

Tender Notice No.PR/BER/MISP/TMT/CAP/213

**ANNOUNCEMENT OF OPPORTUNITY**

FOR

**CNC PROCESS DEMONSTRATION FOR M1 SEGMENT POLISHING**

FOR

**THIRTY METER TELESCOPE (TMT) PROJECT**

26th August, 2011

Indian Institute of Astrophysics  
Sarjapur Road, Koramangala 2nd Block

Bangalore 560034

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## **1. BRIEF STATEMENT OF THE WORK**

The Thirty Meter Telescope (TMT) is a multi-national project envisaged to build next generation ground based telescope. The telescope has a 30m diameter primary mirror (M1) composed of 492 hexagonal segments made of low expansion glass material. Each hexagonal segment has nominal size 1.44m across the corners. This announcement of opportunity is for technology demonstration of -a sub-scale roundel polishing of an optical-blank material using the computer numerical control (CNC) machining process. The design specifications and qualification criteria for the CNC demonstration process are detailed in the Statement of Works in Section A, following the methodology in Section B and terms and conditions in Section C. Additional information are included in the Appendix Sections at the end.

## **2. BACKGROUND INFORMATION**

The optical and infra-red (IR) astronomical community in India, under the umbrella name TMT-India, had made a strong case to the Department of Science and Technology, Government of India for participation in the next generation, 30-m class telescope project. A comprehensive proposal was put together by the Indian Institute of Astrophysics (IIA), Bangalore, the Inter-University Center for Astronomy and Astrophysics (IUCAA), Pune and the Aryabhata Research Institute for Observational Sciences, (ARIES), Nainital. After a careful evaluation of the proposal, the Department of Science and Technology (DST), Govt. of India, announced, on July 24th, 2010, to join the TMT project as an observer with a strong intention of becoming a full partner in due course of time. The TMT project is led by the California Institute of Technology, University of California and Association of Canadian Universities for Research in Astronomy (ACURA) to build a 30-m diameter optical-IR telescope at Mauna Kea in Hawaii, USA. Other partners in the consortium are Japan and China. The TMT construction work is scheduled to start by the middle of 2013 on the summit of Mauna Kea at an altitude of 4200m from sea level. Hereafter, TMT or TMT project refers to the TMT consortium of international members with headquarter at Pasadena, USA, and TMT-India refers to consortium of various institutes in India. As part of India's contribution to the TMT, TMT-India intends to develop, within the country, various sub-systems needed for the telescope and deliver to the TMT project. Towards this, TMT-India, in consultation with the TMT project, has identified various sub-systems. As a first step towards demonstrating the technical capabilities available in India, TMT-India proposes to develop the technology, by manufacturing prototypes of these sub-systems. In pursuance of the above, the Director Indian Institute of Astrophysics, Bangalore, on behalf of TMT-India, invites proposals from potential industries in India for technology demonstration and prototype primary mirror segment polishing for the TMT using the CNC technique.

### 3. SUBMISSION OF THE PROPOSAL

Proposals are invited from Indian industries with proven technical expertise and track record of executing precision fabrication of optical components and subsystem for advanced technology photonics products, imaging devices, optical-infrared telescopes, testing equipments and metrology related to optical instruments and/or executing large astronomical projects -both of national and international importance. Submission of proposal has to be done in two stages. In the first stage, contractors willing to submit proposals are invited to submit a letter of **Expression of Interest (EOI)**. In the next stage, contractors shortlisted by the expert committee will then be requested to put a detailed proposal divided into Technical Bid and Price Bid. Guidelines for submission, including the details of documents required, are provided in Section B.

### 4. PROCESS SCHEDULE

Date of this announcement	29 <sup>th</sup> August, 2011
Deadline for receiving Expressions of Interest	19 <sup>th</sup> September, 2011 3:00PM
Opening of EOI	19 <sup>th</sup> September, 2011 4:00PM
Qualification of contractors	3 <sup>rd</sup> October, 2011
Signing on NDA, circulation of DFM	7 <sup>th</sup> October,2011
Pre bid Technical discussion	
Deadline for receiving Proposals	8 <sup>th</sup> November, 2011 03:00PM
Opening of Technical Bids	8th November,2011 05:00PM
Technical Qualification	21 <sup>st</sup> November,2011
Opening of Price Bids	24 <sup>th</sup> November, 2011
Award of Contract	5 <sup>th</sup> December,2011
Delivery	March, 2012

**Note:** These dates may be revised by IIA through notification on its website.

## 5. CONTACTS:

### Technical Clarifications:

1. Dr Ravinder Kumar Banyal (email: banyal@iiap.res.in), IIA, Bangalore.
2. Prof A. N. Ramaprakash (email: anr@iucaa.ernet.in), IUCAA, Pune.

### Administrative Clarifications:

1. Shri Y. K. Raja Iyengar (email: ykri@iiap.res.in), Purchase Officer, IIA, Bangalore.

## I. Section A

### STATEMENT OF WORK

A brief overview of the TMT Optical Design, M1 Segmentation and a short description of the CNC Mirror Polishing Technology and the Programme Overview is provided in Section 6 and Subsections. A three phase approach (Demo-I, Demo-II and Demo-III) for segment polishing demonstration is preferred. The "**STATEMENT OF WORK – THE CNC PROCESS DEMONSTRATION AND TESTING FOR DEMO-I,**" is given in Section 7. Main Requirements, Acceptance Criteria and Deliverables for Demo-I are outlined in Section 7.1 and Subsections. Guidelines and General Approach, Inspection and Acceptance Procedure are described in Section 7.2.

The segment polishing contract may be extended to Demo-II/III phase after the contractor has successfully completed the Demo-I as per the requirements, qualification criteria and deliverables described in Section 7.1. The Section 7.5 is for the Contractor to provide a complete roadmap and a provisional cost estimates for the CNC technology demonstration and prototyping of the Demo-II/III phase and final M1 Segment Production. The Contractor may use the experience gained during the Demo-I phase in conjunction with the Scope of the Work for the Demo-II/III provided in Appendices B as a guiding tool for making competitive cost estimate and a detailed roadmap for the Demo-II/III.

The final awarding of the contract for M1 segment production is subjected to the approval by Govt. of India and the outcome of Demo-I/II/III. The Terms & Conditions for the final award of M1 Segment Polishing are given in the Appendix C. In order to bid for the final contract, the Contractor shall provide a comprehensive methodology and a readiness plan (see the Appendix D) for designing and commissioning the CNC process approach for M1 production. The recommended guidelines and requirements for the segment configuration during the optical testing, accuracy and inspection report etc are given in Appendix E.

The usage of the term "Segment Polishing" in this document may collectively refer to the process of segment polishing using CNC, optical or mechanical testing of the surface figure etc. Additional technical information related to M1 production process and specifications can be found on the TMT website [http:// www.TMT.org/documents](http://www.TMT.org/documents).

## 6. TECHNICAL BACKGROUND

### 6.1. TMT Optical DESIGN

The TMT optical design, shown in Figure 1, is based on Ritchey Chrétien system. Both the primary (M1) and the secondary mirrors (M2) are hyperboloid. The focal length of the primary mirror is 30-m and the final F-ratio of telescope system is F/15. A tertiary mirror (M3) is used to fold and steer the light beam to any of the eight instruments that



will be mounted on the two main Nasmyth platforms. The telescope has an unvignetted field of view of 15 arcmin. The M1 is segmented hyperboloid (Paraxial ROC = 60.0m,  $k=-1.000953$ , sag = 1.8m, asphericity = 29.3mm) -of an effective diameter 30-m. The secondary is a single piece convex hyperboloid ( Paraxial ROC = -6.228,  $k =-1.31823$ , sag = 196 mm, asphericity = 850  $\mu\text{m}$  ) with 3.2-m diameter. The diffraction limited resolution of TMT will be three times better than the existing 10m class telescopes and wavelength coverage would range from 310nm to 28  $\mu\text{m}$ . To achieve the desired performance, the surface finish of each segment has to be  $\lambda/20$  or better at the specified wavelength.

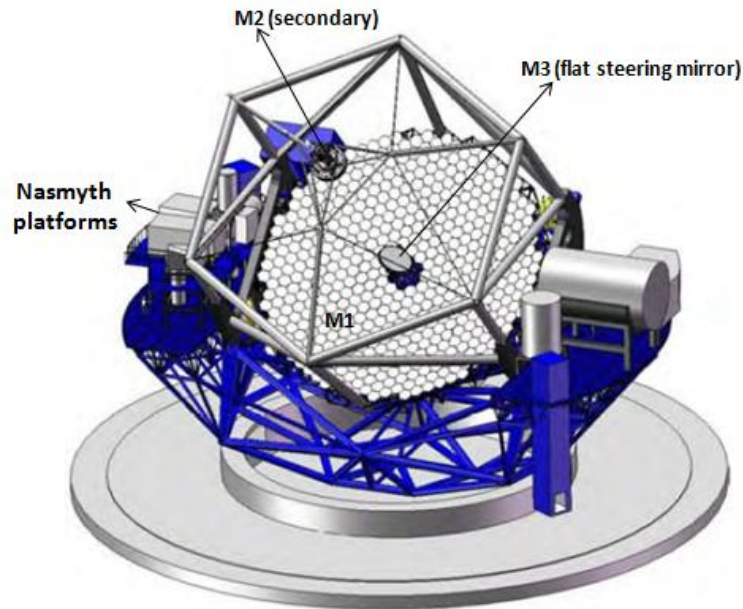


Figure 1: Artistic rendering of the TMT telescope.

## 6.2. M1 SEGMENTATION

The TMT primary mirror is made of 492 hexagonal segments, each having a size of 1.44 m across corners. Figure 2 shows the top view of the M1 segmentation pattern. The entire M1 is divided into 6 identical sectors (A-F). There are 82 hexagonal segments in each sector. The segment arrangement pattern has six-fold symmetry about the vertical axis. That is, the entire M1 can be obtained by rotating any of the sectors in 60 degree steps about the optical axes. Since an array of identical regular hexagons cannot uniformly fill a curved surface, the shape and asphericity for each of 1-82 segments is uniquely defined. For example, the outermost segment (Type-82) has greatest aspheric departure  $\sim 226\mu\text{m}$  PV while the inner most (Type-2) has only  $\sim 6\mu\text{m}$  PV. A detailed description of the hexagonal geometry -of the 82 segment types can be found in the Segmentation Database on TMT website [see Ref. 5]. The TMT requires total 574 segments comprising 7 sets of the 82 unique segments. 492 of these segments will form M1 and remaining 82 will be kept as spares. The segments are closely placed with nominal gaps of 2.5 mm to maximize the fill factor. Each Segment will be mounted on a Segment Support Assembly (SSA) to provide a passive support in the three in-plane

degrees of freedom. There are as many different SSA types (82), as there are number of unique segments. The overall shape of the M1 mirror is actively controlled (tip, tilt and piston) by the Primary Mirror Control System (M1CS) which compensates periodically for the alignment errors caused by the wind disturbance, gravity loading, seismic vibrations, and structural deformations of the telescope resulting from temperature changes.

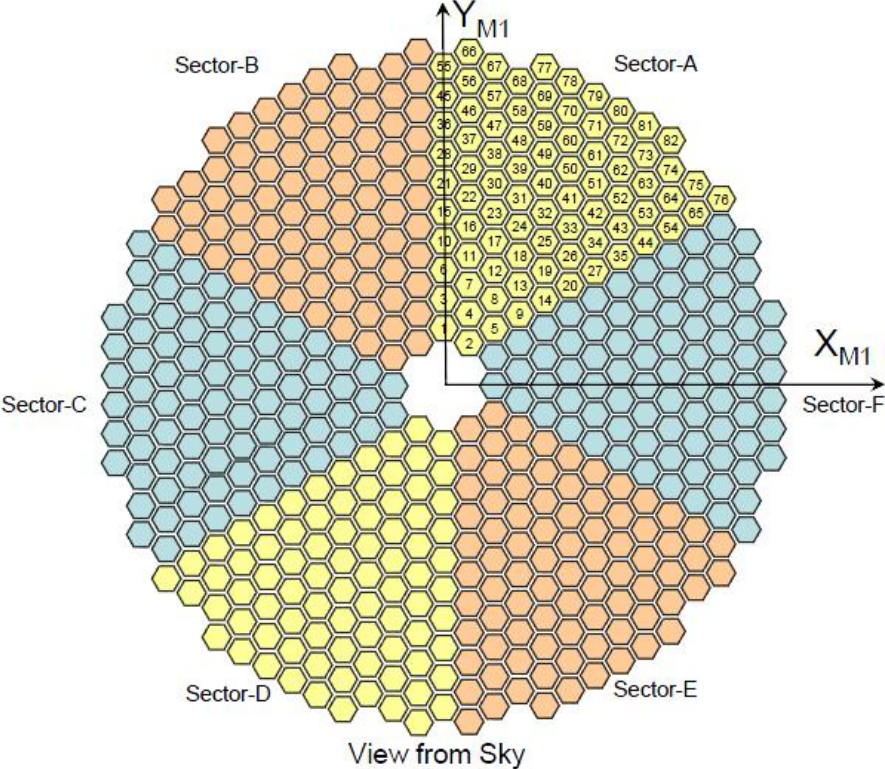


Figure 2: Arrangement of M1 Segments with 6-fold symmetry.

### 6.3. CNC MIRROR POLISHING TECHNOLOGY

Polishing is a process by which material is precisely removed from a workpiece to produce a desired dimension, surface finish and shape. The overall performance of the TMT will ultimately depend on the performance of the segmented primary. The most challenging task is the fabrication of a large number of off-axis segments that meet the TMT requirements. The polishing process has to be rapid, efficient and cost effective, producing smooth, accurate aspheric surfaces. Additionally, it has to be supported by fast, accurate and repeatable metrology that can be used in-situ to control polishing. Considering the complexity, time and investment incurred in the polishing process, TMT is funding several pilot studies to explore fast, accurate and cost effective segment polishing approaches that would meet its requirements.

Clearly, the traditional methods of mirror polishing wouldn't quite work for the production of the large number of M1 segments of high optical quality and aspheric form. Among some competing technologies, the Computer Numerical Control (CNC) polishing process, sometimes also called -Intelligent Robotic Polishing (IRP), seems to be a practical and viable solution. CNC is an automated, multi-axis, active, small-tool (local) polishing approach that is useful for rapidly polishing symmetric as well as aspheric surface forms of varying size. The polishing process is controlled by a computer that has the target surface form, form error (departure of desired surface shape from the current shape) and the tool influence function as inputs. The most commonly used polishing tool of the CNC machine is made of an inflated spherical membrane, called bonnet which spins rapidly about its axis of symmetry while making contact with the workpiece in the presence of a constant supply of polishing slurry and abrasive. The bonnet is covered with a standard detachable polishing 'cloth' such as Polyurethane or Multitex. In principle, any free-form optics surface can be created by precisely controlling the polishing spot, dwell time and angle of contact of the bonnet working against the workpiece. The contact area is varied by advancing and (de)compressing the polishing membrane against the part. In another variant of CNC process, called fluid jet polishing, a stream of premixed slurry coming out from a cylindrical nozzle fixed to a lapping machine is used to remove the surface material that results in the desired shape of the mirror. As described in Reference [8], "...the removal rate and polishing process depend on the concentration, the size and kind of abrasive particles, the kind of fluid, the pressure of the premixed slurry, the machining time, the kind of workpiece material, and the geometry, relative position, and orientation of the nozzle with respect to the surface. Yet another hybrid CNC process called 'grolishing' has been recently developed to achieve still higher volume removal rates [Ref. 9]. Novel aspects and many emerging areas of applications of the CNC polishing technology are increasingly reported in various technical journals and conference proceedings.

This announcement of opportunity call for the proposal from Indian industries to demonstrate the first phase roundel polishing process (Demo-I) of an optical-blank material using multi-axis CNC machine. In this Demo-I phase, also called sub-scale polishing, the contractor has to polish a roundel of size 40cm or above to the prescribed specifications. The 2nd (Demo-II) and 3rd (Demo-III) phases would require a full scale roundel (1.42m) polishing for Type-2 and Type-82 asphericity, respectively. The contract will proceed to Demo-II and Demo-III polishing only after the successful and timely execution of the Demo-I. The polished segments will be tested at TMT facilities for pass-fail requirements at each stage.

#### **6.4. Polishing Technology Demonstration Program Overview**

TMT-India is engaging in a series of technology development and process demonstrations in order to show readiness to produce polished mirror segments for the TMT. Two types of polishing technologies will be explored, followed by a down-select. The two

technologies being explored are the CNC process, described herein, and the Stressed Mirror Polishing (SMP) method [see Ref 6-7], utilized to successfully produce the Keck Telescope mirror segments.

It is anticipated that subscale prototypes will be produced using both methods. These prototype exercises will produce technical data establishing the process capability (accuracy, smoothness, convergence rates, removal rates, and machine process times) that will be used by the Contractor in developing detailed cost/schedule estimates and program plans for production. TMT-India and TMT will use these estimates and plans, along with the prototype process data, to form the basis for a down-select to the polishing technology that provides the best value to the Project.

Once the preferred process has been selected, it is anticipated that additional process demonstrations will be performed, resulting in polished and mounted prototype aspheric mirror segments. This follow-on work may include the fabrication of a Type-2 (least aspheric TMT mirror), and/or a Type-82 (most aspheric TMT mirror).

This Statement of Work describes the first sub-scale prototype to be produced by CNC polishing. Future tenders may be issued, at the sole discretion of TMT-India, to perform the additional steps described above.

## **7. STATEMENT OF WORK – THE CNC PROCESS DEMONSTRATION AND TESTING FOR DEMO-I**

The contractor shall demonstrate efficacy of the CNC process for M1 segment polishing that would meet the required surface accuracy and the acceptance-criteria specified by TMT and TMT-India. The proposed segment polishing process demonstration for the TMT will be carried out in three successive stages namely, Demo-I, Demo-II and Demo-III. Basic requirements, acceptance criteria and deliverables for Demo-I phase of polishing process demonstration are outlined Section 7.1. TMT/TMT-India will supply the roundel blanks of Zerodur or equivalent glass for the Demo-I phase. The final figuring of the blanks after CNC polishing will be done by a third party using Ion Beam Figuring (IBF) technique. A polished segment can only qualify for IBF process if a certain level of surface accuracy has been achieved in the previous stages of grinding and polishing. Therefore, optical-blanks polished by CNC process during Demo-II and Demo-III stage have to meet the pre-IBF specifications (see Requirements for Demo-II and Demo-III in Appendix B).

**In the first stage, the qualified contractor through EOI shall be asked to submit technical and price bid for Demo-I only. Upon successful completion of the Demo-I, same contractor may be asked to put technical as well as cost bids for Demo-II or/and Demo-III process subject to the project schedule and fund availability. To meet the demanding timeline of the TMT project and put the M1 segment production process on fast track,**

The TMT, TMT-India and the Contractor may jointly decide to skip the Demo-II process and directly go for Demo-III.

**7.1. DEMO-I (SUB-SCALE CNC POLISHING DEMONSTRATION)**

The first phase CNC polishing demonstration begins with a sub-scale roundel polishing. Here 'sub-scale' refers to the roundel diameter which is less than the actual size of the M1 segment, and 'polishing' refers to the entire process of generating, grinding, polishing, and acceptance testing the optic. The contractor should demonstrate smoothness, convergence and removal rate. Demo-I -polishing demonstration should be completed within 6 months time after the contract is awarded. The finished roundel should be returned to TMT for further testing.

**7.1.1. Requirements for Demo-I**

	Value
<b>Substrate</b>	
Material:	Zero expansion glass ceramic
Diameter:	≥ 40 cm
Thickness:	≥ 7.5 cm
Type:	Plano-Plano
<b>Optical Parameters</b>	
Clear Aperture:	> 35cm
Radius of Curvature:	> 3m
Asphericity:	10-226 micron (larger is preferred)
Off-axis distance	>30 cm

**7.1.2. Acceptance Criteria for Demo-I**

	Values
<b>Surface Figure Specifications</b>	2nd, 3rd and 4th order errors combined limited to 50nm RMS (surface)
Low order errors:	
Residual errors:	<10nm RMS (surface) after removal of low order terms indicated above.
Surface Roughness:	<2nm RMS (surface)
<b>Acceptance Test Requirements</b>	
Method 1:	Full aperture optical interferometry*
Spatial resolution:	<1mm/pixel
Method 2:	As necessary
Spatial Resolution:	surface roughness to 1mm, inclusive

\* See Appendix E for the optical testing requirements

### 7.1.3. Deliverables for Demo-I

After the completion of Demo-I phase, the Contractor shall deliver the following:

- A roundel of diameter 40cm or above polished with CNC process to the prescribed asphericity, ROC and surface finish as described in Section 7.2.1 and 7.2.2.
- A written inspection and test reports for both *in-process* as well as the final optical metrology tests of the polished mirror.
- The final acceptance test data in electronic format including test data characterizing test set repeatability (lift and set).
- A PSD or Structure Function Curve (TBD) describing the surface figure of the finished prototype over all spatial scales from full aperture down to surface roughness (can be a construction using multiple measurement instruments).
- A written report of smoothness and convergence process rates & surface figure.
- A report documenting the prototype Optical Test Set design, including a detailed error budget.
- Redlines/corrections on the documentation as a result of documentation errors.
- A report documenting the design and analysis of the metrology mount.
- The metrology mount hardware used to support the optic during testing.
- A complete roadmap and a separate cost estimate for the CNC polishing demonstration for the Demo-II/III phase and final M1 Production as described in Section 7.5.1 and 7.5.2.

## 7.2. GUIDELINES AND GENERAL APPROACH, INSPECTION AND ACCEPTANCE PROCEDURE

- i. The contractor should review TMT documents on segment polishing requirements [see Ref. 1-5]. Identify and communicate with TMT-India any clarification or incomplete information.
- ii. The contractor will start the CNC segment polishing Demo-I process only after the Pre-polishing Meeting (described below) and the receipt of a written authorization to proceed by TMT-India.
- iii. At various stages of the segment polishing and testing process, the Contractor is expected to work very closely with the technical team constituted by TMT-India and TMT project.

- iv. The polished segment will go through a comprehensive acceptance testing at TMT head-quarter (or at any other testing facility) with laboratory controlled environmental conditions typical of observatory site.
- v. The polished roundel will be shipped for the optical performance tests that will be conducted by TMT-India and TMT Project. TMT-India and TMT project reserve the right entrust to the responsibility of optical testing to the third party.
- vi. All results for CNC polishing process development and test reports (smoothness, convergence rates & surface figure etc) shall be provided in a single document (both print and electronic) format.

### **7.3. MEETINGS: CNC SEGMENT POLISHING DEMO-I**

The Contractor shall participate in the following meetings. The meetings may be via phone or video link. TMT-India reserves the right to meet at the Contractor's facility.

- 7.3.1.** A meeting will be called with the qualified contractors to sign a Non-Disclosure Agreement (NDA).
- 7.3.2.** A pre-bid meeting with qualified Contractors will be held after two weeks of NDA meeting. In this meeting technical or any other queries related to the contract will be addressed.
- 7.3.3.** A kickoff meeting after the award of contract. The meeting shall be used to answer any questions from the Contractor and also to review the polishing methodology, equipment assembly and test procedures.
- 7.3.4.** A Pre-build meeting where the Contractor shall inform and seek approval of TMT-India for any change or suggestion in polishing and/or testing methodology than what was agreed before. TMT-India will discuss the changes with TMT Project team and shall respond within ten working days.
- 7.3.5.** Review meeting involving TMT experts and TMT-India to discuss the progress status and the ongoing test results. The Contractor shall ship the polished blank(s) to the address specified by TMT-India after the successful completion of this meeting.
- 7.3.6.** A Pre-Ship meeting prior to the shipment of polished roundels. Test reports of Smoothness, convergence and material removal rates etc shall be discussed.
- 7.3.7.** Any other informal meetings as required or requested by TMT-India or Contractor to complete the CNC segment polishing demonstration.

#### 7.4. SCHEDULE – SEGMENT POLISHING (DEMO-I)\*

Meetings and deliverable shall be as per the following schedule. All dates are from Effective Date of Contract.

Item	Description	Completion date from date of contract
1	Kick-off Meeting	Week 1
2	Pre-Polishing Meeting	Week 3
3	Review 1 meeting**	Week 4
4	Review 2 meeting**	Week 8
5	Pre-Ship Meeting	Week 20
6	Delivery of polished segments with all the metrology and test reports.	Week 24

\*Schedule for Demo-II and Demo-III segment polishing meetings shall be worked out by TMT-India in consultation with TMT only after the successful completion of the Demo-I.

\*\* At the time of the contract, TMT-India and the Contractor will sign a MOU about the various milestones to be achieved during the work schedule.

#### 7.5. The ROADMAP AND COST ESTIMATE FOR DEMO-II/III PHASE & M1 PRODUCTION

The segment polishing contract will be extended to Demo-II/III phase after the contractor has successfully completed the Demo-I as per the requirements, qualification criteria and deliverables specified in Section 7.1.1-7.1.3. Based on the outcome of Demo-I, the Contractor shall provide a comprehensive methodology and roadmap for designing and commissioning the CNC process approach for Demo-II/III.

##### 7.5.1. Roadmap For Demo-II/III Phase

The Contractor should prepare a roadmap that should clearly indicate, but not limited to the following:

- I. The Contractor's preparedness to undertake the Demo-II/III.
- II. The Contractor shall describe the strategy to upscale the CNC polishing requirements and in-house facilities needed for the Demo-II/III phase.
- III. The Contractor shall describe the plan for procurement of machines, off-the-shelf material components and tools for Demo-II/III.
- IV. The Contractor shall describe the Hex-cutting methodology and approach.



- V. The Contractor shall describe the in-process and surface figure testing approach.
- VI. The Contractor should describe the plans for data management for the CNC polishing process demonstration, optical testing and hex-cutting.
- VII. The Contractor should provide an anticipated time schedule for Demo-II/III completion.

### **7.5.2. Cost Estimate for Demo-II/III Phase & M1 Production**

While the Demo-I work is in progress, the TMT-India has to plan and make a proposal to the funding agencies about the monetary requirements for the next stage of the project. Based on the experience gained in Demo-I, and the Scope of the Work for Demo-II/III given in Appendix B, the Contractor should give a provisional but competitive cost estimate for the CNC polishing demonstration for the Demo-II/III phase.

The Contractor should also provide a separate cost estimate for the M1 production for 115 segments -which is currently allotted share for TMT-India . Since this number may change at later stage, the Contractor should indicate how the final cost could escalate or deescalate in case the allotted M1 segment number changes. The scope of work for M1 Production is described in the Statement of Work for the Production of TMT Primary Mirror Segments [Ref. 10]. Both cost estimates should be broken into the categories listed below.

1. Cost of all recurring manufacturing labor. Cost breakup for quality control, assembly, testing, reporting, and any other significant recurring costs
  2. Cost for off-the-shelf components
  3. Cost of custom fabricated components
  4. Total cost for the delivery of assembly and test hardware/software
  5. All taxes and duties
  6. Packing and shipping
  7. Overheads and profit
- Total Cost of non-recurring engineering labor for services.
  - Provide feedback on any aspect of CNC process development, polishing assembly, or test that if modified, without compromising performance, would decrease cost. If possible, estimate any potential cost savings.
  - Provide feedback on the delivery schedule. Will the schedule drive cost? Would a more relaxed or a more ambitious schedule reduce cost? If possible, estimate any potential cost savings approach.

## 8. REFERENCES:

1. [TMT M1 Segment Overview and Background](#) (TMT.OPT.TEC.09.003.REL01)
2. [TMT Segment Polishing Principles](#) (TMT.OPT.TEC.10.052.REL03)
3. [Finished Segment Specifications](#) (TMT.OPT.SPE.07.002.CCR03)
4. [Polished Segment Drawings](#)
5. [TMT M1 Segmentation Database](#)
6. [Stressed Mirror Polishing](#)
7. [TMT - Stressed Mirror Polishing Fixture Study](#)
8. Oliver W. Fahnle, Hedser van Brug, and Hans J. Frankena, Fluid jet polishing of optical surfaces, Applied Optics, **37**, 6771 (1998).
9. D.D. Walker, A.T.H. Beaucamp, V. Doubrovski, C. Dunn, R. Freeman, G. McCavana, R. Morton, D. Riley, J. Simms, X. Wei, New results extending the Precessions process to smoothing ground aspheres and producing freeform parts, Proc. of SPIE Vol. 5869, 58690E, (2005).
10. Statement of Work for the Production of TMT Primary Mirror Segments.

## II. SECTION B

### METHODOLOGY OF SUBMISSION AND QUALIFICATION

#### 9. EXPRESSION OF INTEREST (EOI)-PART 1

- 9.1. Sealed EOI shall be submitted in the format specified in the Appendix, enclosing documents listed below and any other documents that would help in the evaluation of the EOI.
- a) The profile of the company
  - b) The management structure and brief bio-data of top most technical personnel
  - c) Technical staff strength in all categories
  - d) Manufacturing plants and equipment of the company
  - e) Financial position of the contractor
  - f) Audited balance sheets for the last three years
  - g) Solvency certificates (not older than 12 months) issued by scheduled/nationalized bank with which the Contractor holds the current account
  - h) Copy of Registration, LST/CST/WCT No., PAN No., and TIN No. allotted by concerned authorities
  - i) Details of past experience of the company in executing precision work, including projects related to astronomical or other sciences if any (including photographs)
  - j) Appreciation/Reward letters from clients
- 9.2. The EOI should be printed on company stationery and the authorized person who signs the offer is required to indicate his/her e-mail ID, mobile no. and also general e-mail ID for easy and fast communication.
- 9.3. The envelopes for EOI shall bear the following: "CNC Process Demonstration for M1 Segment Polishing for TMT project; Expression of Interest", name and address of the contractor. It shall be addressed to:

**THE DIRECTOR,  
INDIAN INSTITUTE OF ASTROPHYSICS (IIA),  
SARJAPUR ROAD, KORAMANGALA,  
BANGALORE – 560 034 KARNATAKA**

#### 10. SUBMISSION OF TECHNICAL AND PRICE BIDS – PART 2: GENERAL TERMS

- 10.1. The Contractor shall prepare original and two copies of the Bid, clearly marking each as "Original Bid" and "Copy of Bid," as appropriate. In the event of any discrepancy between them, the Original shall govern.
- 10.2. Both the Original and Copies of the Bid shall be signed by the Contractor or a person or persons duly authorized by the Contractor. The latter's authorization shall be indicated by written Power of Attorney accompanying the Bid.

- 10.3.** The bid must be submitted in an organized and structured manner. No brochures/leaflets etc. should be submitted in loose form. Please indicate page nos. on your quotations. For e.g., if the quotation is containing 25 pages, please indicate as 1/25, 2/25, 3/25,.... 25/25.
- 10.4.** The contents must be clearly typed without any cancellation/corrections or overwriting. Each page of the bid and cutting/corrections (if any) shall be duly signed and stamped by the Contractor. Failure to comply with this requirement may result in the bid being rejected.
- 10.5.** All pages of the Bid (except for un-amended printed literature) shall be initialed by the person or persons signing the Bid. The Contractor's name stated on the proposal shall be the exact legal name of the firm.
- 10.6.** The Technical and Price Bids shall be sealed in separate envelopes. The envelopes shall bear the following: "Prototyping of the Edge Sensor for the Thirty Meter Telescope Project", and "Technical Bid" or "Price Bid" as appropriate.
- 10.7.** Both the envelopes shall bear the name and address of the contractor.
- 10.8.** The two sealed envelopes shall be enclosed in a third sealed envelope. The envelopes shall bear the following: "CNC PROCESS DEMONSTRATION FOR M1 SEGMENT POLISHING FOR THIRTY METER TELESCOPE (TMT) PROJECT -Technical and Commercial Bids", bear the name and address of the contractor, and shall be addressed to:

**THE DIRECTOR,  
INDIAN INSTITUTE OF ASTROPHYSICS (IIA),  
SARJAPUR ROAD, KORAMANGALA,  
BANGALORE – 560 034  
KARNATAKA**

If the envelopes are not sealed and marked as required, IIA will not take any responsibility for misplacement or loss Bid's or premature opening whatsoever the reason may be.

- 10.9.** The Contractor has the option of sending the Bid by registered post or submitting the Bid in person so as to reach IIA by the date and time indicated. IIA will not be responsible for late, delayed Bids and loss of Bids in transit whatsoever the reason may be.
- 10.10.** IIA, on behalf of TMT-India, reserves the right to accept/reject any or all bids without assigning any reasons.

- 10.11.** Any other condition or guideline for submission of the bids shall be notified by IIA if it finds necessary.
- 10.12.** IIA, on behalf of TMT-India, may, at its discretion, extend the deadline for the submission of Bids by amending the Bidding Documents, in which case all rights and obligations of IIA and Contractor previously subject to the deadline will thereafter be subject to the deadline as extended.
- 10.13.** At any time prior to the deadline for submission of Bids, IIA, on behalf of TMT-India, may, for any reason, whether at its own initiative or in response to a clarification requested by a prospective Contractor, notify changes in the Bidding documents through an amendment.
- 10.14.** In order to allow reasonable time for the prospective Contractors for taking the amendment into account in preparation of their Bids, IIA, on behalf of TMT-India, may, at its discretion, extend the deadline for the submission of the Bids.
- 10.15.** The amendments, if any, shall be notified in writing at IIA's website and the amendments shall be binding on all the Contractors. Hence the Contractors shall view the notification in complete before submitting their Bids.
- 10.16.** The Contractor responding to announcement shall be deemed to have read and understood the documents in complete. Where counter terms and conditions have been offered by the Contractor, the same shall not be deemed to have been accepted by IIA, unless a specific written acceptance thereof is obtained.
- 10.17.** Any effort by a Contractor to influence IIA in the Bid Evaluation, Bid Comparison or Contract Award decisions may result in the rejection of its Bid.
- 10.18.** Any clarifications pertaining to this document may be obtained from IIA by the Contractors by writing at the following address at least fifteen days prior to the due date for submission of bids.

**THE DIRECTOR  
INDIAN INSTITUTE OF ASTROPHYSICS  
BANGALORE 560034, KARNATAKA**

**Contact for Technical Queries:**

1. Dr Ravinder Kumar Banyal (email: banyal@iiap.res.in), IIA Bangalore.
2. Prof A. N. Ramaprakash (email: anr@iucaa.ernet.in), IUCAA, Pune.

**Contact for Commercial/Administrative Queries:**

Shri Y. K. Raja Iyengar (email: ykri@iiap.res.in), Purchase Officer, IIA Bangalore.

## **11. TECHNICAL BID - PART 2A: DETAILS**

**TMT-India requests technical bids for only Demo-I process from the qualified vendors through EOI process. Upon completion of the Demo-I process and subjected to the final outcome of Demo-I and fund availability, TMT-India may then request technical bids for Demo-II or Demo-III. However, the contractor has to provide cost estimate for the Demo-II/III as one of the services in Demo-I.**

- 11.1.** A compliance sheet clearly indicating any deviation with reference to the terms and specifications shall be included. Limitations and assumptions, if any, should be clearly mentioned. Scope description may explicitly state anything which is not covered.
- 11.2.** The Technical Bid shall include but not limited to the following items:
- a) Description of the proposed technological approach to be followed for making the product
  - b) Strategy to be followed for the execution of the project including tools and technologies to be used
  - c) Project execution and management details, including details of the project team, escalation paths etc
  - d) Details of the resources, infrastructure or data expected to be provided by IIA, on behalf of TMT-India, to the successful Contractor for undertaking the project
  - e) Risk identification and mitigation plans
  - f) Quality audit, control and assurance plans
  - g) Change control process
  - h) Detailed time schedule for the project
  - i) Commercial terms and conditions
  - j) Acceptance criteria and test plans in the factory and on-site
  - k) A copy of the Price Bid without indicating the quoted Price
  - l) Earnest money deposit for only CNC segment polishing of Rs.2,00,000/- (Rupees Two Lakhs only) by way of Demand Draft drawn on a Nationalized Bank only in favour of **The Director, Indian Institute of Astrophysics.**

## **12. PRICE BID – PART 2B: DETAILS**

**TMT-India requests price bids for only Demo-I process from the qualified vendors through EOI process. Upon completion of the Demo-I process and subjected to the final outcome of Demo-I, TMT-India shall request price bids for Demo-II or Demo-III. However, the contractor has to provide cost estimate for the Demo-II/III as one of the services in Demo-I.**

- 12.1.** The Price Bids shall include the following:
- a) An item wise break-up of the cost in Indian Rupees, clearly indicating any free-issue material, imports etc.

- b) Applicable taxes, duties or other statutory payments
- c) Any other cost such as for tooling, packaging, travel etc.
- d) Total cost along with proposed payment stages, schedule and percentage to be paid at each stage.

**12.2.** The offer should be complete to indicate that all products and services asked for are quoted.

**12.3.** Price Bids shall be valid for a period of 90 days from the date of opening of bids. IIA, on behalf of TMT-India, may ask for the Contractor's consent to extend the period of validity. Such request and the response shall be made in writing only. A Contractor agreeing to the request of IIA for extension of the bid will not be permitted to modify the bid.

### **13. ELIGIBILITY CRITERIA AND QUALIFICATION PROCESS**

**13.1.** First only the EOI envelopes shall be opened on the date specified by IIA. Contractors or their authorized agents can be present at their own interest when the EOI are being opened.

**13.2.** The EOI will be evaluated by an Expert Committee. Mere submission of EOI will not entitle a Contractor to get selected to the tendering stage. The criteria for qualifying for the tender evaluation stage shall include, but are not limited to the following :

- a) The Contractor should be registered in India for the last 10 years.
- b) The Contractor should have a minimum average annual turnover of Rs. 15 crores during the last five years and should be of sound financial status (supporting documents must be included).
- c) The Contractor should have executed at least two projects involving similar precision fabrication costing above Rs. 3 crores in the past three years (supporting documents must be included).
- d) The Contractor must have the necessary infrastructure, in-house facilities and experience for design, manufacture, integration, testing and packaging the product.
- e) The Contractor must have well defined quality policy and assurance program.
- f) The Contractor should have a well defined plan for the manufacturing the product and organizational structure for project planning, monitoring, schedule tracking, corrective measures etc.
- g) Prior experience working with Government, Semi Government, Government Undertaking and Government Autonomous Bodies will be an added advantage(supporting documents must be included).
- h) EOI submitted by the Contractor shall be complete in all respects and shall include all details asked for in item 9.1 of Section B.

- 13.3.** The parties shortlisted through the evaluation of the Expression of Interest will be intimated and invited for a meeting to sign a Non-disclosure Agreement and receive additional documents.
- 13.4.** Technical Bids from only those parties who have responded to this EOI notice and short-listed by the Expert Committee will be qualified for the tendering process.
- 13.5.** IIA may organize a pre-bid meeting, approximately two weeks prior to the last date of submission of the bids. All the parties who have been shortlisted during the EOI stage, may attend the meeting and obtain clarifications regarding the technical and commercial terms and conditions.
- 13.6.** Technical Bid shall be opened on the date specified by IIA. Contractors or their authorized agents may be present at their own interest when the Bids are being opened.
- 13.7.** The Technical Bids shall be evaluated by an Expert Committee and the shortlisted Contractors may have to make presentations on their detailed proposals to the Committee. The following points should be covered in the presentation.
- a) Contractor's over all profile.
  - b) Contractor's strengths in dealing with the specific requirements in hand.
  - c) Contractor's experience in manufacturing products of similar nature and specification. List of projects executed to be presented and few will be discussed in detail.
  - d) Contractor will discuss few challenging cases where it made specific efforts to manufacture the product using non-conventional and innovative fabrication techniques and approach for schedule and cost control.
  - e) Contractor's understanding about over all scope of work and responsibility for this project. Please identify all activities involved in this job and discuss them in detail.
  - f) Critical areas identified by the Contractor having serious impact on delivery schedule and cost of the product. Contractor's proposed solutions for these problems.
  - g) Any special packing and shipment requirements for product foreseen by the Contractor.
  - h) Contractor will justify his manufacturing and financial capabilities to manufacture and deliver the product in given cost and time schedule.
  - i) Codes and standards regularly followed by the Contractor, especially international ones.
  - j) Details of Contractor's Quality Policy and Program, organizational set-up for Quality Surveillance and Quality Assurance, Quality Audit program, non-conformity control and reporting and testing and inspection facilities.
  - k) If some manufacturing, testing and inspection facilities are not available with the Contractor, it should mention about their access to such required facilities at other places.



- l) Project planning and Execution methodology followed by the Contractor, with specific emphasis on schedule and cost control.
  - m) Contractor's views if any, on the need to form a consortium to meet quality, cost and time schedule.
  - n) Last five years track record of the Contractor in terms of projected and actual delivery schedule and cost for projects above Rs. 5 crores.
  - o) Commitments and loading of the Contractor in terms of projects costing 10% or more of annual turnover.
  - p) Commitment from Contractor's highest authority for complete and credible involvement of the Contractor till completion of the deliveries.
- 13.8.** To assist in the evaluation of Bids, IIA, on behalf of TMT-India, may, at its discretion, ask the Contractor for a clarification of its Bid. IIA may call for meetings with Contractors to seek clarification at appropriate times in its premises in Bangalore. The Contractors shall attend the meeting at their own cost. The request for clarification and the response shall be in writing.
- 13.9.** Following the evaluation of Technical Bids, the Price Bids of qualified Contractors shall be opened to choose the Contractor to execute the Project.
- 13.10.** The evaluation committee may hold techno-commercial discussion with short listed and selected the contractor or contractors or consortium to manufacture and deliver the product as per drawings, technical specifications and delivery schedule given in the tender document. The order(s) may be placed with one contractor or more than one contractors or a consortium.
- 13.11.** During the assessment of the bids, specific weightage will be given to the contractors for innovative suggestions on fabrication feasibility, cost optimization and schedule control. Selection of the successful contractor will be mainly based on procurement optimization from an integrated point of view, involving optimization of manufacturing, shipping, assembly, schedule and cost. Prior experience with similar projects, commitment and risk evaluation will also play an important role in the selection process.

### **III. SECTION C**

#### **14. TERMS AND CONDITIONS**

The successful Contractor who is awarded the Contract as the Contractor shall be subjected to the Terms and Conditions that include, but not limited to the following. A detailed Contract Agreement (MOU) will be drawn and signed by both the parties before the award of the contract.

##### **14.1. SUBCONTRACTS**

- a. The Contractor is an independent contractor.
- b. The Contractor shall provide as an independent contractor, and not an agent of IIA, all necessary personnel, materials, equipment and facilities to perform the Work.
- c. The Contractor shall not assign its rights or obligations to a third party without the prior written approval of IIA.
- d. Notwithstanding any subcontract under this Agreement, whether approved by IIA or not, the Contractor shall remain fully liable and responsible to IIA for the satisfactory and timely completion of the Work.

##### **14.2. PAYMENT**

- a. Payment shall be made by IIA Bangalore on behalf of TMT-India.
- b. IIA shall pay the Contractor the Price in accordance with a Milestone Schedule.
- c. Upon completion of each Milestone, the Contractor shall submit to IIA an Invoice for the amount corresponding to that Milestone in Schedule.
- d. The Contractor shall submit reasonable documentary evidence, including but not limited to photographs and illustrations, as verification of completion of each Milestone. IIA, on behalf of TMT-India, may at its own discretion verify and substantiate that the Milestone has indeed been performed or completed as invoiced by the Contractor. Such verification may require Contractor to submit to IIA, additional documentation with regard to quality control normally expected during process of manufacture, and/or inspection by IIA representatives. Any request for substantiation under this clause shall be made by IIA within fourteen (14) days of its receipt of the corresponding Invoice.

##### **14.3. VESTING OF TITLE AND ASSUMPTION OF RISK**

- a. On each item to be delivered by the Contractor, including an item of work in progress, in respect of which payments have been made in accordance with item 15.2 of Section C above, IIA shall have a security interest in such items which shall be deemed to be released only at the time when the applicable Deliverable Item is finally delivered to and accepted by IIA, on behalf of TMT-India.
- b. Risk for loss or damage to Deliverable Items provided by the Contractor shall rest with the Contractor, until final acceptance by IIA, on behalf of TMT-India.
- c. Title to all Deliverable Items provided by the Contractor shall pass from the Contractor to IIA upon final acceptance or the final payment under item 14.2 of Section C above, whichever last occurs.
- d. TMT-India shall not accept any liability for the Contractor and its subcontractors, their subsidiaries and/or their officers, employees or agents, servants, and assignees, or any of them or for their property. The Contractor shall indemnify and keep harmless TMT-India, its officers, employees consultants, servants, agents and assignees, or any of them, against any loss or liability, costs or claims, action or proceedings which they or any of them may incur by reasons of damage to property or injury, including death, caused to the employees of the Contractor, its subsidiaries and/or their officers, employees or agents, servants and assignees, or any of them in connection with the performance of Work under this Agreement, and caused by an act of commission or omission by the Contractor, its subsidiaries and/or their officers, employees or agents, servants and assignees, or all or any of them.

#### **14.4. INTELLECTUAL PROPERTY RIGHTS**

- a. All Intellectual Property Rights existing in a party prior to the Contract (“**Existing Intellectual Property Rights**”) shall remain with that party. Except to the extent necessary to complete the Work or expressly stated otherwise, neither party grants any rights in its Existing Intellectual Property Rights to the other party.
- b. All Intellectual Property Rights arising directly from the Work (“**Work Intellectual Property Rights**”) shall, upon completion of the Work, vest in TMT-India and TMT project.

#### **14.5. CONFIDENTIAL INFORMATION**

- a. The Receiving Party shall protect the Confidential Information and keep it secure, and shall not at any time (except with the prior written consent of the Disclosing Party):

- b. directly or indirectly disclose or distribute the Confidential Information to any person other than a representative, employee, agent or advisor of the Receiving Party; or
- c. directly or indirectly disclose or distribute the Confidential Information to a representative, employee, agent or advisor of the Receiving Party except where such disclosure is necessary for the purpose of the Work; or
- d. use or copy the Confidential Information except for the purpose of the Work.
- e. Where the Receiving Party discloses Confidential Information to a representative, employee, agent or advisor, the Receiving Party shall ensure that such person is aware of the confidential nature of that Confidential Information and is bound by suitable obligations of confidentiality to ensure that that person protects and keeps secure that Confidential Information and does not use the Confidential Information for any reason other than the purpose of the Work.
- f. The Receiving Party shall, on demand by the Disclosing Party, or where the purpose of this Agreement has been served, promptly return to the Disclosing Party all Confidential Information (including copies or reproductions of the same) which is reasonably capable of being returned which is in the possession or control of the Receiving Party.
- g. This Agreement is not intended to restrict the use or disclosure of Confidential Information by the Receiving Party to the extent that it is required to be disclosed by law provided that the Receiving Party has taken such steps as are available under law (but not the institution of legal action) to protect such Confidential Information and notifies the Disclosing Party hereunder of its obligation to make such disclosure prior to the time such disclosure is made.
- h. The provisions of this item 14. 5 are subject to the provisions of item 14.4.

#### **14.6. SETTLEMENT OF DISPUTES**

- a. All disputes arising in connection with the interpretation or implementation of the Contract shall be amicably settled by IIA, on behalf of TMT-India, and the Contractor, by direct discussion.
- b. If IIA and the Contractor are unable to resolve a Dispute within 30 working days of the Dispute being referred to them, the parties may agree to refer the Dispute to mediation.

- c. IIA and the Contractor appoint a Mediation Committee comprising of two nominees by IIA and two nominees by the Contractor. IIA and the Contractor will seek the opinion of this Mediation Committee to amicably settle the disputes.
- d. In the event of a dispute or difference which cannot be resolved by mediation, the same shall be referred to an Arbitration Tribunal consisting of three members. Either party shall give notice to the other regarding its decision to refer the matter to arbitration. Within 30 days of such notice, one Arbitrator shall be nominated by each Party and the third Arbitrator shall be nominated by agreement between the Parties to this Agreement. The venue of the arbitration will be Bangalore. Subject to the aforesaid, the Indian Arbitration and Conciliation Act, 1996 and the rules there under and any statutory modification thereof for the time being in force shall be deemed to apply to the Arbitration proceedings.

#### **14.7. FORCE MAJEURE**

- a. Neither party shall be held responsible for any losses, if the fulfillment of any terms and conditions of this Contract are delayed or prevented by acts of lawful Government, revolutions and other disorders, wars (declared or undeclared), acts of enemies, strikes, fires, floods, acts of God and, without limiting the foregoing, any other cause not within the control of the party whose performance is interfered with and which, by the exercise of reasonable diligence, he is unable to prevent.
- b. Each party will promptly notify the other in writing when a condition of Force Majeure described in item 14.7 (a) arises. Neither party will be liable for any failure to perform its obligations hereunder if prevented from doing so by reason of Force Majeure, provided that it will have used all reasonable endeavours to perform its obligations notwithstanding such situation or event.
- c. As soon as practicable after the lodging of such notice the Contractor and IIA shall jointly determine whether the situation constitutes Force Majeure and if so the appropriate measures to meet the situation. Either party shall not be liable for any penalty or damage resulting in delays to perform its obligations as a consequence of Force Majeure.

#### **14.8. TERMINATION**

- a. IIA, on behalf of TMT-India, may terminate the Work with sixty (60) days prior written notice any time without assigning any reason or cause by notifying the Contractor in writing. In the event that the Work is so terminated by IIA then IIA shall pay the Contractor total amount of the costs and liabilities incurred by the Contractor up to the date of termination.

- b. IIA may at any time terminate the Contract by giving written notice with immediate effect in any of the following cases.
- c. If the Contractor is adjudged insolvent or if its financial position is such that within the framework of its national law, legal action leading towards bankruptcy is taken against it by its creditors or its Government, or
- d. If it is determined through appropriate proceedings that the Contractor has resorted to fraudulent or corrupt practices in connection with its securing or implementation of this Agreement.

#### **14.9. PACKAGING, TRANSPORTATION AND INSURANCE**

- a. The packing of the product for shipment shall be appropriate depending upon the nature of transportation and handling hazards. The stores shall be packed securely to avoid any damage to the consignment in transit, loading, unloading and storage. The package shall contain a Packing Note quoting Contract number and date, Copy of Shipping Release and one set of test certificates. The Package shall be marked with name and address of the Contractor, lifting points and special handling instructions, if any.
- b. The Contractor is responsible for its delivery to TMT, USA including transportation charges and transit insurance.

#### **14.10. ACCEPTANCE PROCEDURE: Please refer to item 7.0 of Section A.**

#### **14.11. PATENTS, COPYRIGHTS AND OTHER PROPRIETARY RIGHTS**

The Contractor warrants that any Deliverable Item provided to IIA on behalf of TMT-India shall to the best of its knowledge and belief be free of any rightful claim of any third party for infringement of patent, copyright, or other proprietary right.

#### **14.12. ACCESS TO WORK**

- a. Work in progress and data and documentation related to the Work, including setting up the CNC mirror polishing facility and metrology necessary to understand the ability of the Work to meet the specifications are subject to examination, evaluation, and inspection by IIA, on behalf of TMT-India, at reasonable times and with reasonable notice to the Contractor.
- b. The Contractor shall provide IIA, access to such documentation and to those of its premises where Work on or in connection with the subject of this contract is being performed during normal business hours and subject to prior arrangement.

- c. IIA may depute engineers/scientists of its choice from time to time who will be allowed by the Contractor to participate in the Work in respect of the disciplines in which they are specialized.

#### **14.13. WARRANTY**

- a. The Contractor warrants that all Deliverable Items shall be free and clear of all liens and encumbrances pertaining to title at the time of delivery to TMT-India or TMT USA. The Contractor's liability and IIA's sole remedy under this Warranty shall be limited to the Contractor procuring the removal of any such lien or encumbrance or the replacement of the goods and parts thereof that has been identified as defective of title. The Contractor will provide a one year warranty from date of acceptance of the Deliverables by IIA.

And the Contractor warrants that:

- b. all Deliverable Items that are procured or furnished by the Contractor or its subcontractors or suppliers shall be new and shall conform in grade and quality to all the requirements of the Contract; where the grade or quality is not specifically defined therein, they shall be of a grade or quality suitable for their intended use;
- c. all workmanship employed in the manufacture of Deliverable Items shall be of good quality, free from faults and defects, and shall conform to the relevant specifications applicable to the said manufacture; and
- d. all Deliverable Items shall be free from defects arising out of the use of defective equipment or materials that would result in a total or partial failure of any Deliverable Item or which would render a Deliverable Item unsafe for its intended use.

#### **14.14. DELIVERABLE DOCUMENTATION AND STANDARDS**

*The Deliverable Documentation shall include a complete CNC Process Demonstration Report, Testing procedures, Process flow, Machine times, removal rates (all process steps itemized) Surface Figure Testing Report (both in-process and final), and Metrological Errors Budget. All documentation shall be written in clear and concise English language. The author should also adhere to consistent terminology and use acronyms that are well defined in the document.*

#### **14.15. PROGRESS REPORTS**

The Contractor shall provide IIA with detailed reports on progress of the Work and notify any deviations on the schedule, at least monthly highlights and bi-monthly detailed reports on the progress of the Work, up to the Delivery Date.

**14.16. PERFORMANCE GUARANTEE**

IIA shall withhold 5% part of each Milestone Payment towards Performance Guarantee and pay the total sum on completion of 6 months since delivery, subject to the Deliverable Items meeting the Final Acceptance Tests.

**14.17. GOVERNING LAW**

This Agreement shall be governed by, and construed in accordance with, the law for the time being in force in India.



**IV. APPENDIX A**

**APPENDIX A: FORMAT FOR SUBMISSION OF "EXPRESSION OF INTEREST"**

*IIA RFP No ( to be Inserted)*

**Bidder's Offer No.** -----

**Dated** -----

FROM

M/s -----

-----

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To

The Director,

Indian Institute of Astrophysics (IIA),

Sarjapur Road, Koramangala,

Bangalore, Karnataka – 560 034,

India

Dear Sir,

We have gone through the conditions pertaining to the Announcement of Opportunity and by accepting the same, we are submitting herewith our Expression of Interest.

We hereby agree to supply the Stores conforming to the specifications incorporated in Section – A.

Yours faithfully,

Stamp and Signature of the Contractor

## V. APPENDIX B

(For reference only)

### FULL-SCALE CNC POLISHING DEMONSTRATION FOR DEMO-II/III PHASE

#### Scope of Work: Demo-II (Type-2)\*

A future contract may be supported for CNC polishing development, in which case, the contractor should proceed to Demo-II (Full-scale CNC polishing demonstration Type-2) only after the successful completion of the Demo-I to be independently tested and certified by TMT and TMT-India. In addition, the contract for Demo-II will also be subjected to the availability of the funds and the Government approval. Here, 'Full-scale' refers to the actual dimension of the M1 segment, i.e., 1.44m. Type-2 refers to the irregular hexagonal shape and unique optical prescription of the innermost M1 segments. The aspheric departure of the Type-2 segment is about  $6\mu\text{m}$  PV.

#### Requirements for Demo-II:

- The minimum diameter of the blank should be 1.44m.
- The segment should be polished to paraxial radius of curvature (RoC) of M1 which is 60m.
- Segment should be off-axis polished with  $6\mu\text{m}$  PV asphericity.
- Should demonstrate smoothness, convergence and low-order shape removal rates.
- Should demonstrate hex-cutting & SSA mounting after the polishing.

#### Acceptance Criteria for Demo-II:

- Low-order shape errors < 2 microns PV
- Mid spatial frequency errors (smoothness) < TBD
- Roughness < 2nm RMS
- Demo-II full scale roundel polishing demonstration should be completed tentatively by July 2012.

**Deliverable for Demo-II:** After the completion of Demo-II phase, the Contractor shall deliver the following:

- A full scale polished, hex-cut and SSA mounted segment conforming to the prescribed asphericity, ROC and surface finish.
- A written inspection and test reports for both *in-process* as well as the final optical metrology tests of the CNC polished, hex-cut and SSA mounted mirror.

- A detailed report on smoothness, convergence process rates, surface figure and metrology error budget.
- Redlines/corrections on the documentation as a result of documentation errors.

\* Any change in specifications for Demo-II at later time will be conveyed to the Contractor by a written communication.

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### **Scope of the Work: Demo-III (Type 82)\*\***

A future contract may be supported CNC polishing development for Demo-III. Demo-III, the last stage for full-scale polishing demonstration, may start after the successful completion and testing (to be done by TMT) of the Demo-II. In addition, the contract for Demo-III will also be subjected to the availability of the funds and the Government approval. Here, 'Full-scale' refers to the actual dimensions of the M1 segment, i.e., 1.44m. Type 82 refers to the irregular hexagonal shape and unique optical prescription of the outermost M1 segments. The aspheric departure of the Type-82 segment is about 226 $\mu$ m PV.

#### **Requirements for Demo-III**

- The minimum diameter of the blank should be 1.44m.
- The segment should be polished to paraxial radius of curvature (RoC) of M1 which is 60m.
- Segment should be off-axis polished with 226 $\mu$ m PV asphericity.
- Should demonstrate smoothness, convergence and low-order shape removal rates of CNC process.
- Should demonstrate the hex-cutting & SSA mounting after the CNC polishing.

#### **Acceptance Criteria for Demo-III:**

- Low-order shape errors < 2 microns PV
- Mid spatial frequency errors (smoothness) <TBD
- Roughness < 2nm RMS
- Phase 2 full scale roundel polishing demonstration should be completed tentatively by July 2013.

**Deliverable for Demo-III:** After the completion of Demo-III phase, the Contractor shall deliver the following:

- The full-scale finished blank cut into hexagonal shape and mounted on segment support assembly as per the prescribed asphericity, ROC and surface finish.
- A written inspection and test reports for both *in-process* as well as the final optical metrology tests of the Demo-III CNC polished, hex-cut and SSA mounted mirror.
- A detailed report on smoothness, convergence process rates, surface figure and metrology error budget.
- Redlines/corrections on the documentation as a result of documentation errors.
- A competitive cost estimates and a complete methodology and roadmap for M1 Segment Production.
- Additional report suggesting any changes in the CNC methodology to facilitate the efficient segment production process and/or to minimize the cost of the mass production or any suggestion which adds value to the system. The recommended design changes should not significantly affect the design or performance of the hardware.

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\*\* Any change in specifications for Demo-III at later time will be conveyed to the Contractor by a written communication.

## **VI. APPENDIX C**

### **TERMS & CONDITIONS FOR THE FINAL AWARD of M1 SEGMENT POLISHING**

#### **(For reference only)**

The Contractor successfully demonstrating the CNC polishing process on Demo-I may be asked to put technical and cost bid for Demo-II or/and Demo-III stages. The contractor upon successful completion of Demo-III only will be considered for the final contract for the M1 segments polishing. The Contractor shall provide a comprehensive methodology and roadmap for designing, commissioning and CNC process-development approach for M1 segment polishing. The allotted share to TMT-India at present is about 115 segments. The number, however, may change at later date due to various reasons. Awarding the contract for the full-scale mirror polishing is subjected to the following terms and conditions:

- The polished roundels in all Demo phases meet the design requirements and acceptance criteria, tested and authenticated independently by TMT and TMT-India.
- Govt. of India approves the proposal for full partnership in the TMT project.
- The TMT board assigns to TMT-India a part of the M1 segment polishing work package.
- Any condition which are deemed necessary for the successful partnership between TMT-India and the TMT project as well as for the timely and cost effective completion of the construction of TMT.
- The cost estimate for the final M1 segment production using CNC should be competitive among TMT partner countries which include China, Japan, Canada, and U.S.

## VII. APPENDIX D

### THE CNC PROCESS DEVELOPMENT: METHODOLOGY AND ROADMAP FOR M1 PRODUCTION (For reference only)

Based on the outcome of Demo-I/II/III, the Contractor shall provide a comprehensive methodology and roadmap for designing and commissioning the CNC process approach for M1 production. In addition, a statement regarding the readiness and anticipated time schedule for the full Production of the M1 segment shall also be included. The Terms & Conditions for the Final Award of M1 Segment Polishing is given in the Appendix C. The scope of work for M1 Production is described in the Statement of Work for the Production of TMT Primary Mirror Segments [Ref. 10]. The Methodology and Roadmap shall include, but not limited to, the following:

- i. Includes a capacity analysis demonstrating the ability to achieve the required tasks of M1 Production using CNC polishing and testing based on the results from Demo-I/II/III.
- ii. Defines the Contractor's CNC-segment polishing approach for M1 Production.
- iii. Defines the Contractor's in-process and final surface figure testing approach for M1 Production.
- iv. Defines the Contractor's segment hex-cutting approach for the M1 Production.
- v. Defines additional procedures that will be used to setup the assembly line CNC polishing facility to accomplish segment polishing requirements for M1 Production.
- vi. Defines the in-house facilities and fixtures that will be required to polish, test, hex-cut and SSA mounting of the finished segment for the M1 Production.
- vii. Defines the strategy for procurement of machines, off-the-shelf material components and tools that will be used for the segment polishing for Production.
- viii. Describes plans for data management for the CNC polishing process demonstration, optical testing and hex-cutting for the M1 Production.
- ix. Describes plans for re-working of the CNC polishing process or test metrology, that don't pass the final acceptance tests for the M1 Production.

Should give a detailed cost and schedule estimates for Production, including the following:

- Procurement and /or leasing of CNC machine,
- CNC machine assembling and initial testing,
- Setting up the testing facility,

- Starting of the CNC polishing process,
- Optical testing & metrology ,
- Hex-cutting
- Report preparation,
- Mounting polished segment in SSA and
- Final packing and shipping of the SSA mounted polished.
- Facilitization for final M1 segment production

The cost estimates shall be organized such that Non-recurring expenses are itemized separately from the recurring expenses.

## **IX. APPENDIX E**

### **TESTING REQUIREMENTS**

The following section briefly describes the TMT-recommended [see Ref. 3] guidelines and requirements for the optical testing, optical configuration, test accuracy and related inspection report.

#### **OPTICAL TESTING**

The surface figure accuracy of the full aperture optical surface of the polished blank shall be measured by interferometry. The resolution of the interferograms over the full aperture shall be at least 500 by 500 points. Data dropouts in any interferogram shall be no more than 0.1 % of the data points. The surface figure accuracy near the edges of the optical surface shall be verified by interferometry having a resolution element no larger than 1 mm over the outer 50 mm of width along the edge, which can be accomplished by high resolution full aperture interferometry, expanded scale sub-aperture interferometry, the use of local test plates, or other suitable means. The entire perimeter of each Segment shall be tested to this resolution. Testing of the surface near the edges can be performed at optics shop temperature. Any exceptions to this test procedure (e.g., to only test sample locations rather than the full perimeter) shall be approved by TMT prior to being used in the acceptance test.

#### **OPTICAL TEST CONFIGURATION**

- The optical tests that constitute the acceptance tests for each Polished Mirror Assembly (the “Acceptance Optical Tests”) shall be performed with the Segment mounted on its SSA.
- The Acceptance Optical Tests shall be performed with the Optical Surface facing upwards, i.e. with the ZPSA-axis vertical. The warping harnesses shall be adjusted so that they do not exert any moments on the Segment.
- In the telescope, the mass of the edge sensors will have a small but non-negligible effect on the segment figure. Therefore, these sensors shall be simulated in the Acceptance Optical Test by dummy masses temporarily attached to the back of the segment at 12 points around the edge. Each dummy mass shall be 95 grams. The locations of the dummy masses and their centers of gravity shall be as specified in TMT drawing [TBD].
- The Segment shall be aligned in the optical test to ensure that the Segment will have the correct optical figure for its position in the primary mirror when it is mounted in the telescope. Alignment of the Segment in the telescope is accomplished by the registration features on the base of the Tower Assembly of the SSA. In the Acceptance Optical Test, the Segment shall be positioned such that its figure is measured relative to the true position defined by the interface features on the Tower Assembly, within a tolerance of +/- 50 microns in the XPSA and YPSA directions and a tolerance of +/- 250



micro-radians of rotation about the ZPSA axis. Any error or uncertainty in the segment position or rotation during the Acceptance Optical Test shall be considered when determining compliance to surface figure accuracy and testing accuracy [ Section 3.9.2, 3.10.3 of Ref. 3].

- The full-aperture test shall be performed with the Segment and its support system at a temperature to be specified by TMT. The specified temperature will be between 2°C and 9°C. The Segment and its support system shall be maintained in thermal equilibrium within  $\pm 2^\circ\text{C}$  of the specified temperature during testing.

### **TESTING ACCURACY**

All tests and measurements used to verify compliance with the requirements of this specification shall be of sufficient accuracy to ensure the requirements have been met with a 90% confidence level. This means that the measured values shall be sufficiently within the allowable range that, when measurement error is included, there is a 90% probability that the parameter being measured is in compliance with the requirement.

### **DEMONSTRATION OF SUBSURFACE DAMAGE REMOVAL**

Processes used to remove subsurface damage (e.g. polishing or etching) shall be qualified. Qualification shall demonstrate that the processes used in the production of the Segments routinely produce surfaces that are free of subsurface damage, using the TMT blank material.

### **CRACKS AND CHIPS**

No visible cracks shall be allowed in the Segment. If a crack develops in a Segment surface, the crack shall be ground out, leaving a depression that is approximately spherical. The depth of any such spherical depression shall be less than half the diameter of the sphere. A ground out spherical depression shall be considered to be a Chip as defined in this specification. All surfaces of a Chip must be ground out to remove sharp edges and cracks. No Chip shall exceed 10 mm in mean diameter after grinding. No more than three Chips are allowed on any Segment. No more than one Chip is allowed on the Optical Surface, and no more than one Chip is allowed on the Back Surface.

### **INSPECTION REPORT**

A final data package shall be delivered with each polished segment . Along with a paper copy, an electronic version (contained in a single data file) shall be provided to TMT. Interferometric data shall be in surface error data files that can be read and analyzed in Matlab. Scanned images of plots shall not be acceptable. This data package shall include, at a minimum, the following information.

#### **Optical Metrology Data**

- Full-aperture metrology interferometer data files
- Amplitude of low-order-aberrations subtracted as permitted by [SPEM1.SEG.POL-1920, Ref. 3]

- Sub-aperture metrology data files (e.g. interferometer data files of edge measurements made per [SPE-M1.SEG.POL-2015, Ref. 3])
- Surface Roughness measurement results
- Error analysis supporting a 90% confidence level that accepted part meets all specifications, considering all potential error sources

**A dimensional inspection report, including the following information**

- Compliance with all dimensions and drawing requirements of front and back surfaces of the segments
- Compliance with Scratch/Dig specifications given in [Section 3.9.4 of Ref. 3]
- Compliance with Crack and Chip limitations given in [Section 3.11 of Ref. 3]
- Location of any Chips

## **X. APPENDIX F**

### **ABBREVIATIONS**

CNC: Computer Numerical Control

CTE: Coefficient of Thermal Expansion

EOI: Expression of Interest

IBF: Ion Beam Figuring

IIA: Indian Institute of Astrophysics

M1: Primary Mirror

M1CS: Primary Mirror Control System

MOU: Memorandum of Understanding

NDA: Non-Disclosure Agreement

PMA: Polished Mirror Assembly

P-V: Peak-to-Valley

RFP: Request for Proposal

RMS: Root Mean Square

SMP: Stress Mirror Polishing

SSA: Segment Support Assembly

SOW: Statement of Work

TBD: To Be Decided

TMT: Thirty Meter Telescope Project or Thirty Meter Telescope