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Department of Space
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Ref No: HSFC/EoI/01/2022-23

September 9, 2022

INVITATION FOR “EXPRESSION OF INTEREST FOR DESIGN AND REALIZATION OF DYNAMIC TRAINING SIMULATOR FOR CREW TRAINING”

“**Human Spaceflight Centre [HSFC, ISRO]**, Government of India invites Expression of Interest from global vendors for Gaganyaan Program to Design and Develop necessary Technologies and Infrastructure Elements to undertake Human Spaceflight to Low Earth Orbit with a Crew of Astronauts.” **Brief Specification is available in the ISRO website www.isro.gov.in under ‘Tenders’.**

Interested Vendors having sufficient know-how, experience, required facilities and financial background are invited to express their interest to submit their signed and sealed Envelope to HSFC, Bengaluru.

Along with “Expression of Interest” please furnish the following information also in detail:

1	Registered address with Phone, Fax, Email, Web etc.	8	Details of Specialized Manpower in each area related to the Project Development
2	Company Status (Proprietary / Partnership / Private Ltd. Etc.) with Name and Address of Proprietor, Partners, Board of Directors etc.	9	Financial Capacity / Credit facilities available
3	Associates: (a) Indian (b) Foreign	10	Establishment’s Goods Service Tax Registration Number, PAN Number, ISO Certification or equivalent
4	List of Major Customers with full address and their Contact Persons	11	Trade Association to which you belong to
5	Details of other Contracts, if any now in hand	12	Name and Address of the Bankers
6	Details of Infrastructure Facilities owned / available	13	Nature of Business
7	Capital and Turnover for last Three years with copy of latest Annual Report	14	Any other information you consider relevant

The Expression of Interest with all the above information should reach the following address superscribing the envelope as **EoI No: HSFC/ADVT/01/2022 dated 09.09.2022. The Due Date for submission of EoI is September 30, 2022 at 14.00 Hours IST.**

**Purchase & Stores Officer,
Human Space Flight Centre, ISRO HQ Campus,
New BEL Road, Anthariksh Bhavan,
Bengaluru – 560 094**

The EoI cover should indicate “SENDERS” Address and HSFC Reference Number. For any clarification you may please contact us on +91-080-2217 2670/71 and email ID veena-hsfc@isro.gov.in. EoI received after due date and time will not be considered for evaluation. HSFC reserves the right to accept or reject all or any such “Expression of Interest”; without assigning any reasons what so ever.

Sd/-
Sr. Purchase & Stores Officer

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1 Introduction

The scope of Gaganyaan program is to design and develop necessary technologies and infrastructure **elements** to undertake Human spaceflight to Low Earth Orbit with a Crew of astronauts. The mission can be divided in different phases mainly ascent, on orbit, de-boost and descent phase.

To familiarize the Crew with all the phases of the mission and train them for various nominal and off-nominal operations, training through simulators is a necessity. Virtual Reality has been instrumental in space mission training which has the capability to simulate anything from extra-vehicular space walks outside the International Space Station to operating an emergency spacecraft operation. In order for the astronauts to be familiar with how to control the spacecraft and use the tools, the virtual assets need to look as close to the real thing as possible.

Subjecting the Trainee to dynamics is essential to familiarize them with the level of acceleration, attitude and vibration of the module during dynamic phases of the mission so that their performance during mission can be enhanced.

Virtual Reality can be used to train a range of mission scenarios (both nominal and off-nominal) from pre-launch to touchdown phase. The training experience should be realistic enough for Trainee to be able to sit down comfortably and navigate with confidence in the actual manned mission.

2 Scope of the document

This document defines the top-level requirements for Dynamics Training Simulator (DTS), for enabling suitable vendors to submit Expression of Interest in undertaking these activities. Based on the requirements identified, parties shall submit their proposal on the capability of realizing the simulator meeting all the requirements.

3 Simulator requirements for Gaganyaan mission

Gaganyaan Crew and mission control personnel will need extensive training before undertaking human spaceflight demonstration. Astronaut Training needs to be carried out to prepare the Gaganyaan Crew for all the conceivable contingencies and equip them to manage all the mission situations. Such a preparedness calls for various levels of training modules such as basic training, advanced training and mission-specific training (MST). MST is supported by various Crew Training Simulators (CTS) identified based on different capabilities for Crew training. One of the types of simulators is Dynamic Training Simulator (DTS). The important functions of DTS are as follows:

1. To familiarize the Trainee with the Crew Module (CM) dynamics (angular rates and orientation) during various phases of the mission

2. To familiarize the Trainee with the levels of vibration and acoustic levels at different stages of the mission
3. To practice SOPs under various off-nominal and nominal mission scenarios.

4 Functional Requirements of Dynamic Training Simulator

The simulator shall be used to familiarize the Trainee with the CM dynamics during various phases of mission and practice SOPs during dynamic phases of mission. The major functional requirements of the DTS are as follows:

- It shall have the provision to train maximum two Trainees at a time with space suit (multi-trainee training experience). In case of absence of one Trainee, provision shall exist to match the CG requirements with dummy mass.
- It shall have provision to simulate the interior of Crew Module using Virtual Reality hardware and software.
- It shall have provision to include essential hardware in physical form in the simulator, such as console and other systems for actual operation. This calls for development of Mixed reality-based platform.
- It shall simulate the attitude and body rates during various mission phases
- It shall have the provision to simulate the vibration of the Trainee seat during dynamic phases of mission
- It shall have the capability to perform real-time closed loop mission simulation (console-related activities and various hardware handling operations)
- It shall have the provision to communicate (audio) with Control Centre and trainer for a more realistic simulation of the actual flight. Low latency networked solution is preferred for a multi-user experience.
- It shall have the provision for haptic feedback to enhance the feeling while touching objects in virtual space
- It shall have provision to record the training scenario and related data and performance document shall be generated of each training session.

In addition to the above, based on the configuration of the simulator, provision shall exist to carry out training independently on either the dynamic simulator without Virtual Reality headset or wearing the VR headset without the dynamic simulator.

DTS shall consist of the following hardware components:

1. 6-DOF platform driven by control system and required power systems
2. Virtual Reality/Mixed Reality based platform including hardware and software components.
3. Seating provision for the Trainee as well as subsystems such as console on the dynamic simulator.
4. Simulation computers and other interface systems to Dynamic simulator and Virtual Reality systems.
5. Support systems for powering and interfacing with the console as well as other systems mounted on the platform.

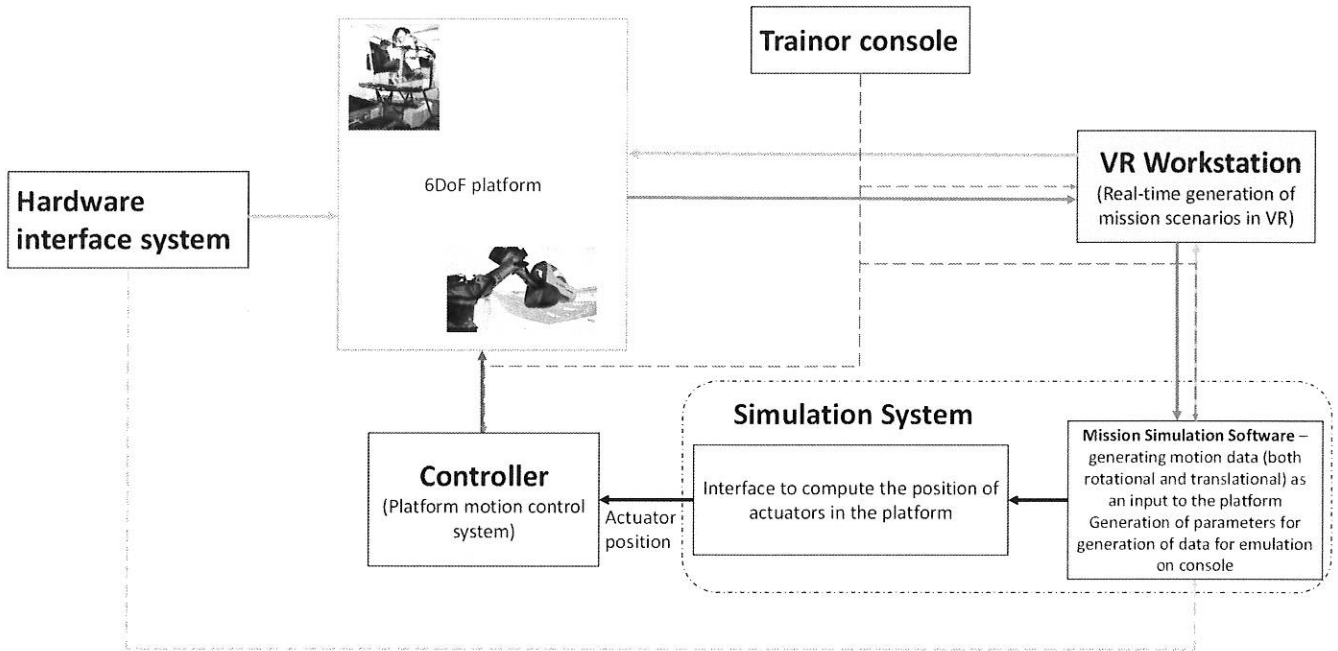


Figure 1: Configuration of DTS

A brief description about the configuration of the DTS is given in this section. DTS shall consist of following subsystems:

1. **6DoF platform** - It consists of the following components.
 - a. 6 DoF platform with specifications as mentioned in Annexure 1.
 - b. **Controller** - motion control system. It will give command to the actuator and regulate the leg lengths and orientation. It shall also have power drive for the actuators to meet the training requirement.
2. **VR subsystems**
 - a. VR workstation for real-time generation of Crew Module interior view as per mission phases and interface to VR headset for real time experience.
 - b. VR headset shall stream the view in real time
 - c. Interface to simulation system for receiving the mission parameters in real time
3. **Simulation System**
 - a. **Mission Simulation Software** - Generates the dynamics data for various mission phases (both rotational and translational motion) as an input to the platform. It also includes other simulation softwares for other subsystems in the Orbital Module and Launch Vehicle.
 - b. **Interface software in Controller** - Interface to compute the position of each actuator for translating the vehicle states to commands for the platform.
4. **Hardware interface system** - Interface to the console or other systems mounted on the platform as well as data acquisition of essential monitoring for the subsystems as well as the Crew.
5. **Payload systems** - Console and other subsystems to be mounted on the platform for carrying out operations during the training. Any support systems

for powering, data interface or drive interface shall also be provided in the form of racks placed near the simulator.

6. **Haptic full body suit** - The suit shall be provided to simulate whole body tracking for usage in the VR simulator as well as provide haptic feedback during operations. It shall also be used to simulate vibration during specific phases of the mission based on the mission information.
7. **Trainer console** - A GUI based system for initiation and control of the simulation by having interfaces with all systems in the simulator.

In addition to the above, essential systems for video monitoring the trainee during the simulation, logging of all essential data etc shall be provided.

4.1 Training requirements in DTS

The training requirements are identified as per given in Table 1 which are to be incorporated in the simulator. To meet each of the below mentioned requirements, hardware and software have to be identified. Table 1 lists down the requirement of hardware and software requirement against each training requirement.

Table 1: Training requirements in DTS simulator

Training requirement	Hardware required	Software required
Multi-Trainee training experience	Motion capture system	Multi-user virtualization platform
Networking and Communication	<ol style="list-style-type: none"> 1. High-speed Server / Workstation/ Storage systems 2. Microphones within the VR Headset 	Audio logging
Haptic feedback	Full-body Haptic vest / suit	
Touch sensation in virtual space	Haptic gloves/ Hand tracking gloves	
Real-time closed loop mission simulation	Linux based Workstation. The specifications to be worked out during implementation phase. Configuration similar to or better than HP Z6G4 (based on previous simulator configuration) is required	<ol style="list-style-type: none"> 1. Integrated Mission Simulation software (deliverable from HSFC) 2. Display Emulation software (deliverable from HSFC) 3. Game and physics engine
Vibration feedback during the dynamic phases of the mission	Full-body Haptic suit	
Dynamics Simulation	<ol style="list-style-type: none"> 1. 6-DOF Platform 2. Payload 3. Integrated power amplifier and real-time controller 4. 6-DOF IMU sensors 	<ol style="list-style-type: none"> 1. GUI for the 6DoF platform 2. Interface software
3D modelling		Modelling in VR platform
View port simulation		Real-time view port simulation integrated with STK
Acoustic simulation	3D Audio Headset	

Training requirement	Hardware required	Software required
Analytics and Data capture	<ol style="list-style-type: none"> 1. External monitors for observers 2. Storage Systems 	<ol style="list-style-type: none"> 1. Instructor-GUI software 2. Testing and Analytics software

4.1.1 Virtual/Mixed Reality requirements

As per the training requirements and configuration, Virtual Reality/ Mixed reality systems shall be designed. It shall have depiction of the Crew Module interior as per the CAD model shared by HSFC, with provision for interactions inside the console including valve operations, console operations etc. The console shall be designed with real time simulation and display changes. Suitable audio simulations shall be included for mission phase simulation.

View port changes during the mission shall be generated based on STK softwares and trajectory of the module during the mission. Relative motion of the module and vibration of systems inside the module shall be simulated. In the on-orbit phase, microgravity simulation shall be included. Any relative motion of the Crew with respect to the module shall be simulated with full body tracking.

The design of the software shall be carried out in open source softwares such as Unity or Unreal (preferable).

4.1.2 6 DoF platform

Following design points need to be considered for the design of 6DoF platform

1. Payload specification
 - a. Number of Trainee - 2
 - b. Interface systems to be mounted around the trainee including console and other interaction systems.
 - c. Mounting structure design for the required Interface systems
 - d. Trainee seat orientation in the platform, as in flight
2. Motion requirements, both translational and rotational motion - specified in Annexure 1.
3. Software interface - GUI software for testing of the platform as well as interface with the simulation system for
4. Mounting options for 6DoF platform
5. Accuracy specifications and bandwidth in the linear and rotational motion are defined in Annexure.
6. Design details of Crew seat orientation as well as console design will be provided for realization by the vendor.

4.1.3 Simulation system

Simulation system consists of softwares for generating the orientation and dynamics information to be used in the Virtual reality system as well as for motion of the platform. The simulation softwares will be provided by ISRO based on the interfaces

defined during the design phase. Provision shall exist to run the simulation softwares in real time.

4.1.4 Trainor console

GUI based system for controlling the test case simulation and monitoring the health of all the systems during the training. It shall have interface with all systems, gather information from all systems, logging of all data, provide video monitoring during the training etc.

It shall provision to start/pause/resume/stop simulation at any point of time and interfaces with backup server for data storage related to training.

4.1.5 Audio communication

During training, Audio communication of the trainee with Trainor shall be enabled with logging provision.

4.1.6 Safety requirements

The platform has provision to have trainee be seated in the platform and carry out dynamic simulation with attitude and rate changes. Hardware and software provisions shall exist in the 6DoF simulator to limit the rates within the allowed values and even due to failure of any interfaces, the rates shall not be exceeded. Provision shall exist in the controller to auto shutdown in case of any errors and return to home position by manoeuvring within the limits defined.

Suitable grounding scheme shall be followed to ensure no electrical shock to the trainee due to any failure. Provision shall exist for the trainee to discontinue the session at any point of time by their own.

Suitable health monitoring and cameras shall be provided along with the platform so that crew's medical condition as well as physical condition can be monitored and logged continuously during the testing. Based on the health monitoring, cognitive load assessment shall also be attempted for the Crew along with participation of ISRO team.

4.2 ISRO Responsibilities

ISRO shall provide the following inputs during the development for the realization of the software

1. Mission Simulation Software
2. Configuration layout for the Crew Module interior
3. Sequence of events for each phase of the mission - both nominal and off nominal cases and joint definition of test cases to be simulated
4. List and design of systems to be placed on the platform as payload.
5. Review and clearance of the design for realization - suitable design forums will be constituted during the project for review.

4.3 Vendor Responsibilities

1. Realization/Development of the 6 DoF platform meeting the specified requirements. Design details of Crew seat orientation as well as console design will be provided for realization.
2. Verification and validation of test cases as defined for all the mission phases needs to be done and demonstrated
3. Trainor console with an Instructor GUI software shall be developed for the front-end operation by the instructor and shall have the provision for commanding and parameter display.
4. VR workstation along with software to generate real-time mission scenarios integrating the VR headset with the DTS
5. Provide full body haptic suit integrated with the simulation system and VR work station for tracking the body movement as well as simulate haptic feedback.
6. Training and knowledge transfer for simulator operation
7. Source Code and design transfer to HSFC
8. Design and Test and evaluation document. The test plan for the evaluation shall be worked out by HSFC and vendor together and shall be reviewed by appropriate committee constituted at ISRO side.
9. Vendor shall be responsible for the maintenance of the product for minimum of 3 years post-delivery including software updates rectification of errors etc.
10. All the required documents (like operating manual/installation reports, hardware design document, software design documents, calibration certificates (if applicable), warranty certificates) as specified by ISRO shall be provided by Vendor
11. All the required software licenses that are used in the product development shall be provided by the vendors for a minimum duration of 3 years
12. Vendor is responsible for conducting the required training sessions for familiarizing the product to ISRO
13. Sub - contracting of any specified activities as well as procurement of equipment's from vendors shall be highlighted.

4.3.1 Facility requirements at vendor site

Following are the facility requirements at vendor site

- The vendor shall have suitable equipment for fabrication of the structures including the platform to be placed on the platform, any console-based systems, seat and other structures.
- Design of Virtual Reality software along with head set programming.
- Design and development of hardware systems, servers, interfaces etc.
- Experience in carrying out closed loop simulations for validating the simulator.
- Provision to carry out harness wiring and integration among the systems.
- QA team for closed monitoring of hardware and software level design.

Necessary computing systems for design of the softwares shall be available with the vendor. Required space for setting up the simulator, carrying out integrated testing shall be available at the vendor site.

4.4 Schedule

Timely delivery is the essence for the Contract and the Party shall take all necessary measures to ensure that the delivery schedule is met without fail. The schedule is given below:

- T0 : PO placement and supply of inputs by ISRO to party
- T0 + 1 month : Configuration design and review by HSFC
- T0 + 4 months : Design completion of the software subsystems
- T0 + 6 months : Availability of all hardware elements at vendor site
- T0 + 7 months : Integration of hardware and software systems.
- T0 + 8 months : Completion of testing and installation at identified place
in

Bangalore specified by HSFC

The delivery schedule projected is inclusive of all time required for the Party to get all export related clearances.

4.5 Vendor Qualification Criteria

Vendor shall meet the qualification criteria as per the Table 2.

Table 2: Vendor criteria

SI no	Evaluation criteria	Vendor's Reply (Specifications or brief details required in place of "Yes/No")
1.	Experience in VR modelling software, preferably in open-source software platform. Compliance to the VR/MR development requirements mentioned in the indent Party to furnish necessary proofs related to completion of previous projects relating to the experience	
2.	Vendor shall have experience in working out the specifications and development of platforms along with control system and shall have delivered similar platforms Compliance to develop the platform as per the specifications mentioned in the indent Party to furnish necessary proofs related to above experience	
3.	Vendor shall have experience in integrating the platform dynamics with the Virtual reality or mixed reality Vendor shall work out block level configuration diagram of the simulator, based on the requirements including hardware identification and software requirements Party to furnish necessary proofs related to development.	
4.	Ability to develop applications for Audio-Video communications and encoding using standard interfaces such as Ethernet.	
5.	Vendor shall have experience in development and delivery of training simulator systems for Aerospace or Automobile industries. Party shall furnish proof towards realization of such simulators and certification of the same for training	
6.	Vendor shall have experience with following technical background: C++, database-based programming and handling real-time programming eg. on Linux.	

SI no	Evaluation criteria	Vendor's Reply (Specifications or brief details required in place of "Yes/No")
7.	Vendor shall have wide experience in development of Embedded systems; software development experience in the system environment with multiple processes, thread-based programming, Device drivers, application software and front-end GUI software development.	
8.	Partial solution is not acceptable. End to end solution to be provided. No splitting of order is permitted.	
9.	List of prospective vendors or sub-contractors for subsystems required in the development	
10.	Details of any prevailing tie up with national or international agencies for development of the system	
11.	Facilities required for the development of the project at vendor site shall be listed	
12.	Compliance to delivery schedule as specified in the indent	
13.	Turnover of the company in last three years	
14.	Man power details of the company with specialized man power in each area related to the project development	
15.	Vendor shall ensure confidentiality of the design inputs provided during the project and handover all the project files/design files to ISRO at completion. The design/files used for realization shall be stored in dedicated servers/systems used for the project.	
16.	ISO certification or equivalent	

4.6 Vendor Selection / Shortlisting methodology

1. Final short listing of vendors shall be based on compliance to qualifying norms (Compliance matrix to be filled by vendor).

4.7 Intellectual Property

Any intellectual property that evolves during the course of this activity will be owned jointly by ISRO and the Vendor.

- 4.8 Government Orders of Preference to Make in India Order NO. P-45021/2/2017-PP(BE-II) dated: 16/09/2020 issued by Department of Promotion of Industry and Internal Trade shall be applicable.

Annexure 1: Specifications of Simulators

Sl no	Parameter	Specification
1.	Payload mass (Two Trainee along with seats, console and structure)	500kg
2.	Total footprint on the platform (For mounting the payload)	2m x 2m
3.	Attitude change	Pitch: 0-180 degrees Yaw: +-90 degrees Roll: 0-360 degrees
4.	Body rate in three axes	± 400 deg/s
5.	Angular acceleration	2250 deg/s ² (max)
6.	Vibration	To be defined as per the mission phase.

* The above specifications are tentative and are subject to change within $\pm 10\%$ during the development of the project.