Request for Proposal (RFP) for 3-Axis Angular Motion Simulator with Thermal Chamber based on Liquid Nitrogen

1.0 Introduction

This document describes the system configuration and required performance characteristics of the electronic and mechanical subsystems and the computer interface requirements of a 3-Axis Angular Motion Simulator with built in Thermal Chamber (TC).

The system shall be of standard configuration with very minimal customization for tabletop and slip ring configuration. **Controller features and their safety provisions and interlocks shall be of field proven type.**

Basically the system comprises of a 3-Axis table with removable thermal chamber compartments, power amplifier and a controller.

The thermal chamber shall be configured in such a way that, the system shall be operated either with thermal chamber or without the thermal chamber by easily removing the thermal chamber compartments. Necessary interlocks shall be implemented to ensure the safety during both the operations.

The system shall be capable of

- Operation from the control console in local mode.
- Remotely from a computer in remote mode.
- Accept analog signals in analog I/P mode.

In local and remote mode, the system should be capable of being commanded in position control mode, angular velocity mode, sinusoidal synthesis and track mode. In analog I/P mode the system should be capable of being commanded either in position control mode or angular velocity mode. It should be possible to command these modes for all the three gimbals.

The controller must provide a flexible and user-friendly environment for the control of the table by way of data entry, display, monitoring and data logging.

It should be possible to make data entry in local mode through touch screen.

In remote mode, it should be controlled by an external computer through any of the built-in computer interface. If the controller is built around two parts like Real Time PC & GUI PC, then all the remote interfaces shall be implemented only in Real Time PC so that even if the GUI PC of control console is not working, it should be possible to operate the system through any of the remote interface

Built in diagnostics, data logging capability and servo debug tools shall be provided to ascertain system health prior to its utilization. The controller must provide features for easy fault diagnosis of the total system.

Quantity : 1 System

2.0 System Configuration

2.1 General

The 3-Axis Angular Motion Simulator must have three gimbals/axis designated as inner, middle and outer. The three axes shall intersect at a common point. The outer axis shall be vertical, middle axis horizontal and inner axis orthogonal to middle axis. The outer gimbal is of open frame design and the middle and the inner gimbals are of closed frame type with two tabletops on the inner gimbal with necessary tapped holes with threaded inserts for mounting the unit under test (UUT). The hole pattern shall be customer specified hole pattern with solid thread inserts with locking keys. In addition, tapped holes with threaded inserts must be provided at suitable locations (details will be provided at later time during CDR) on the inner gimbal frame for anchoring of the cables running between the two platens.

Each gimbal shall be capable of full angular freedom around its support axis and each axis shall be supported on anti friction bearings. The outer axis bearing and drive system shall be housed in a suitable base to permit rigid attachment of the system to the foundation.

A base template hardware along with six point mounting arrangement with precision leveling wedges to permit levelling of the system within ±1" with a range of ±1° must be provided.

2.2 Servo components

The drive for each axis shall be direct drive torquers. The position transducer package for each axis shall be of absolute encoder, directly mounted to the axis shaft and have absolute position encoding. The offered system shall not demand for "Homing" or "Initialisation" as demanded by non absolute position encoding. Each axis shall have a manual clamp with vernier adjustment knob with the resolution of <0.1" and a range of >0.25° and stow locks.

2.3 Static Balancing

Necessary provision shall be incorporated for attaching suitable counter weights to the table top and middle axis for static balancing of the two axis for different size and weight of the payload. Suitable counter weights shall be provided for balancing inner and middle axis.

2.4 Table Top

The table top of the inner axis assembly shall interface with the UUT. Suitable MIL standard connectors mounted at the periphery of the table top shall permit electrical access to UUT. Two sets of mating connectors suitable for both table top and table base connectors must be provided.

The design of the table top attachment to the gimbal should be such that no change takes place in level and azimuth due to repeated dismounting and mounting of the table top. Suitable locating pins (Dowel pins) must also be provided for retaining the

established angular position. Removing the table top must not disturb level and azimuth alignment.

The material used for the table top must be Titanium alloy Ti6Al4V annealed condition, which maintains the level on its entire surface over a period of time. The flatness of the table top must be 30 microns or better for the entire area of the tabletop. The grade of the material used must be corrosion resistant, dimensionally stable and stiff.

Customer specified hole pattern equipped with solid thread inserts with locking keys must be provided, for which detailed drawing will be provided by the user at a later time during CDR. The hole patterns needed for mounting adapter plates for calibration must also be taken care of.

2.5 Thermal Chamber

The thermal chamber shall be realized as two halves, which shall have the provision to attach and detach to the middle gimbal. The thermal chamber compartments shall be well insulated, thermally, to avoid the thermal disturbance inside the chamber due environmental temperature variations and energy loss. Each half shall contain sufficient numbers of heaters and circulating fans so as to avoid any hot spot either in the chamber compartment or on the UUT and ensure uniform temperature distribution with in the chamber. One number of 4 wire RTD shall be provided in each compartment in such a way that they are diagonally opposite. One RTD shall be used for temperature control and other RTD shall be used for monitoring as well as for secondary safety device for lower & upper temperature limits. Necessary plug and lock type connectors shall be provided on the middle gimbal frame and each thermal chamber compartments to establish the electrical connectivity to the heaters, fans and RTDs.

The cooling medium shall be **Liquid Nitrogen (LN_2)**. The passage of cooling medium into the chamber shall be in such a way that, the setup shall be easy to implement, ensure reliable operation over a period of time without any major breakdown, shall not affect the performance of the system in any way and safe to implement regarding human safety. Injection of LN_2 into the chamber shall be in such a way that no cold spots are generated either on the thermal chamber or on the UUT.

Necessary integrated gas monitoring system, gas sensors, controller with audible and visual alarm, shall be included along with the offer and shall be installed along with the system.

Provision shall exist for monitoring windows on both sides of the thermal chamber as well as illumination light suitably protected for temperature and non interfering with UUT.

Provision shall also exist for purging the chamber with dry air or dry nitrogen before the start of thermal chamber operation.

2.6 Temperature controller

The temperature controller and the sensor shall be a 4 wire system. The temperature controller shall be tuned to the maximum extent for stable temperature control as well as optimum usage of cooling medium. It shall have the provision to operate either from the control panel or remotely through the computer. The controller shall have the provision to program the profile and execute them with the provision to pause and resume. Necessary documentation shall be provided regarding the local as well as remote operation of the temperature controller through computer.

Software shall be provided to acquire and store the set temperature and process temperature in the computer.

The controller shall also have the provision to limit the upper and lower value of the set temperature, limit the heating and cooling rate of the chamber temperature and provision to disable the thermal control devices in case of exceeding the lower or upper temperature limits and all these limits shall be user configurable.

2.7 Secondary safety temperature device

The system shall be equipped with a secondary safety device, which shall disable the thermal control devices when the process temperature exceeds the lower or upper set limits. This shall be totally independent from the main temperature controller except that the trip mechanism will be in series to the main temperature controller's trip mechanism.

This system shall also be 4 wire system and shall have the provision to acquire and store the process temperature, lower and upper temperature limit values through a computer.

Software shall be provided to acquire and store the above said values.

2.8 Electrical Access / Slip Rings

Slip ring capsules in all the three axes must be provided for electrical access of the UUT as per the details furnished under system specifications. The wiring schematic of the user slip rings must be furnished in the offer.

Construction of the machine should be such that slip rings of each axis is accessible for maintenance without complete tear down to avoid recalibration of the system.

The slip ring make offered must be of proven make / type especially with regard to specifications like insulation resistance, noise, life etc.

Ultra low capacitance cables shall be used to interconnect the slip rings so as to pass high frequency analog & digital signals through the slip rings.

Maximum frequency of the signals that can be passed through each type of slip ring shall be clearly mentioned in the offer.

The life of the slip rings offered in terms of number of millions of rotations shall be clearly mentioned in the offer.

2.9 Test Payload

A standard test inertia (of 1.40 Kgm^2 about inner axis and 3.75 Kgm^2 about middle axis) package must be delivered, which will be used to verify the system performance periodically and for calibration of the system.

2.10 Reference level surface

Necessary reference level surface must be provided on the middle & outer gimbal to check the level of the table after installation and for periodic verification.

2.11 Alignment

Necessary adapter sets to attach alignment mirrors, cube and polygon shall be listed in the offer and provided along with the system to conduct necessary system alignment / accuracy tests, calibration tests and payload alignment with respect to gimbal axes.

2.12 Mounting Holes on Outer gimbal

Mounting holes (4 numbers square pattern) should be provided on both sides of outer gimbal (bottom) for fixing of reflecting mirror later. (Drawing will be provided during CDR)

2.13 Thermal Management

Necessary forced air-cooling must be provided in order to avoid any hot spots in the sub systems namely controller, Power amplifiers etc.

2.14 Spares

Essential spares like 1xPower Supply for the controller, 1xAuxiliary Power Supply for the Power Amplifier, 1xPower Amplifier for each axis (3 Nos), 1xPower Amplifier Filter for each axis (3 Nos), 1xAxis Controller Card, Set of Fuses, 10xLimit Switches, 1xReal Time Controller Computer, 1xReal Time Controller Backplane, 1xOperator Interface Panel PC, 2xHeaters, 6xCirculating Fans, 6x4-Wire RTDs, 1xTemperature Controller and 1x Electrical Connector for Thermal Chamber must be quoted as an option. Any other essential spares other than the above required for the system shall be explicitly spelt out and quoted as an option.

3.0 System Specifications

3.1.0 General

3.1.1 Payload

a.	Package envelope	:	660mm dia x 650 mm high
b.	Table top size	:	660mm diameter for both table tops

Distance between the table tops : 660 mm

Note: Detailed drawing to be submitted to the user for approval and any change in size, hole pattern and any cut outs required to be confirmed before releasing for production.

c. Package weight

Nominal : 60 Kg
Maximum : 100 Kg

3.1.2 User Slip Ring and Electrical access to UUT

a. Mechanical

i. 9 pairs of 5A at 150 Volts DC twisted and pair wise shielded (18 lines).
ii. 50 pairs of 2A at 150 Volts DC twisted and pair wise shielded (100 lines).
iii. 10 lines of 2A at 150 Volts DC individually shielded (10 lines).
iv. 6 numbers of MIL standard 1553 bus (6 x 4 lines).
v. 4 numbers of Full Duplex RS485 bus (4 x 4 lines).
vi. 1 number of shield line for every connector.

Note : The slip ring wiring drawing including the spare rings to be submitted along with the offer and any small changes as may be required to be incorporated before releasing for production.

b. Electrical

i Noise : <30 milli ohms for two lines at a rate 10 deg/sec
* two lines will be tested in series
* one line means three rings in series
* this shall include MIL-1553 & RS485 lines also

ii. Insulation : >500 Megohms @ 250 V DC
* Between any slip ring and chassis
* Between any two slip rings

3.1.3 Dimension

The detailed dimensions along with mass of the 3-axis table with and without thermal chamber, control console and power amplifier rack shall be submitted along with the offer and shall be included in the instruction manual and supported by all mechanical drawings.

3.1.4 Mechanical axis specifications

a. Angular freedom : **continuous for all the three axis**

b. Wobble : < 2 arc sec for all the three axis

c. Orthogonality

c.1 Between Inner & Middle axis : < 3 arc sec

c.2 Between Middle & Outer axis : <3 arc sec

d. Gimbal Structure

d.1 Inner : Closed gimbal with two table tops

d.2 Middle : Closed gimbal

d.3 Outer : Open gimbal

3.2.0 System performance specifications

Sl. No	Parameter	Unit	Specification		
			Inner axis	Middle axis	Outer axis
1	Position Accuracy	arcsec	±2	±2	±2
2	Position range	deg	0 to ±180	0 to ±180	0 to ±180
3	Maximum rate	deg/sec	±1000	±500	±300
4	Maximum peak acceleration peak with standard load and w/o TC	deg/sec^2	±1200 @ 1.4 Kgm^2	±600 @ 3.75 Kgm^2	±200
5	Maximum continuous acceleration peak with standard load and w/o TC	deg/sec^2	±600 @ 1.4 Kgm^2	±300 @ 3.75 Kgm^2	±100
6	Rate accuracy averaged over 360 deg, entire rate range, with & w/o TC	ppm	< ±10	< ±10	< ±10
7	Rate stability averaged over 360 deg, entire rate range, with & w/o TC	ppm	< ±1	< ±1	< ±1
8	Rate stability averaged over 10 deg, 5 to 10 deg/sec range, with & w/o TC	ppm	< ±25	< ±25	< ±25
9	Rate stability averaged over 1 deg, 0.1 to 5 deg/sec range, with & w/o TC	ppm	< ±150	< ±150	< ±150
10	Position Resolution	deg	0.00001	0.00001	0.00001
11	Rate Resolution	deg/sec	0.0001	0.0001	0.0001
12	Small signal Bandwidth with standard load and w/o TC	Hz	50 @ 1.40 Kgm^2	20 @ 3.75 Kgm^2	20
13	Flatness of frequency response in the pass band	dB	± 1dB up to 10 Hz, < +2dB over the rest$^{\$}$	± 1dB up to 10 Hz, < +2dB over the rest$^{\$}$	± 1dB up to 10 Hz, < +2dB over the rest$^{\$}$

The following points may be noted:-

a. The small signal bandwidth figures given are on the basis of –3dB gain or –90 deg phase lag, 'Whichever occurs earlier'

b. The torque motors must be sized to give problem free operation within the specified dynamic range. It is expected that the system when exercised to verify the small signal bandwidth will operate flawlessly over sustained periods without motor or power amplifier over temperature trip.

Motor type :- Direct drive, BLDC or Permanent Magnet AC

c. Frequency response$:-

Necessary servo settings/adjustments shall be made to ensure that the response is as flat as possible in the pass band (not exceeding ± 1.0 dB up to 10 Hz and < +2 dB over the rest of the range).

d. The lowest integrated mechanical resonance frequency of the system should be as high as possible so that it does not constrain the dynamic response.

e. All efforts must be made to achieve the best possible figures for rate stability & accuracy (for all axes). FAT shall include demonstration of the required servo settings to achieve this specification.

3.2.1 Thermal chamber performance specifications

Temperature range	: -40°C to +100°C
Maximum rate of heating	: 3°C/min
Maximum rate of cooling	: 3°C/min
Temperature reading accuracy	: ±1°C
Temperature stability	: ±1.5°C (instantaneous)
Spatial temperature uniformity	: ±2°C

4.0 Controller Operating modes

The following shall be provided.

4.1 Position Mode

For moving to a fixed position, the system must take the shortest route to the new position. The system must accelerate to a constant rate and decelerate to the commanded position without any overshoot. The rate and acceleration limits must be user programmable and independent of data entry window.

Data entry shall be either manual in local mode or by computer in remote mode.

Rate and acceleration must be contained to programmable limits so that smooth motion trajectories are maintained.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.2 Rate Mode

This mode is for moving the axis at a constant rate. The system must accelerate at a constant acceleration until the commanded rate is achieved. The actual rate must not overshoot the commanded rate. The maximum commandable rate and acceleration limits must be user programmable and independent of data entry window.

Data entry shall be either manual in local mode or by computer in remote mode.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.3 Synthesis Mode (for sinusoidal motion)

The axis oscillates at a commanded amplitude (position or rate) and frequency. Provision shall exist to sweep either amplitude or frequency or both. The sweep rate for amplitude and frequency shall be user programmable. The sweep mode shall be user selectable between logarithmic and linear.

It shall be possible to combine the sinusoidal motion of commanded amplitude and frequency over a DC rate also.

The rate and acceleration limits must be user programmable and independent of data entry window

Data entry shall be either manual in local mode or by computer in remote mode.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.4 Track Mode

It should be possible to track an arbitrary motion profile commanded by an analog signal or through a digital interface. When commanded through a digital interface, the remote computer outputs a sampled data series of motion state vectors (eg:- position, rate and acceleration). The system shall be commanded with any combination of position, rate and acceleration vectors (position vector alone or position and rate vector or position, rate and acceleration vector).

In any case the motion shall be self contained with in the rate and acceleration limits defined for this mode in the system.

The rate and acceleration limits must be user programmable and independent of data entry window

Data entry shall be either manual in local mode or by computer in remote mode.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.5 Abort Mode

In the event of any situation, where any or all the axis servo has to be disabled, the respective axis or all the axis depending on the error condition shall enter into abort mode, where the axis motion shall be brought to stop with the controlled deceleration. The deceleration value shall be user programmable and independent of data entry window.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.6 Analog command

The analog input ports on the I/O panel must be enabled for position or for rate control from a function generator or other analog source.

Position and rate scale factors and bias must be user programmable so that $\pm$ analog input range can correspond to any desired full-scale range.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.7 Real Time Mode

In order to implement a smooth trajectory in real time to any combination of the three axis, the offered controller shall have the highest servo loop update frequency but not lower than 1 KHz. The demand from the host computer shall get updated in multiples of the servo frame rate which shall be 1 millisec/frame or better. The system shall be commanded with any combination of position, rate and acceleration vectors (position vector alone or position and rate vector or position, rate and acceleration vector). Provision shall exist to configure the data update rate on the real time interface, demand state vectors (position only, position + rate, position + rate + acceleration), configure the dynamics of the system (bandwidth) and monitoring variables to be read back by the host controller during this mode of operation.

The rate and acceleration limits must be user programmable and independent of data entry window

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

4.8 Controller Manual

Detailed controller manual illustrating all the demanded features and provisions shall be attached along with the offer. If required, soft copy of the same is also sufficient. If available, a demo version of the controller software shall be made available to the user, in order to validate the features and provisions claimed in the offer.

5.0 Axis Servo Configuration

Provision shall exist to configure the direction sense of axis (increasing angle as either CW or CCW), offset the position by any angle within the range.

The settings must be user programmable and independent of data entry window

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

6.0 Data readout

6.1 Absolute position readout system

Outputs from the position transducer must be accessible both at touch panel display and by a computer via a standard bus interface. The output display must include absolute angles in degrees and the rate at any instant. The display parameters shall be user configurable between any of the system variables like axis position, rate, acceleration, position demand, rate demand, synthesis amplitude demand, synthesis frequency demand, current synthesis frequency, axis control cards temperature, output torque command values, analog input values

6.2 Analog outputs

It should be possible to view the internal variables as analog outputs on an oscilloscope/recorder. All output ranging and scaling must be user configurable. The analog output parameters shall be user configurable between any of the system variables like axis position, rate, acceleration, position demand, rate demand, synthesis amplitude demand, synthesis frequency demand, current synthesis frequency, axis control cards temperature, output torque command values, analog input values, internal controller power supply values, position sensor outputs, etc.. The list of variables available for monitoring must be furnished along with the offer. Two analog outputs per axis (total 6 nos) shall be provided.

The parameter, low range, high range, channel must be user programmable.

Data entry shall be either manual in local mode or by computer in remote mode.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

6.3 Event pulses

A termination must be provided for monitoring of the event pulses, which are position dependent TTL pulses triggered at equally spaced positions over the full range of the motion travel. It should be possible to select the number of pulses per revolution. Each axis shall have independent event pulse output.

The pulse width, number of pulses per revolution, active high or low must be user programmable.

Data entry shall be either manual in local mode or by computer in remote mode.

Each axis shall have independent setting. Provision must exist to save and restore this setting for each UUT configuration in a single file

7.0 Data logging

Provision shall exist to log any combination of the system variables as listed above. Provision shall exist to log maximum of 32 channels simultaneously in synchronous to the servo frame rate (user configurable number of frames per sample) to the maximum of $2x10^6$ samples ($32 \times 2 \times 10^6$ data). The start of the data acquisition shall be either manual or event triggered. In case of event trigger, provision shall exist to configure the event such as threshold parameter value, +ve or –ve triggering. Provision shall exist to configure pre-trigger event also in terms of no of samples or percentage of total number of samples configured.

Provision shall exist to store the acquired data either in the operator interface panel PC or other locations with user defined file names.

8.0 Computer interfaces

It should be possible to control the system through any of the computer interface listed below in remote mode. All the functional modes must be available to the system user in the remote mode through the computer interface. It must have a capability to connect a host computer through the following interfaces:-

a. General Purpose Interface Bus - IEEE 488.2
b. LAN Interface - (TCP/IP)
c. Real Time Interface – SCRAMNet
d. Pseudo Real Time Interface – UDP

PCI or PCI-Express bus interface based SCRAMNet card with interconnecting optical patch cable shall be supplied separately along with the system for use in host computer.

9.0 Servo loops

The Servo loops should be software configurable for easy adaptation for varying test loads in position and rate modes. The servo gain/compensation adjustments due to inertia variation through software are very important requirements for operational convenience and trouble free operation and must be provided as a standard feature.

Provision shall exist for either auto tuning or manual tuning of the servo for each axis of the system. In both cases the detailed procedure for tuning shall be specified in the offer and shall be included in the instruction manual.

In any of the case, the maximum rate and acceleration imparted on the axis shall be user configurable, so as to take care of the UUT dynamic capability and shall not exceed the limits in any case.

The rate and acceleration limits must be user programmable and independent of data entry window

Each axis shall have independent setting. Provision must exist to save and restore this setting along with tuned servo parameters for each UUT configuration in a single file

10.0 Safety provisions and Interlocks

The following safety provisions and interlocks must be provided.

10.1 Rate trip

These are self-latching interlocks, which disconnect power to the motors when the pre-selected rate is exceeded in any mode of operation. This shall be possible through settings in the console through software. Each axis shall have independent setting. It must be possible for the user to configure this setting. Provision must exist to save and restore this setting for each UUT configuration in a single file.

10.2 Manual clamps

The system shall be provided with manual clamp with fine adjustment knob on each gimbal to enable the respective gimbals to be clamped manually at any angular position rigidly and provide fine adjustment capability. In this case interlock switches shall be provided for each gimbal to prevent energizing the torquer motor on a particular gimbal, when the gimbal is clamped. The resolution of the movement by Vernier movement shall be <0.1" and the maximum movement in the clamped condition shall be >0.25°.

10.3 Stow locks

Each axis shall be provided with manually operated stow lock. Inner and Outer axis shall be lockable in one position where as Middle axis shall be lockable in four positions (2 vertical and 2 horizontal). The servo operation must be inhibited, if the stow lock is engaged.

10.4 Rate clamp

Necessary rate clamps shall be provided in each axis of the system for the safety of the UUT in rate mode of operation. When the commanded rate exceeds the set rate limit value, the system must clamp to the set value of rate. This shall be possible through settings in the console through software. Each mode of operation shall have independent setting. It must be possible for the user to configure this setting. Provision must exist to save and restore this setting for each UUT configuration in a single file.

10.5 Rate and Acceleration limits

It shall be possible to program and control the rate and acceleration limit for each mode of operation of the system namely Position mode, Rate mode, Sine Synthesis mode, Track mode and Abort mode. Provision shall exist to ensure that these setting

doesn't exceed the extremes of the system capability. These limits shall be in force during the servoed operation of any of the axis including servo tuning. This shall be possible through settings in the console through software. Each mode of operation shall have independent setting. It must be possible for the user to configure this setting. Provision must exist to save and restore this setting for each UUT configuration in a single file.

10.6 Position limiting provision

Necessary provision shall be made to limit the gimbal positions independently for each gimbal over the entire dynamic range. This shall be possible through settings in the console through software. It must be possible for the user to configure this setting. Provision must exist to save and restore this setting for each UUT configuration in a single file.

10.7 Servo disable

A disable button must be provided on the front panel of controller which when pressed stops motion in all the axis and disables the servo as a safety feature.

10.8 Emergency off

An emergency off push button with latch must be provided on the front panel of controller rack which when pressed disables the power to the power amplifiers as a safety feature.

10.9 Servo loop component temperature

Torque motor temperature, power amplifier temperature and axis control card temperature monitoring and interlock must be provided. In the event of temperature exceeding the limits, the respective axis must shut down.

10.10 User Disable Jumper

A jumper shall be provided either at the base of the table or inside the controller rack (location to be decided during CDR), which when opened makes all the served axis to enter into abort mode and come to rest with preprogrammed deceleration defined by the user in abort mode and then the power to the drives shall be removed.

10.11 Thermal chamber temperature

The thermal chamber system shall be provided with three levels of temperature protection and all the levels shall be connected in series. As the first level, the temperature controller itself shall have the provision with user programmable upper and lower temperature limits, which when exceeded will disable the thermal control. This setting shall be latched. As a second level of protection, an independent secondary safety thermal device with independent 4 wire RTD shall be provided with user programmable upper and lower temperature limits, which when exceeded will disable the thermal control. As the third level, the thermal chamber shall be provided with fusible over temperature protection device. Fusible bulbs shall be provided with

different temperature ranges starting from 80°C to the maximum range of the chamber. Provision shall also exist to heat the shafts of the corresponding axis, when the chamber temperature goes below the permitted design temperature of the bearings.

11.0 Installation and other requirements

11.1 System Power requirements

The system power requirements shall be clearly spelt out in the offer. The system shall be compatible to Indian power conditions (400V, 50Hz Three Phase). The peak power and nominal power requirement also shall be included in the offer. Any specific requirement for the electrical safety device for the incoming supply to the system shall be clearly spelt out in the offer.

11.2 Foundation

The foundation details duly supported by necessary calculations must be submitted along with the offer. The construction of the foundation as per the design will be IISU's responsibility. However, the grouting of the base template to the foundation will be the responsibility of the supplier.

11.3 Critical Design Review

A comprehensive CDR document, including all the details shall be submitted to the customer for clearance before commencing the manufacturing.

11.4 Safety Requirements

All the safety requirements that has to be implemented related to the exhaust gases during the operation of the system with thermal chamber has to be spelt out in the offer.

11.5 Pre-shipment inspection, testing and training

Pre-shipment inspection and testing of the system shall be conducted in the presence of customer at manufacturer's facilities to verify all the system specifications in full system configuration. All the performance specifications shall be demonstrated during the pre-shipment inspection, including wobble of middle axis. The system shall be tested along with thermal chamber also for temperature stability, extreme temperature range and a typical temperature profile test with controlled rate of cooling and heating. Slip ring insulation measurements shall also form part of the pre-shipment inspection and testing. The manufacturer shall prepare an acceptance test plan and procedure, which shall address comprehensively to all aspects including a time table and the number of working days and have it reviewed and approved by the customer. Testing shall include verification of performance over sustained periods. Spares supplied along with the system shall be tested for functionality by substituting into the system. Training shall be imparted to the customer's representatives. Detailed acceptance test plan and procedure to be submitted along with the offer.

11.6 Installation, commissioning and acceptance testing at customer's site

The manufacturer must install and commission the system at customer's site. Acceptance test shall be carried out after installation to demonstrate the system performance and shall be as comprehensive as the FAT. The customer acceptance testing must include critical tests like Position accuracy, wobble, orthogonality etc. The system shall be tested along with thermal chamber also for temperature stability, extreme temperature range and a typical temperature profile test with controlled rate of cooling and heating. Any impracticability in this regard must be specifically addressed and agreed by the customer. Detailed acceptance test plan and procedure to be submitted along with the offer.

11.7 Documentation

The documentation shall include system parameters and ratings including maximum torque value for continuous operation of the three axes, mechanical configuration drawings, electrical schematics, circuit diagrams, interconnection diagrams, operational manuals, service cum troubleshooting manuals, part list, software manuals, procedure for transducer calibration, calibration and acceptance test procedures and results. The instruction manual, technical details and manufacturer's certificate of brought out items like power amplifier, motor and slip ring must also be supplied. All documents shall be in English and supplied to the customer in duplicate.

11.8 Warranty

All items shall be under warranty for a period of at least one year from the date of successful installation and commissioning at customer's site. Service support and availability of the spares must be ensured even after the expiry of the warranty for a period of at least 10 years.

All hardware/software updates on controller that are brought out during the warranty period shall be installed in the system free of charge together with the necessary documentation.

11.9 Price

Cost and risk up to unloading at installation site (IISU, Trivandrum) shall be to seller's account. The unpacking of the machine and installation on the foundation shall be the seller's responsibility. The necessary tools required for installation shall be arranged by the supplier. Cost impact on account of departure from standard system configuration e.g. additional remote interfaces, spare cards, sliprings, components etc. must be spelt out.

The cost for Installation and Commissioning shall be separately mentioned in the offer.

Mode of transportation shall be explicitly mentioned in the offer.

Also, if there is significant cost impact due to any specifications, it may be identified as an option.

11.10 Insurance

Warehouse to warehouse transit insurance to be borne by the supplier.

11.11 Delivery Schedule

a. Quotation shall include the end user statement format for export license, if applicable. This will enable IISU to submit the signed end user statement along with purchase order.

b. The supplier should make all efforts to obtain the export license, if applicable, at the earliest from the date of the purchase order and intimate the same to IISU.

   The CDR documents to be submitted within two months from the date of export license. In case of non-applicability of export license, the CDR documents to be submitted within two months from the purchase order.

c. CDR documents shall be complete in all respects and upon submission of CDR documents, IISU will review and submit the comments/clearance paper on priority.

d. Base template and outer axis slip ring protection enclosure hardware along with anchoring tools and levelling wedges shall be supplied to IISU, within two months from the date of clearance of CDR documents.

e. Exact schedule of pre-shipment inspection shall be communicated to IISU at least two months in advance from the date of FAT.

f. The system shall be offered for Factory Acceptance Testing within 9 months after the submission of approved CDR by IISU.

g. The system shall be installed, commissioned and CAT shall be performed, within 2 months from the date of intimation of site readiness from IISU.

11.12 Customer's List

Detailed list of Indian customers for similar configuration systems along with the P.O date & date of supply should be provided along with the offer.

11.13 Service Support

a. The details of the service support available for the offered system shall be clearly mentioned in the offer.

b. The methodology of providing the service support during warranty and post warranty shall be clearly spelt out in the offer.

c. The details of the service center along with the competency of the personal within the country shall be clearly spelt out in the offer.

12.0 Submission of Technical and Commercial price bids

This is a **two-part tender** enquiry. The quotations are invited in **two parts in separate sealed covers**.

Part 1 :- This sealed cover shall contain technical details covering all the technical aspects with necessary technical attachments, literature, supporting documents, catalogues, data sheets, **compliance statements of each point of the RFP**, commercial terms and conditions **without mentioning the cost. Unpriced Copy of Priced Bid shall be made available in this sealed cover**.

Part 2 :- This sealed cover shall contain only the commercial bid with cost.