are provided for controlling the cross axis movement of the armature and guide the armature in a uniaxial direction.

6.1.7. Seal boot assembly: The shaker is pneumatically sealed and the static load capability of the shaker is obtained through internal pressurization and supporting the armature.

6.2 Power Amplifier

Power amplifier has three entities namely LCU/RCU, power supply and power modules. Local control Unit (LCU) receives interlock signals from shaker elements, drive signal from vibration controller, voltage feedback signal from transformer output and health status signals from different power amplifier elements. Based on the received signals, LCU commands for powering of shaker cooling system, shaker hydraulics, field power supply and gain for drive signal to shaker armature. The remote-control unit (RCU) is used for switching ON the power amplifier from a remote location. The shaker has multiple power bays that houses power modules. Each of the bays have an independent DC power supply unit. The power amplifier also has a DC field power supply (FPS) for energizing field coils of the shaker. All the interlocks associated with these power modules, power bays and power supplies are monitored by LCU/RCU for power amplifier operation. Bay interface unit (BIU) in each power bay directs all the interlock signals to the LCU, it also distributes the control signal to power modules.

6.3 Slip table:

The slip table system is required for testing of specimens in the lateral axis. It consists of a base plate, a set 'T' and 'V' type hydrostatic thrust bearings and a Mg alloy slip plate.

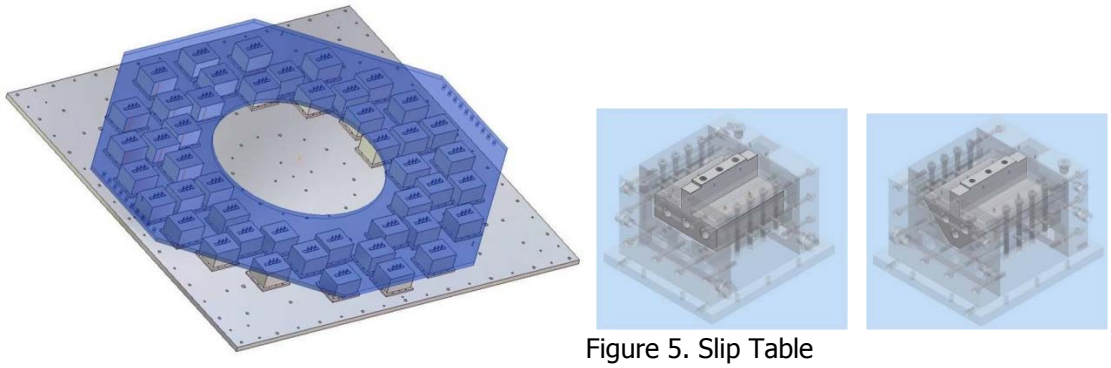

Figure 5. Slip Table

6.4 Guided Load Bearing Platform:

The Guided Load bearing Platform (LBP) is required for testing heavy payloads like satellites in the vertical axis. The LBP has internal bearing to provide guidance and to provide required offset-load capability. The LBP provides additional load bearing capability with the help of additional air bellows to enable to test heavier payloads.

6.5 Other systems:

These includes hydraulic power packs for the shaker, slip table bearings, cooling system for armature &field coils, DM water plant, air compressor, Mg Alloy driver bar and H Adaptor etc. Seismic Base interface requirements and embedded structure design shall be provided. PCDs for interfacing of payloads shall be incorporated as per details that will be provided.

7. Overall configuration

Figure *6*. Overall Configuration of Shaker Slip Table System shows the overall configuration of shaker-sliptable system. 6 numbers of V bearings are provided along the center line of the slip table and 20 numbers of T bearings are provided on either side. The proposal is for a combobase construction, with the base plate attached to a stiffened box platform.

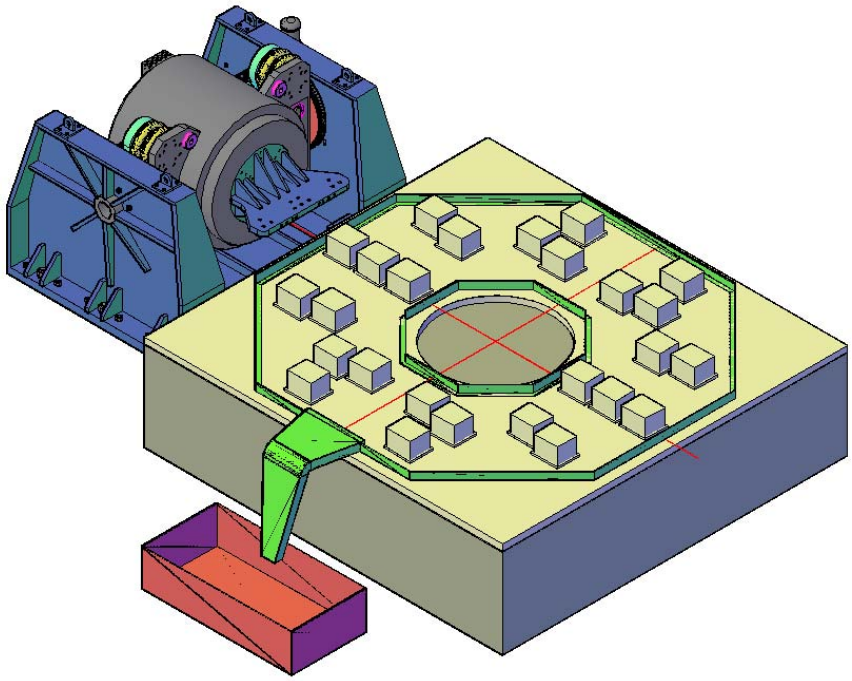

Figure 6. Overall Configuration of Shaker Slip Table System

8. General Instructions for the submission of Expression of Interest (EOI)

8.1. This project is for design, development, realization, testing, supply, installation and commissioning of 290kN force rating electrodynamic shaker system under leadership of an Indian industry.

8.2. The proposal has to be submitted by vendor in the form of an Expression of Interest (EOI). This proposed activity requires experience in multi-disciplinary engineering areas. The applicants should have net worth of 20 Crore and above at close of proceeding financial year. It shall possess sufficient technical human resources with adequate knowledge, skill and experience in the areas of design, fabrication, assembly and testing, preferably of high capacity electrodynamic shaker systems (10Tons and above).

8.3. The vendor has to develop and demonstrate all technologies pertaining to the proposed work. The design of such systems should be fully shared with ISRO for review by an expert committee. Suggestions/modifications by the committee shall be incorporated. Mandatory approval from ISRO should be obtained prior to commencement of realization. Evaluation and/or demonstration of subsystems, at

intermediate stages, as deemed necessary by ISRO committee, shall have to be complied with.

8.4. The EOI proposal has to be provided by an Indian industry as the lead. This vendor should submit documentary evidence that it is an Indian industry. However, the lead vendor is allowed to form consortiums / joint ventures / partnership/ collaboration with other Indian as well as international industries, except China, supplying systems of similar nature. Such group of industries should provide the full details of the systems supplied and indigenous content. It is to be ensured that overall indigenous content should be 20% or more. In case of consortiums / joint ventures/partnership/collaboration, EOI shall contain details of all contributing agencies. Order will be placed only on the lead industry and execution of the total order will be the responsibility of this lead industry.

8.5. The vendor shall have the capability to demonstrate design, fabrication, assembly, integration and acceptance testing of the systems at a suitable site for Pre Delivery Inspection (PDI) and Factory Acceptance Testing (FAT) with participation from ISRO.

8.6. The EOI shall include audited annual report for three financial years in chronology immediate preceding FY 2022-23. Available infrastructure related to realization of high capacity shaker system has to be mentioned. Technical manpower as available with the vendor along with technical qualifications has to be attached as per format provided as annexure II.

8.7. Based on the EOI, vendors may be invited for further discussions at VSSC, Trivandrum for assessment of the capabilities stated in the EOI and for providing any clarifications.

8.8. Vendors will be shortlisted based on EOI and assessment of capabilities to carry out the proposed work. These shortlisted vendors only will be issued with formal tender inquiry / Request for Proposal.

8.9. The expected period for completion of the proposal is 24 months.

8.10. EOI shall be submitted in a sealed cover complete in all respect as per the requirement.

8.11. ISRO reserves the right to accept or reject any Expression of Interest without assigning any reasons thereof.

8.12. ISRO reserves the right to verify all claims made by the vendor, which includes inspection, evaluation of the facilities and evaluation of products supplied earlier.

Vendors who are meeting the requirements as specified in Section 8 of the EOI invitation document for design, development, fabrication, assembly and testing of high capacity electrodynamic shaker systems may submit their EOI along with copies of supporting documents for verification/evaluation at ISRO.

ANNEXURE - I

Checklist to be submitted along with EOI

Sl.	Document / Proof	Attached or Not-attached with EOI	Remarks
1	Company registration details		
2	Brief introduction on capabilities related to the proposed work		
3	Proof for experience in the area of fabrication, assembly and testing in the area of large scale multi-disciplinary system preferably high capacity electrodynamic shaker system(greater than 10Ton force rating).		

4	Audited copies of balance sheet and IT statements for the last 3 years.		
5	Company profile, management structure and human resources and their experience, facilities available including that of consortium parties.		
6	Company brochure		
7	Technical Manpower Details (Annexure II)		
8	Copies of similar purchase/work orders executed by the company		
9	Any other information you consider Relevant		

ANNEXURE – II

Technical Details to be submitted along with EOI

Sl.	Details	
1	Total Technical Workforce a) Engineers b) Diploma c) ITI	
2	Number of Technical personnel exclusively deployed for R&D activities similar to the proposed work. a) Engineers b) Diploma c) ITI	

We affirm that the information submitted is complete in all respects and true to the best of our knowledge and that we are authorized to submit this application. We understand that the information furnished in the form above is liable to be verified and any misrepresentation may lead to our disqualification from the tendering process.

Name:
Designation:

Signature of the authorized Signatory
Date: