भारतीय उष्णदेशीय मौसम विज्ञान संस्थान
(पृथ्वी विज्ञान मंत्रालय, भारत सरकार का एक स्वायत्त संस्थान)
डॉ. होमी भाभा मार्ग पाषाण, पुणे- ४११ ००८
IITM
INDIAN INSTITUTE OF TROPICAL METEOROLOGY
(An Autonomous Institute of the Ministry of Earth Sciences, Govt. of India)
Dr. Homi Bhabha Road, Pashan, Pune - 411 008. India

150 YEARS OF CELEBRATING THE MAHATMA

सं. पीएस/125/07/2025 दिनांक – 03 जूलाई 2025

सेवा में / To,

विषय- एसटीबी, टोमो, स्टीरियो, पीएफपीआईवी, पीटीवी और बीओएस क्षमताओं के साथ टोमोग्राफिक पार्टिकल इमेज वेलोसिमेट्री (टोमो-पीआईवी) (उच्च गति और निम्न गति उपप्रणालियां) की आपूर्ति, स्थापना और कमीशनिंग - मात्रा 01 सेट की खरिद के संदर्भ में।

Sub – Supply, Installation & Commissioning of Tomographic Particle Image Velocimetry (Tomo-PIV) (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities Qty. 01 set

संदर्भ - इस संस्थान का दिनांक 22/05/2025 समसंख्यक निविदा जांचपत्र

Ref - This Institute's Tender enquiry of even number dated 22/05/2025

प्रिय महोदय/ Dear Sirs,

यह संस्थान उपरोक्त विषयानुसार सामग्री की खरिद करना चाहता है। इसलिए इच्छुक बोलीदाताओं से अनुरोध है कि अपनी तकनिकी तथा कीमत बोली निम्नलिखित निर्देशानुसार प्रस्तुत करें।

This Institute wishes to procure goods as per subject cited above. Therefore, interested bidders are requested to submit their Technical and Price bids as per the instructions given below;

बोली प्रस्तुत करने की अंतिम तिथि 19 जून, 2025 से 17 जूलाई, 2025 को 1500 बजे तक बढाई जाती है।

The last date of submission of bids is extended from 19th June, 2025 to 17th July, 2025 upto 1500 hrs.

तकनिकी बोली उसी दिन 1530 बजे ऑनलाइन पद्धती व्दारा खोली जाएगी ।

Techical Bids will be opened on the same day at 1530 hrs. through online mode only.

तकनिकी विशिष्टीकरण और अन्य सभी विनिमय एंव शर्ते अपरिवर्तित रहेंगी।

Technical specifications and all other terms and conditions will remain unchanged.

बोलीदाता जो उपर्युक्त निविदा में भाग लेना चाहते हैं, उन्हें वेब पोर्टल https://moes.euniwizarde.in पर उपलब्ध सूचना के अनुसार पंजीकृत करना होगा।

Bidders willing to participate for the above tender, has to get registered themselves on web portal https://moes.euniwizarde.in as per the instruction available at there.

धन्यवाद / Thanking you.

भारतीय उष्णदेशीय मौसम विज्ञान संस्थान Indian Institute of Tropical Meteorology आय.आय.टी.एम. I.I.T.M. Pune-8 पुणे-8

3/7/2025

(श्रीमति योगिता कड / Smt. Yogita Kad)
प्रशासनिक अधिकारी / Administrative Officer
कृते निदेशक / for Director
ईमेल /e-mail : psu.iitm@tropmet.res.in

भारतीय उष्णदेशीय मौसम विज्ञान संस्थान, आईआईटीएम

Indian Institute of Tropical Meteorology, IITM

Minutes of the Technical Evaluation Committee (TEC) Meetings No. 07 and 08

TEC Members

The Director, IITM, Pune has constituted the above TEC for processing IITM part of Mission Mausam instruments vide office order no. Comm./2024/208 dated October 28, 2024.

Minutes of Meeting No. 08

Agenda:

1) Review the changes by the PIs and the justifications, if any, and finalize the technical specifications of the 03 instruments - Aerosol Lidar with extended capabilities (02 nos.), and

Digitally signed by BABASAHEB TUKARAM PAWAR
Date: 2025.07.03 13:26:03 IST

Impact Disdrometer (JWD, 20 Nos.) and Skycast instrument (02 nos.).

2) Prepare the pre-bid minutes for the GTE bids of PTRMS, Tomo PIV and PDI+LDV based on the queries raised by the bidders and the responses by the PIs to those queries

3) New proposals of the 05 instruments – (1) Differential Optical Absorption Spectrometer (DOAS, Qty.=03 for ATCOMP and Qty.=04 nos. ACROSS), (2) High Resolution Gas Chromatograph Mass Spectrometer with Thermal Desorption unit (GCMSMS with TD, Qty.=01 nos. for ATCOMP), (3) Integrated Confocal Raman Microscope, Combined Scanning and Transmission Electron Microscope with Shared EDX for Automatic Microplastic and Nanoplastic Particle Identification with Elemental Composition (Integrated Raman Microscope, Qty.=01 nos.), (4) Eddy Covariance Systems (EC systems, Qty.=23 for OBSERVE_ALL, Qty.=05 for ATCOMP, Qty.=04 for WEATHER_MOD) and (5) Aerosol and Ozone Lidar (Qty.=01 nos.).

Meeting No. 08 of the TEC was convened at Sikka Hall on June 12, 2025 from 03:30 pm to 05:30 pm in hybrid mode (online + offline); Shri. V. Gopalakrishnan, Shri. P. Murugavel, Dr. Manish Ranalkar and Prof. Bhas Bapat could not attend the meeting.

At the outset, the Chair extended a warm welcome to all members of the committee. The agenda points were then sequentially discussed and deliberated upon by all members present.

---

2. Prepare the pre-bid minutes for the GTE bids of PTRMS, Tomo PIV and PDI+LDV based on the queries raised by the bidders and the respective responses by the PIs

(B) **<u>Prebid minutes of Tomographic Particle Image Velocimetry (Tomo-PIV) PIV (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities - Qty. 01 set -</u>**

For the Tomo PIV system (PI – Dr. Shivsai Ajit Dixit) that was processed earlier through this TEC, the GTE bid was floated and two bidders (and their Indian Agents) participated in the prebid meeting. TEC noted that the queries by the bidders are mainly technical in nature. TEC carefully went through the queries and scrutinized the draft responses prepared by the PI. The TEC noted that all the queries of both bidders have been satisfactorily addressed. It is noted that M/S Dantec Dynamics, Denmark (Indian Agent M/S Laser Science Services Pvt. Ltd.) in their prebid queries stated that "we do not have/support 3D BOS as well as 3D Shadowgraphy". They further requested a relaxation of the specifications on these two techniques and suggested "You may kindly put this in the optional items if you feel the absolute need for these method in your experiments/applcaitions". The committee deliberated on this request and concluded that 3D BOS and 3D shadowgraphy techniques cannot be considered optional items since these are essential for quantifying convective

plumes and shapes of cloud droplets in the cloud chamber. Further, the committee also noted that these techniques have been published in the peer reviewed literature many years ago (see Di Nunno et al 2020 Meas. Sci. Technol. For 3D shadowgraphy and Raffel 2015 Exp. Fluids for 3D BOS). Finally, the TEC also deliberated upon moving some items from either of the subsystems to optional items' list for making efficient use of the resources. A list of such items is also indicated at the end of the document that contains the prebid queries and IITM responses to them. The technical specifications of "Tomographic Particle Image Velocimetry (Tomo-PIV) PIV (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities - Qty. 01 set", revised based on the above-mentioned points, are also attached. The TEC recommends the document of prebid queries and IITM responses (attached) and the revised technical specifications (attached) for approval of the Director, IITM. After approval, the prebid responses may be communicated to the bidders. This point (B) along with the prebid queries, IITM responses, and revised technical specifications is the **Prebid minutes** of the "Tomographic Particle Image Velocimetry (Tomo-PIV) PIV (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities - Qty. 01 set" and these **prebid minutes** are recommended by the TEC for approval of the Director, IITM.

Recommendations of TEC after meeting no. 08:

1. The instruments Aerosol Lidar with extended capabilities (02 nos.), and Impact Disdrometer (JWD, 20 Nos.) and Skycast instrument (02 nos.) are recommended by the TEC for further processing after reviewing the justifications (if any) provided by the PIs and the revised technical specifications.
2. The prebid minutes of PTRMS instrument, Tomo PIV system and PDI plus LDV system are prepared by the TEC including the responses to the prebid queries and the revised technical specifications. TEC recommends them for further processing.
3. The instruments Differential Optical Absorption Spectrometer (DOAS, Qty.=03 for ATCOMP and Qty.=04 nos. ACROSS), High Resolution Gas Chromatograph Mass Spectrometer with

Thermal Desorption unit (GCMSMS with TD, Qty.=01 nos. for ATCOMP), Integrated Confocal Raman Microscope, AND Scanning and Transmission Electron Microscope with Shared EDX for Automatic Microplastic and Nanoplastic Particle Identification with Elemental Composition (Integrated Raman Microscope, Qty.=01 nos., SEM-EDX Qty.=01 nos.) and Eddy Covariance Systems (EC systems, Qty.=23 for OBSERVE_ALL, Qty.=05 for ATCOMP, Qty.=04 for WEATHER_MOD, Qty.=05 for ACROSS ART) are recommended by the TEC for further processing after reviewing the revised technical specifications.

4. TEC recommends to consider the case of Aerosol and Ozone Lidar (Qty.=01 nos.) in the next meeting.

Meeting ended with thanks to the Chair.

Enclosed:

1. Technical specifications and justifications, if any, signed by the respective PI(s) of the instruments that are recommended by the TEC for further processing.

Director, IITM is requested to kindly **approve** the following:

1. Minutes of the Technical Committee meeting No. 07 and 08 as above.
2. Uploading of the prebid responses and revised technical specifications (from the prebid minutes) for PTRMS, Tomo PIV system and PDI plus LDV system with an extension of 03 weeks, as per requirement, in each of the cases.

Digitally signed by BABASAHEB TUKARAM PAWAR
Date: 2025.07.03 13:26:03 IST

Prebid queries and IITM responses
Tomographic Particle Image Velocimetry (Tomo-PIV) PIV (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities - Qty. 01 set
(PI – Dr. Shivsai Ajit Dixit)

The following technical points are raised / noted by the two firms and the responses by IITM (in italics following >>>) are listed.

(1) Queries by M/s LaVision, GmbH, Germany (Indian Agent – Tesscorn AeroFluids Inc., India)

a. Do we need to submit the supporting documents as the software module screenshots, manuals, published research papers on 2DPIV/STEREOPIV/TOMOPIV/STB/2D-3D Shadowgraphy/2D-3D BOS/ Simultaneous LIF Concentration & Temperature with 2DPIV/STEREOPIV?

   >>> *Publications in peer-reviewed journals are to be submitted to demonstrate the capabilities of the system being offered. Other documents may be submitted as information. The bidders should make a table listing each technique/capability of the system and the citations of the publications supporting it. The pdf copies of these publications should also be submitted. Please see the revised technical specifications.*

b. Low speed laser: Military standard, monolithic design: to accept vibration and to maintain pulse-pulse stability. Do we need to submit the supporting document on the software module screenshot to show the 4 pulse beam combination (laser multiplexer)? High speed laser: monolithic design: to accept vibration and to maintain pulse-pulse stability. Rep rate: Single shot to 10KHz. Humidity indicator on the laser head.

   >>> *It is clarified that the explosions in the mine testing field of a defense lab close to the IITM campus could pose serious concerns regarding stability of lasers in terms of beam alignment / overlap etc. as per our experience till date. Such issues are expected to become more acute given the tall structure of the proposed cloud chamber and possible positioning of lasers at different levels along the height of the chamber on fabricated platforms. Therefore, monolithic construction of lasers (for both low-speed and high-speed subsystems) is an essential technical requirement that has been added to the revised technical specifications.*

   For the laser of the low-speed subsystem, two double-pulsed PIV lasers are to be combined to generate a range of repetition rates and pulse energies as per the tender specifications. Supporting documents demonstrating the tests carried out at the vendor's end are an essential part of the technical bid document since this approach is to be implemented by the vendor and is not available as an off-the-shelf item from the laser manufacturers.

c. We recommend to have two sets of System computers (one for Image acquisition and other for processing).

>>> The acquisition system and processing system are to be separated by providing two separate computers with specifications optimized to do these tasks separately. The modifications are included in the revised version of the technical specifications.

d. Software licenses: one full hardware control license for Image acquisition system computer, one analysis license for processing system computer, network user license to be used with HPC Server (we need to specify the number of network users who will use the software simultaneously).

>>> The PIV software license on the acquisition system computer shall be a full standalone software license that would have full capabilities of all hardware control as well as all processing features. The PIV software license on the processing system computer shall be an analysis license that would have all processing features.

The tender asked for HPC license of PIV software to be quoted as an optional item. The intent was to use the GPU capacity of IITM's Supercomputer system (based on Linux OS) for fast processing of PIV data. This is different from a network license where multiple users can connect to a server and use the software installed on the server at the same time. The vendor clarified that their PIV software does not work with Linux platforms and therefore they do not have an HPC license for distributed computing. Therefore, the HPC license item is removed from the revised technical specifications.

e. Our software is perpetual license but all updates within the version are free. For example: Davis 11 is perpetual license and all updates are free before Davis 12 version.

>>> The bidders are required to comply with the revised technical specifications.

f. Low-speed / High-speed 3D Shadowgraphy technique (low velocity): if we use 4 x low speed camera to capture the 3D shadow image of the bubbles/ particles then we need to 4 x LED backlighting. Using this 3D shadowgraphy, we can get 3D shape and 3D velocity of the bubbles, 2D sizing information of the bubble and 3D flow velocity around these bubbles. Low-speed / High-speed 3D Shadowgraphy technique (high velocity): if we use 4 x low speed camera to capture the 3D shadow image of the bubbles/ particles then we need to 4 x laser based diffused lighting. Using this 3D shadowgraphy, we can get 3D shape and 3D velocity of the bubbles, 2D sizing information of the bubble and 3D flow velocity around these bubbles.

>>> The bidders are required to comply with the revised tender technical specifications in this regard. Appropriate lighting covering all possibilities should be provided.

g. Low-speed 3D (TOMO) BOS: We need minimum 6 to max 8 views. So we need to use 6-8 low speed cameras, 6-8 front LED illuminations, frame to mount 6-8 cameras, 6-8 LED

illumination and Big size background speckle pattern. Using 3D (TOMO) BOS, one can get quantitative temperature measurements. We need to use the existing old 2 or 4 low speed cameras. For high-speed 3D (TOMO) BOS: We need minimum 6 to max 8 views. So we need to use 6-8 low speed cameras, 6-8 front LED illuminations, frame to mount 6-8 cameras, 6-8 LED illumination and Big size background speckle pattern. Using 3D (TOMO) BOS, one can get quantitive temperature measurement. We need to both 9MPx and 4MPx cameras together.

>>> The bidders are required to comply with the corresponding revised tender technical specifications in this regard. Appropriate lighting, speckle pattern etc. covering all possibilities should be provided.

h. Simultaneous Liquid LIF Concentration Vs 2DPIV/StereoPIV or Simultaneous Liquid LIF temperature Vs 2DPIV/StereoPIV are possible. For LIF Temperature, we need to have Dye calibration cell, to get absolute temperature calibration in water.

>>> Both concentration and temperature LIF are required. The bidders are required to comply with the corresponding revised tender technical specifications in this regard.

i. Light sheet optics: recommend to have UV version so that we can use the same light sheet optics for 532/527/ 355/266 nm. Laser guiding arm: recommend to have UV coating to cover wavelength 532/527/355 so that we can use the same laser guiding arm for PIV / LIF application and also for LIP – Laser induced phosphorescence application (to get the velocity and temperature in the air flow). Laser sheet optics and laser guiding arm must have damage threshold of 2J/cm2. Points 4.a.5 and 4.b.6: For sheet optics, The F=-5 will have similar divergence of F=-10. Therefore, we recommend to go for -10, -20 & -30. For Volume optics, F=-120 it not available. Instead we can provide F=-130. Is it okay?

>>> Revised technical specifications mention that the sheet and volume optics, optomechanical components and laser guide arm should have coatings for enabling their use in PIV + LIF (fluorescence) and PIV + LIP (phosphorescence) applications and these components should have damage threshold of >=2 J/cm^2. The quantities and focal lengths are also revised for the sheet and volume optics.

j. Laser beam steering from the cloud chamber bottom to reach the height of 16m height is not recommended due to energy loss and laser safety aspects. It is recommended to use lift to transport the hardware to every 4m stage and perform the laser flow diagnostics experiments. Point 4.a.5, “optical elements for beam guidance (from laser head to the sheet or volume delivery optics) covering the height of the cloud chamber

for delivery to various heights between 0- 12 m from the ground" – Do we need to provide any steering mirrors or a beam tool to ensure a beam path?

>>> Provision for an elevator shall be incorporated in the design of the supporting structure of the cloud chamber. However, beam delivery optics (steering mirrors etc.) should still be provided as per the tender requirements.

k. Camera lens: We recommend 24mm, 35mm, 50mm, 100mm, 135mm, 200mm, 300mm based on minimum working distance of 1m and FOV 50mm x 50mm & 600mm x 600mm and Camera resolution (25MPx, 9MPx, 4MPx). Calibration plate: 50 x 50mm, 100 x 100mm, 300 x 300mm dual plane 3D calibration plate is available but for 5mm x 5mm: we can recommend to use micro calibration plate and for 500mm x 500mm: We recommend to use 2D calibration plate. We need to discuss on how to create pan/tan/tilt of the 2D calibration plate inside the cloud chamber. Optomechanical parts: we recommend Qioptiq, Thorlabs.

>>> FOVs and lens focal lengths have been specified in the revised technical specifications. Calibration targets should be able to provide 3D calibration of the PIV system.

(2) Queries by M/s Dantec Dynamics, Denmark (Indian Agent – M/s. Laser Science Services, Pvt. Ltd., India)

a. "Shake-the-Box (STB)" is a term in the field of fluid dynamics, refers to a 3D Lagrangian PTV method developed by LaVision for tracking tracer particles in densely seeded flows at high spatial resolution. (https://www.smart-piv.com/en/download.php?id=2908&name=download.pdf) This method is developed by La-Vision and hence cannot be used in a public open tender let alone this is mentioned in the title of the tender.

>>> The information provided by the vendor is misleading and erroneous. The STB algorithm is developed by DLR Institute of Aerodynamics and Flow Technology (German Aerospace Labs) and more information about it can be found on their website (https://www.dlr.de/en/as/about-us/departments/experimental-methods/shake-the-box-3d-lagrangian-particle-tracking-at-high-particle-densities). The title of the tender cannot be changed at this stage since the tender has been already published. However, a clarifying line has been added in the brief details about the instruments section of the revised technical specifications as follows. "Note that the words STB and TOMO in the name of the system are to be understood in a general sense of the kind of technique i.e. 3D Lagrangian Particle Tracking Velocimetry and 3D Tomographic Particle Image Velocimetry."

b. Reg. A. Technical Specifications 4. a.1. Two PIV lasers to be combined to obtain a wide range of repetition rates (single pulse to 60 Hz) and pulse energies (max. pulse energy being > 700 mJ / pulse) in combined operation using appropriate combination optics,

polarizers and timing control. We do not confirm that the combined pulse energies of all 4 cavities will give an output of >700mJ/pulse since there are a lot of variable that needs to be considered like the pulse delay and the jitter between them. This Jitter also gets amplified when you are using 4 cavities, also since the OEM does not have any standard optical configuration as such we are unable to confirm on the same as of now.

>>> The combined pulse energy of > 700 mJ/pulse is an essential technical requirement of the project due to the large energy required for flow visualizations of large areas of interest in the cloud chamber. Supporting documents demonstrating the tests carried out at the vendor's end are an essential part of the technical bid document since this approach is to be implemented by the vendor and is not available as an off-the-shelf item from the laser manufacturers.

c. Reg. A. Technical Specifications 4. a.4 and b.5. We are unable to provide an HPC license as it uses Linux as its operating system.

>>> The tender asked for HPC license of PIV software to be quoted as an optional item. The intent was to use the GPU capacity of IITM's Supercomputer system (based on Linux OS) for fast processing of PIV data. The vendor has clarified that their PIV software does not work with Linux platforms and therefore they do not have an HPC license for distributed computing. Therefore, the HPC license item is removed from the revised technical specifications.

d. Reg. A. Technical Specifications 4. a.5. and b.6. sheet optics of various focal lengths (-5, -10, -20, -30mm each qty.= 05 nos.), volume optics of various focal lengths (-60, -90, -120, -150 mm each qty.= 05 nos.) Instead of mentioning the focal lengths for the sheet optics and the volume optics, could you please give us the FOV required for both the measurements.

>>> The FOV range anticipated in the cloud chamber is clarified in the revised technical specifications and the sheet and volume optics focal lengths required are also mentioned.

e. Reg. A. Technical Specifications 4. a.6. please mention the required type and size of the support required for the breadboard.

>>> We will prepare the breadboard supports as per our requirement from the mounting accessories. No need to quote separate supports for breadboards.

f. Reg. A. Technical Specifications 5. Although this is an optional items, and hoping that this will not be considered as a point for rejecting us technically at a later date. We are in no position to support the cameras supplied by the competition Low-speed cameras – LaVision Imager Pro SX 5M, LaVision CX3-25. However the lasers mentioned should be ok.

>>> Inability expressed by the bidder to support existing LaVision cameras is noted.

g. Reg. A. Technical Specifications 8. Post Warranty Services - Comprehensive Annual Maintenance Contract (CAMC) we understand that this will be revised to Annual Maintenance Contract (AMC).

>>> This typo has been corrected in the revised specifications. These systems require expert attention, and IITM has the requisite expertise for that. As such, OMC or CAMC is not required.

h. Reg. A. Technical Specifications 4. a.4. We also do not have/support 3D BOS as well as 3D Shadowgraphy, this is something that only competition can offer and we request you to kindly relax the specs on this to have an Apple to Apple comparison of specs during the technical bid evaluation. You may kindly put this in the optional items if you feel the absolute need for these method in your experiments/applcaitions.

>>> Visualizing and quantifying the convective plumes and shapes of cloud droplets in the cloud chamber are essential requirements of the project. As such, the 3D BOS and 3D Shadowgraphy techniques are essential indispensable capabilities of the system from a scientific point of view and cannot be considered optional. Further, it is added that 3D BOS and 3D shadowgraphy are not new or proprietary techniques and have been published several years ago in peer-reviewed literature (see Di Nunno et al 2020 Meas. Sci. Technol. For 3D shadowgraphy and Raffel 2015 Exp. Fluids for 3D BOS).

(3) Modifications in the Technical Specifications other than those prompted by the bidders

As per the discussions in the Technical Committee regarding the requirements of the project, some modifications, other than those prompted by the queries of the bidders, are made to the technical specifications. The major modifications are listed below:

Low-speed subsystem:

1. Detailed specifications of the acquisition unit, processing unit, and storage unit are given to enable a fair comparison of the bids.
2. K2 distamax lenses have been removed.
3. KVA of the UPS is mentioned.
4. The quantity for sheet and volume optics is reduced.

High-speed subsystem:

1. 09 MPX cameras are moved to optional items.
2. Acquisition unit and processing unit are moved to optional items. Corresponding PIV software licenses have also been moved to optional items.
3. Schiempflug mounts, calibration plates, LED backlighting for shadowgraphy are removed.
4. K2 distamax lenses have been removed.
5. KVA of the UPS is mentioned.
6. The quantity for sheet and volume optics is reduced.
7. LIF calibration cell is removed.

Optional items, Factory acceptance test and training, Notes and Cloud Chamber Schematic are all updated.

Revised Technical Specification for
Tomographic Particle Image Velocimetry (Tomo-PIV)
PIV (high speed and low-speed subsystems) with STB, TOMO, Stereo, PFPIV, PTV and BOS capabilities Qty. 01 Set (GTE Bid)

1.	**Vertical(s) of Mission Mausam to which the instrument belongs**	Weather_Mod
2.	**Purpose of the instrument**	For Cloud Chamber
3.	**Brief details about instrument**	Tomographic PIV system shall consist of two subsystems namely the low-speed subsystem and the high-speed subsystem. Each subsystem shall be capable of obtaining 2D PIV, Stereo PIV and 3D Tomographic PIV measurements in the Cloud Chamber at different spatial and temporal resolutions, and over a range of fields of view using the state-of-the-art Tomo reconstruction algorithms. The system shall also be capable of Lagrangian particle tracking (high speed subsystem only), pressure field from PIV measurements (both subsystems), Background Optical Schlieren (BOS) for 2D and 3D density and temperature fields in the Cloud Chamber (both subsystems), 2D and 3D shadowgraphy for imaging particles, bubbles, droplets etc. (both subsystems), Laser Induced Fluorescence (LIF) with simultaneous measurements of 2D scalar (temperature as well as concentration) and 2D2C and 2D3C velocity fields in liquids (both subsystems). Note that the words STB and TOMO in the name of the system are to be understood in a general sense of the kind of technique i.e. 3D Lagrangian Particle Tracking Velocimetry and 3D Tomographic Particle Image Velocimetry.
4.	**Technical specifications including accessories**	• **Tomographic PIV System** The Tomographic PIV system should have demonstrated capability to perform the desired measurements of the types supported by all the software and hardware modules mentioned below as evidenced by the published research papers in peer-reviewed journals to be submitted in addition to technical data sheets, product catalogues and brochures etc. A table should be made listing each technique/capability of the system and citations of the publications supporting it.

		a. Low-speed Subsystem 1. Twin Dual cavity double pulsed PIV lasers, each with 2 x 200 mJ / pulse energy or higher at 15 Hz repetition rate or higher at 532 nm wavelength. Two PIV lasers to be combined to obtain a wide range of repetition rates (single pulse to 60 Hz) and pulse energies (max. pulse energy being > 700 mJ / pulse) in combined operation using appropriate combination optics, polarizers and timing control. Both lasers should have monolithic construction for stability of operation and internal optical elements. Documentation of the tests done at the vendor's factory should be submitted in the technical bid as evidence of the successful implementation of this configuration. (Qty. 01 nos.) 2. PIV camera with resolution 24 MP (megapixel) or higher at frame rate of 90 Hz (single frame mode) or higher and interframe time <= 0.5 microseconds (Qty. 04 nos.) 3. Dedicated image acquisition and processing system (Qty. 01 set) – (a) External Timing and Synchronization Unit (Qty. 01 nos.)– for synchronizing lasers and cameras for image acquisition (latest version), capable for use with both low- and high-speed subsystems, with 08 simultaneous cameras, two PIV lasers and external triggers (b) Acquisition Unit (Qty. 01 nos.) - Motherboard - ASUS PRO WS W790E-SAGE SE or more advanced, Processor - Intel Xeon w5-3535X or more advanced, RAM - ECC 1024GB (1TB) or higher with speed 4800MT/s or higher, OS Drive - 1024GB (1TB) NVMe M.2 SSD or higher, Internal Storage drive 1 - NVMe SSD in RAID 0 with 4 x 15 TB (>= 50TB usable) or higher, Internal Storage drive 2 - NVMe SSD in RAID 0 with 4 x 4 TB (>= 12TB usable) or higher, GPU - NVIDIA RTX 5000 Ada with 32GB VRAM or more advanced, Windows 11 Pro or latest for workstation x64 OEM, appropriate hardware cards for camera and laser connections for handling both low-speed and high-speed PIV systems hardware, internal timing and synchronization unit (with same specifications as (a) above), High quality power supply unit, Display > = 32", mouse and backlit keyboard

		(c) Processing Unit (Qty. 01 nos.) - Motherboard - ASUS PRO WS W790E-SAGE SE or more advanced, Processor - Intel Xeon w7-3565X or more advanced, RAM - ECC 1024GB (1TB) or higher with speed 4800MT/s or higher, OS Drive - 1024GB (1TB) NVMe M.2 SSD or higher, Internal Storage Drive - HDD RAID 0 with 8 x 24TB (>= 140TB usable) or higher, GPU - NVIDIA RTX 5090, 32GB VRAM or more advanced, Windows 11 Pro or latest for workstation x64 OEM, appropriate hardware cards, High quality power supply unit, Display > = 32", mouse and backlit keyboard (d) Storage unit (Qty. 02 nos.) – Cabinet / Enclosure Form Factor – Tower / Rack, Capacity – 512 TB or more usable in RAID 6, Connectivity – Thunderbolt, 10 GbE/25GbE LAN support or better, compatible with Processing Unit. Storage unit to be connected to Processing unit via high-speed connectivity link, high-quality 50 meter Cat6 LAN cable with transfer speed up to 10 Gbps. 4. Latest version of system software (01 full standalone lifetime license for Acquisition Unit and 01 lifetime license for all modules analysis and processing capabilities for Processing Unit) - System software shall contain all modules for 2D PIV, Stereo PIV, 3D Tomographic PIV, 3D PTV using state-of-the-art algorithms, Pressure from PIV, 2D and 3D Background Optical Schlieren (BOS), 2D and 3D shadowgraphy for droplets, bubbles, particles etc. in two phase flow (all these with 08 or more cameras), Laser Induced Fluorescence (LIF) with simultaneous measurements of 2D scalar (temperature as well as concentration) and 2D2C and 2D3C velocity fields in liquids and any other modules deemed essential for smooth working of the system. All calibration, preprocessing, processing, postprocessing, data export modules with state-of-the-art algorithms to be included. All upgrades for the supplied version (including all modules) and the upgrade of the supplied version to the next version (including all modules) should be free of cost for all licenses for lifetime. Module to be included for exporting the processed (after corrections and dewarping etc.) camera images into a universal format that can be analyzed by open-source PIV software. 5. Accessories such as laser guide arm >= 02 m length (with

optical coatings suitable for PIV, LIF (fluorescence) and LIP (phosphorescence) and damage threshold >= 2 J/cm^2), optical elements such as steering mirrors for beam guidance (from laser head to the sheet or volume delivery optics) covering the height of the cloud chamber for delivery to various heights between 0-16 m from the ground (with optical coatings suitable for PIV, LIF (fluorescence) and LIP (phosphorescence) and damage threshold >= 2 J/cm^2), LED and laser-based background lighting for shadowgraphy measurements, UPS (20 kVA) of renowned make to run the subsystem for minimum 30 minutes in case of power failure, fog machine or seeding generator (water based fog fluid for producing thick fog with high seeding densities) for seeding in air, 95" or larger interactive display for educational and outreach purposes, appropriate seed particles for water (04 bottles of 250 gm each), LIF dyes (04 grams each), LIF calibration cell, camera sensor and lens cleaning kits, laser alignment goggles (06 nos.), laser safety google (10 nos.), laser alignment tools, laser energy/power meter (01 nos.), connecting cables for simultaneous operation of 08 or more cameras, camera cables >=10 m long, light sheet optics of various focal lengths (-10, -20, -30mm each qty.= 02 nos.) with optical coatings for 532/527/355/266 nm and damage threshold >= 2 J/cm^2, volume optics of various focal lengths (-60, -90, -130, -150 mm each qty.= 02 nos.) with optical coatings for 532/527/355/266 nm and damage threshold >= 2 J/cm^2, Schiempflug mounts (Qty.= 04 nos.), prime macro lenses (20mm, 35mm, 50mm, 100mm, 200mm) and zoom lens (300mm) - one such set for each camera, of renowned make with manual aperture control (no wide angle) for all cameras with appropriate mounts for lenses and working distance of 1000 mm and covering FOV limits from 50 x 50 mm to 600 x 600 mm, camera filters and polarisers for LIF and PIV (one set for each camera), calibration plates of various sizes for 3D calibration (covering 5mmx5mm, 50mmx50mm, 100mmx100mm, 300mmx300mm, 500mmx500mm areas), and any other components or accessories deemed essential for smooth functioning of the entire system with multi-camera operations.

6. Other mounting accessories are given below:

Item with specs.	Sr. No.	Qty.

X95 Profile		
3m	G026125300	4
2.5m	G026125000	4
2m	G026120000	8
1.5m	G026115000	8
1m	G026110000	10
0.5m	G026105000	10
Carrier X95 w/ hole pattern		
300mm	G026429000	12
200mm	G026428000	20
120mm	G026423000	18
80mm	G026422000	28
50mm	G026421000	28
30mm	G026420000	16
Carrier Positioner X95 – 30		
30mm	G026426000	12
X 95 Clamping Carrier	G026408000	16
Cross Carrier X 95	G026424000	8
X 95 Corner Connector	G026210000	25
X 95 End Plate	G026201000	25
X95 Levelling		
Foot	G026202000	32
Disk	G026261000	32
Mounting Base	G024343000	20
X 95 Double Leg	G026310000	20
Mounting Plate MP 80.U	G024988000	32
Optical Post 25 mm	G061201000	16
X 95 Hinged Connector	G026218000	16
FLS95 Rail System		
2m	G022087000	12
1m	G022083000	12
0.5m	G022081000	16
Right-Angle Prism Mirrors for Nd:YAG Laser along with cage mounting system with fine adjustments (Thor Labs)		

Damage threshold >= 7 J/cm2 for 532 nm	MRA25-K13	8
Motorized Lab-Jack		
	MLJ300-300	8
Breadboards		
900x1200x50mm	G437513512	2
600x1200x50mm	G437511912	2
600x900x50 mm	G437511512	2
450x600x50mm	G437510412	2

b. High-speed Subsystem

1. Dual cavity PIV laser with 2 x 60 mJ / pulse energy or higher at 01 kHz repetition rate or higher and 527 nm wavelength, variable repetition rate - should be able to go up to 10 kHz repetition rate or higher, should have monolithic construction for stability of operation and internal optical elements (Qty. 01 nos.)
2. PIV camera with resolution 04 MP (megapixel) or higher at frame rate of 09 kHz (single frame mode) or higher with onboard memory 256 GB or more (Qty. 04 nos.)
3. Accessories such as laser guide arm >= 02 m length (with optical coatings for 532/527/355 nm and damage threshold >= 2 J/cm^2), optical elements such as steering mirrors for beam guidance (from laser head to the sheet or volume delivery optics) covering the height of the cloud chamber for delivery to various heights between 0-16 m from the ground (with optical coatings for 532/527/355 nm and damage threshold >= 2 J/cm^2), high-speed laser-based background lighting for shadowgraphy measurements, UPS (20 kVA) of renowned make to run the subsystem for minimum 30 minutes in case of power failure, fog machine or seeding generator (water based fog fluid for producing thick fog with high seeding densities) for seeding in air, 95” or larger interactive display for educational and outreach purposes, appropriate seed particles for water (04 bottles of 250 gm each), LIF dyes (04 grams each), camera sensor and lens cleaning kits, laser alignment goggles (06 nos.), laser safety google (10 nos.), laser alignment tools, laser energy/power meter (01 nos.), connecting cables for simultaneous operation of 08 or

		more cameras, camera cables >=10 m long, light sheet optics of various focal lengths (-10, -20, -30mm each qty.= 02 nos.) with optical coatings for 532/527/355/266 nm and damage threshold >= 2 J/cm^2, volume optics of various focal lengths (-60, -90, -130, -150 mm each qty.= 02 nos.) with optical coatings for 532/527/355/266 nm and damage threshold >= 2 J/cm^2, prime macro lenses (20mm, 35mm, 50mm, 100mm, 200mm) and zoom lens (300mm) - one such set for each camera of point b.2. - of renowned make with manual aperture control (no wide angle) for all cameras with appropriate mounts for lenses and working distance of 1000 mm and covering FOV limits from 50 x 50 mm to 600 x 600 mm, camera filters and polarisers for LIF and PIV (one set for each camera) and any other components or accessories deemed essential for smooth functioning of the entire system with multi-camera operations.
5.	**Other Remarks**	Optional Items: 1. Acquisition Unit (Qty. 01 nos.) - Motherboard - ASUS PRO WS W790E-SAGE SE or more advanced, Processor - Intel Xeon w5-3535X or more advanced, RAM - ECC 1024GB (1TB) or higher with speed 4800MT/s or higher, OS Drive - 1024GB (1TB) NVMe M.2 SSD or higher, Internal Storage drive 1 - NVMe SSD in RAID 0 with 4 x 15 TB (>= 50TB usable) or higher, Internal Storage drive 2 - NVMe SSD in RAID 0 with 4 x 4 TB (>= 12TB usable) or higher, GPU - NVIDIA RTX 5000 Ada with 32GB VRAM or more advanced, Windows 11 Pro or latest for workstation x64 OEM, appropriate hardware cards for camera and laser connections for handling both low-speed and high-speed PIV systems hardware, internal timing and synchronization unit (with same specifications as (a) above), High quality power supply unit, Display > = 32”, mouse and backlit keyboard. 2. One full standalone lifetime license of latest PIV system software for the Acquisition Unit with all hardware and processing capabilities (modules) as mentioned in the main specifications. 3. Processing Unit (Qty. 01 nos.) - Motherboard - ASUS PRO WS W790E-SAGE SE or more advanced, Processor - Intel Xeon w7-3565X or more advanced, RAM - ECC 1024GB (1TB) or higher with speed 4800MT/s or higher, OS Drive -

		1024GB (1TB) NVMe M.2 SSD or higher, Internal Storage Drive - HDD RAID 0 with 8 x 24TB (>= 140TB usable) or higher, GPU - NVIDIA RTX 5090, 32GB VRAM or more advanced, Windows 11 Pro or latest for workstation x64 OEM, appropriate hardware cards, High quality power supply unit, Display > = 32", mouse and backlit keyboard 4. One lifetime analysis license with all modules having analysis and processing capabilities for the Processing Unit as mentioned in the main specifications. 5. PIV camera with resolution 09 MP (megapixel) or higher at frame rate of 01 kHz (single frame mode) or higher with onboard memory 128 GB or more (Qty. 04 nos.) 6. Dual cavity PIV laser with 2 x 100 mJ / pulse energy or higher at 01 kHz repetition rate or higher, should be able to go up to 10 kHz repetition rate or higher (Qty. 01 nos.). 7. Registration and Integration of existing cameras and lasers in the new PIV hardware and software to the best possible extent. Required to be quoted as optional item. The existing PIV hardware is as follows: (a) Low-speed cameras – LaVision Imager Pro SX 5M, LaVision CX3-25 (b) High-speed cameras – LaVision Mini UX100 (c) Low-speed laser – Litron Nano PIV 2 x 200 mJ/pulse at 15 Hz, (d) Quantel Q-Smart 850 Twins 2 x 380 mJ/pulse at 10 Hz (e) High-speed laser – Photonics Industries 2 x 22.5 mJ/pulse at 01 kHz
6.	**Installation, Testing of equipment and calibration, details of training, etc.**	1. Factory Acceptance Testing and Training (01 week) for IITM persons (02 nos.) before dispatch to be included in the bid free of cost. Expenses of IITM personnel to IITM account. 2. Installation for minimum 10 working days and onsite training at IITM, Pune to be included in the bid. Both 1 and 2 to be quoted separately in the bid.
7.	**Warranty**	01-year warranty (w.e.f. the date of acceptance)
8.	**Post Warranty Services**	(i) 01-year extended warranty for the entire system. (ii) 05 years of AMC for Lasers (02 visits/year for inspection, optics alignment etc., visiting and inspection charges to be included, replacement of consumable items such as laser chiller filters, desiccants, anti-algae agents etc. in every visit to be included, other spare parts not to be included). Rate for each year to be quoted separately.

Notes: Price of each item and subitem to be quoted individually and separately in the commercial bid. Prices of local supply items to be quoted in INR and prices of foreign supply items to be quoted in foreign currency. The commercial evaluation will be done considering the AMC rates and optional items, if any. During commercial discussions, the committee may remove some items or subitems or add optional items.

Schematic of the proposed Cloud Chamber:

Optical access windows are tentatively sized to be 500 mm x 100 mm each and their positions shall be decided strategically to maximize the utility for different kinds of optical measurements.