ASSOCIATION OF UNIVERSITIES FOR RESEARCH IN ASTRONOMY, INC. (AURA)

Operating the National Solar Observatory (NSO)

INSTRUCTIONS TO OFFERORS

FOR

REQUEST FOR PROPOSAL
RFP NO. N00051392C

FOR

DM11KM DEFORMABLE MIRROR DESIGN STUDY

On behalf of

THE DANIEL K. INOUYE SOLAR TELESCOPE (DKIST)
HALEAKALĀ OBSERVATORY, MAUI, HAWAI'I

PROPOSALS MUST BE RECEIVED BY:
AUGUST 31, 2025 3:00PM MST
(Tucson, U.S.) (CLOSING DATE)

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REQUEST FOR PROPOSALS (RFP)

No. N00051392C

SECTION 1. ANNOUNCEMENT OF OPPORTUNITY

The Association of Universities for Research in Astronomy, Inc. (AURA)/Central Administrative Services (CAS) Contracts Office, is soliciting Request for Proposals (RFP) from qualified Contractors to provide exhibit planning, design and installation supervision.

PURPOSE

The Work is defined as the development, design, and analysis of the 11km Deformable Mirror System and all included components as specified by MCAO.DM11KM.MIRROR.STUDY.SPEC (hereafter "Specification") and as required by this document. Note that the Work detailed in this SOW does not include any prototype fabrication. If any sort of prototype fabrication or other work beyond modeling and analysis is necessary to ensure the success of the DM11km final design and fabrication, Contractor shall propose a Risk Reduction Study following this design study. Contractor shall be responsible for all aspects of the Work.

The DM11km System is composed of the following:

- A deformable mirror device (referred to as "the DM" herein)
- A mount that interfaces to the deformable mirror device
- Driver electronics (referred to as "the DM Driver" herein) with a digital interface to control the actuators in the deformable mirror device
- Analysis of DM performance under expected operating conditions
- Detailed Design Documentation

SCHEDULE

The Work shall be subdivided into three (3) Phases, as shown in Table 1 below.

Phase	Deliverable	Month	Milestone Payment
Phase 1: Planning and Development	Kick-off Meeting Project Plan	1	25%
Phase 2: Mid-Progress Report	Mid-progress Report Mid-progress Meeting	4	25%
Phase 3: Final Report	Final Report Final Meeting Proposal for Risk Reduction Study (optional) Proposal for DM11km final design and fabrication	8	50%

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SECTION 2. STATEMENT OF WORK

Please see Appendix 1 - MCAO.DM11KM.MIRROR.STUDY.SOW.REVA

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SECTION 3. INSTRUCTIONS TO OFFERORS

Article 1. Definitions

1. All definitions set forth throughout as well as in any attachments and appendices are applicable to these Instructions to Offerors.

2. The “Request for Proposal Documents” (hereinafter “RFP Documents”) consists of the following:
   A. Instruction to Offerors;
   B. Amendment(s) to the solicitation documents issued prior to Closing Date (if any);
   C. Statement of Work (SOW); and
   D. Representations and Certifications.

3. “Amendment” means the written or graphic instruments issued prior to the Closing Date which modify or interpret the RFP Documents, including specifications, by additions, deletions, extensions, answers to questions posted on the RFP Webpage, clarifications or corrections.

4. “Contract Documents” may include any, or all, of the following:
   A. Contract between AURA and the Contractor;
   B. Representations and Certifications;
   C. Terms and Conditions;
   D. Statement of Work;
   E. Construction Drawings;
   F. Construction Specifications;
   G. Photos of Area of Work; and/or
   H. Amendments and all modifications incorporated in the documents before their execution.

5. “AURA” means the Association of Universities for Research in Astronomy, Inc., an Arizona non-profit corporation. The term "AURA" includes its authorized representatives. AURA operates the Vera C. Rubin Observatory (Rubin) and is engaged in managing, operating, and maintaining observatories and related activities for research in the field of astronomy. AURA desires to enter into a Contract to complete a design study into the fabrication of the 11km Deformable Mirror System (DM11km) for the DKIST, as described in Appendix 1 - Statement of Work.

6. “Foundation” means the National Science Foundation, an agency of the United States of America created under the National Science Foundation Act of 1950. The term "Foundation" includes its authorized representatives.

7. “Offeror” means the person, authorized representative(s), or organization submitting a proposal, and if awarded, shall perform the Work described in the Contract as the “Contractor.”

8. “Contractor” means the person, authorized representative(s) or organization responsible for the completion of the Work. If a proposal is submitted on behalf of multiple parties, the term “Contractor,” shall apply to the party or parties responsible for completion of the Work.

9. “Work” means those tasks, requirements, and obligations described in the SOW as included in the Contract Documents.

10. “Subcontractor” means a person or organization, with a direct agreement with the Contractor to furnish labor, or labor and materials, in support of the Statement of Work. The term also includes lower tier contractors of a Subcontractor, but it does not include suppliers who furnish materials not worked to a special design according to the drawings and specifications. Nothing contained in the Contract Documents shall be deemed or construed to create any contractual relation between AURA and any Subcontractor as defined above.

11. "Closing Date” means the specified date and time by when all proposal documents must be received by AURA.

Article 2. Description of Project

AURA/NSO is anticipating entering into a Contract for the development, design, and analysis of the 11km Deformable Mirror System and all included components as specified by Appendix 2 - MCAO.DM11KM.MIRROR.STUDY.SPEC (hereafter “Specification”) and as required by this document.

The DM11km System is composed of the following:

- A deformable mirror device (referred to as “the DM” herein)
- A mount that interfaces to the deformable mirror device
- Driver electronics (referred to as “the DM Driver” herein) with a digital interface to control the actuators in the deformable mirror device
- Analysis of DM performance under expected operating conditions
- Detailed Design Documentation

Article 3. Proposal Procedures

1. Proposals shall consist of the elements described in these RFP Instructions, including those described in SECTION 3. Offeror's Proposal for Contract. **The Offeror's Proposal Documents, must be completed in its entirety and submitted to the email address indicated in this Article 3, Section 8 below.** The Offeror's price and technical proposals shall be in accordance with the format indicated in Section 3. The entirety of the proposal shall be in English. Offeror's Proposals shall be limited to 2 (two) documents, clearly titled as either Price Proposal or Technical Proposal. **Any proposal or part of a proposal not conforming to the specified formats shall be cause to reject the entire proposal**

2.

   A. Due to AURA's tax-exempt status, prices quoted shall not include federal, state, or local sales or excise taxes. Offerors subject to a mandatory value-added tax (VAT) may include VAT in the comprehensive price quote.

   B. Prices quoted in the proposal(s) shall include furnishing of all transportation, materials, equipment, tools, supplies, labor and services necessary or proper for performance and completion of the Work, except such as may be otherwise expressly provided for in the RFP documents.

   C. Offeror shall conform its price in accordance with the payment and milestone schedule. Prices shall be in U.S. Dollars ($USD).

3. In the event of discrepancy between the prices quoted in the RFP in words and those quoted in figures, the words shall control.

4. Subject to the following procedures and requirements, Proposals shall be submitted electronically to the Contracts Officer in charge of this project, outlined in paragraph 8 below.

5. Offerors shall submit the documents described in Section 4 electronically, in PDF format. **The date/time signature-marked no later than the due date and time for receipt of Proposals for this RFP.** Failure to timely submit these documents to AURA in accordance with these rules shall result in the elimination of Offerors Proposals from consideration.

6. **In case of technical difficulties, a phone call must be received by the Contracts Officer by the date/time due, and a plan to have a copy hand delivered to the Contracts Officer will be arranged.**

7. No other forms of submission of Proposals will be considered. No other forms of submission for modifications to Proposals will be considered. Modifications to Proposals submitted may be made electronically or via the delivery of a hard copy of the modified Proposal Documents, if the modified Proposal Documents are delivered

to AURA in accordance with the rules set forth in in this Article, on or before the 3:00 o'clock P.M. Mountain Standard Time on the Proposal due date.

8. A Proposal may be deemed non-compliant if the entire submission package has not been received at the designated location by the Closing Date. Proposals may be delivered to:

   Suzanne Baron Helming
   Procurement Manager
   AURA
   Email: sbaronhelming@aura-astronomy.org

9. Offeror may withdraw its Proposal by written request, at any time prior to the Closing Date. If a qualified Offeror determines that it will not submit a Proposal, notice of such is requested by AURA.

10. Offeror's Proposal shall be valid for one hundred and twenty (120) days beginning with the Closing Date.

Article 4. Communication and Questions

Any questions or requests for clarification of this request for Proposals must be solely directed to the Contracts Officer via electronic mail to: sbaronhelming@aura-astronomy.org. Questions must be submitted by email and must be received at least three (3) business days before the Closing Date. All questions and responses from any Offeror will be provided to all parties via the AURA Proposal Opportunities Webpage. Responses will be anonymous as to the questioner/Offeror. Any question not conforming to this format will be disregarded. Offerors shall disregard references to any other contract, such as that found on the AURA Proposal Opportunities Webpage. AURA will endeavor to respond to questions within three business days.

Article 5. Review of Documents

1. AURA reserves the right to make additions, deletions, or modifications to the RFP Documents in writing by amendment at any time prior to the Closing Date. If, in the opinion of AURA, any such change causes an increase in the time required for submission of proposals, AURA may, at its sole discretion, adjust the Closing Date in the form of an Amendment posted on the AURA website.

2. Offerors shall examine the RFP Documents carefully. Any request for interpretation or correction of any ambiguity, inconsistency, or error that Offeror discovers must be made as per Article 3, not later than three (3) days prior to the Closing Date.

3. All interpretations and corrections to the RFP or to the Contract Documents will be issued in the form of an Amendment posted on the AURA website. Offerors shall not rely on any interpretation or correction to the RFP or Contract Documents given by any

other method.

4. Prior to receipt of proposals, addenda, if required, will be posted on the AURA website.

5. The failure of Offeror to receive or examine any form, instrument, amendment or other document, or failure to acquaint itself with existing conditions shall not relieve Offeror from obligations and responsibilities with respect to its proposal or to the Contract. The submission of a proposal will be taken as prima facie evidence of agreement with this section.

Article 6. Representations

1. Offeror, by submitting a proposal, represents that it is familiar with existing conditions under which the Work will be performed, including, but not limited to, environmental, cultural, and operational requirements.

2.
   A. Offeror, by submitting its proposal, represents that it has read and understands all the RFP Documents and by submitting a proposal acknowledges acceptance of all of the Terms and Conditions of the RFP Documents as defined in Section 1.2 of these Instructions.

   B. **Any exceptions to the Contract Documents by Offeror shall be stated in writing on Offeror's letterhead and submitted with its proposal with clear and concise justification(s). Offeror shall provide alternative wording for consideration by AURA.**

   C. Offeror, by submitting a Proposal, certifies that the Contract Documents, including the Terms and Conditions and SOW, have been reviewed and accepted by the Contract Representative of the Offeror, or similar binding authority, or has noted such exception with its Proposal.

3. Offeror shall be prepared to submit a resolution giving evidence of its qualification of corporate signature authority, if requested.

4. Offeror shall complete, sign, and submit the Representations and Certifications of Section 3 with the Proposal.

Article 7. Alternative Provisions

1. Offeror represents that its Proposal is based upon the specifications, terms and conditions described in the RFP documents, unless alternative provisions are expressly permitted by an Amendment.

2. A proposal containing an alternate provision(s) shall be accompanied by full and complete justification and technical description of the alternate provisions(s) along with a detailed cost analysis of the differences between the alternate and original provisions. AURA reserves the right to request such other additional information as may be required for approval either before or after receipt of proposals.

3. Failure to provide justification or technical descriptions for approval purposes may be cause for AURA to reject the proposal.

Article 8. Completion Time

Offerors shall represent in the proposal that they can complete the Work within the timeline indicated by the SOW or propose an alternative completion date with justification. The time of performance shall be dated from receipt of a Contract, and all costs included in the proposal shall be for the Work to be completed within that period.

Article 9. Evaluation of Proposal

1. Proposals will be opened and evaluated privately by AURA after the Closing Date.

2. Proposals will be evaluated according to the following major factors, ranked or weighted in no particular order:

   - ***Technical Criteria***
   - ***Price***
   - ***Schedule***
   - ***References***
   - ***Experience***

3. All proposal documents received will be considered confidential and will not be released. The award of the Contract(s), if any, made by AURA, will be made to the Offeror(s) that presents the best value. AURA reserves the right to determine, at its sole and exclusive discretion, which proposal, if any, properly meets the “best value” requirement and whether it is in the best interests of AURA to accept the proposal. Therefore, Offeror shall ensure that all requested information is included in its proposal.

Article 10. Time Period for Evaluation of Proposals; Rejection of Proposals; Irregularities

1. AURA reserves the right to hold any or all Proposals for a period of up to one hundred twenty (120) calendar days.

2. AURA shall have the right to take up to one hundred twenty (120) calendar days to evaluate the Proposals submitted and to make a decision.

3. AURA reserves the right to accept or reject any or all Proposals or any combination thereof, to withhold an award for any reason it may determine, or to waive any irregularities or informalities in the Proposals or in the submission of Proposals.

Article 11. Form of Agreement

The form of agreement that will be used shall be a "Fixed Price Design Agreement." A template of the above mentioned contract and the terms and conditions incorporated by reference into said agreement may be found at AURA Proposal Opportunities webpage. The final form of agreement presented to the Contractor selected to perform the work may vary from the template format attached hereto, depending on the Proposal documents submitted by Contractor and other facts and circumstances deemed relevant by AURA.

Article 12. Law

The laws of the state of Arizona shall govern the interpretation of these Proposals Documents and the interpretation of the Fixed Price Design Contract.

Article 13. Limitations of Liability

Offeror's Proposal should clearly describe its limitations of liability as well as that of its retained subcontractors, as applicable.

Article 14. Offeror's Contract

Given the specialty nature of the tasking herein, AURA requests that Offerors include their own form of contract conforming to the requirements of the SOW and these RFP Instructions.

Article 18. Contract with Small Businesses, Minority-Owned Firms and Women's Business Enterprises

AURA encourages small businesses, minority owned firms and women's business enterprises to Proposal on AURA jobs that they are qualified to Proposal on. Contractors seeking to Propose on this "11km Deformable Mirror Design Study" project are encouraged to utilize, as much as possible, small businesses, minority owned firms and women's business enterprises as subcontractors.

SECTION 3. OFFEROR'S PROPOSAL FOR CONTRACT

(This document **MUST** be completed and returned to AURA with Proposal)

DATE: _____

TO: AURA/CAS
Procurement Office
Attn: Suzanne Baron Helming
Email: sbaronhelming@aura-astronomy.org
950 N Cherry Ave
Tucson, AZ 85719
Procurement Manager

FROM: _____
(Legal Name of individual, firm or corporation proposing)

_____
(Business Address Line 1)

_____
(Business Address Line 2)

_____
(Business Address City, State and Zip)

_____
(Signature)

_____
(Title)

1. By submitting this Proposal, the Offeror accepts all of the terms and conditions of the RFP Documents as described in Section 3, Article 1 of the Instructions to Offerors or has enclosed written exceptions to the terms of the Draft Contract. AURA will review the exceptions, but is not obligated to accept (any or all of) them in a final contract if awarded.

2. In compliance with AURA's Request for Proposal No. N00051392C, the Offeror hereby proposes to furnish all labor, materials, equipment and supplies to perform the Work for AURA's DM11km Deformable Mirror Design Study, in accordance with the Specifications, pertinent Contract Documents and Statement of Work.

3. Offeror's Proposal submittal shall include the following:

   A. A Cover Sheet including: contracting General Information (RFP Number, if given; Proposal Title name/address of the firm; Technical and Administrative points of contact; DUNS/UEI number, Teamed Organizations, if any; and any other pertinent information);

   B. An abstract summarizing the proposed effort, not to exceed 500 words;

   C. The Technical Proposal, which shall address:

   1) Relevant technical experience of Offerors;
   2) Relevant technical experience and role of any proposed subcontractors;
   3) Names, resumes, and role of key technical personnel;
   4) A minimum of 3 references on projects of a similar size, complexity and nature;
   5) Unique qualifications;
   6) Preliminary project plan, including project schedule and your proposed milestone or payment schedule;
   7) **Description of the full scope of services offered and expressly any exclusions;**
   8) Proposed deviations from requirements with justifications and impact on price and schedule; and,

   D. Any other relevant information.

4. The Offeror hereby specifies, in accordance with Article 7, Completion Time, of Instructions to Offerors that Work shall be completed within _____ calendar days after receipt of the Contract.

5. In accordance with the above completion schedule (Paragraph 4) and enclosed specifications, the Offeror hereby proposes to accomplish the work described above for the total project sum of:

   _____ DOLLARS ($_____)

This proposal is submitted by Offeror and endorsed by its authorizing official by the signature below:

By: _____
(Signature)

Name: _____
(Printed/Typed Name)

Title: _____

SECTION 4. QUALIFICATIONS PACKAGE

(This document **MUST** be completed and returned to AURA with Proposal)

CONTRACTOR/CONSULTANT QUALIFICATIONS

This form is used to obtain information from Contractors/Consultants about their qualifications. The information that is used to evaluate them is taken from this form as well as from other sources, including but not limited to the proposal submitted by Contractor/Consultant, performance evaluations, any additional data requested by the Association of Universities for Research in Astronomy, Inc., outside research and interviews with the most highly qualified Contractors/Consultants and their references.

GENERAL INSTRUCTIONS

This form presents the qualifications for a specific contract. Carefully comply with instructions when preparing and submitting this form. Be as concise as possible and provide all information pertaining to this project and contract.

DEFINITIONS

Association of Universities for Research in Astronomy, Inc. (AURA): AURA is a consortium of universities, and educational and other non-profit institutions that operates world-class astronomical observatories that AURA terms "centers". AURA's members are 42 U.S. institutions and 5 international affiliates. AURA views itself as acting on behalf of the science communities that are served by its centers, and as a trustee and advocate for the centers' missions.

Contractor/Consultant: (Contractor): A company or individual providing goods and/or services required for a program or project.

Discipline: Primary technical capabilities of key personnel, as evidenced by academic degree, professional registration, certification, and/or extensive experience.

Key Personnel: Individuals who will have major contract responsibilities demonstrated through unusual or unique expertise, e.g. architects, engineers.

The NSF's National Solar Observatory (NSO): The National Science Foundations (NSF's) National Solar Observatory (hereinafter "NSO") headquarters are located at 3665 Discovery Drive, Boulder, CO 80303.

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SPECIFIC INSTRUCTIONS

Contract – Specific Qualifications

Section A. Contract Information

Contractor Point of Contact

1 - 5. Name, Title, Name of Contractor, Telephone Number, Fax (Facsimile) Number and E-mail (Electronic Mail) Address. Provide information for a representative of the contractor that AURA may contact for additional information.

Section B. Sub-Contractor Information

6 - 8. List any sub-contractors (if applicable). Provide Company name, address, and role in this contract. Then provide the firm's name, full mailing address, and a brief description of the role of each firm's performance activities in this contract. The named subcontractors and outside associates or consultants must be used. Any changes warrant approval by the AURA/NSO contracting officer. If needed, attach an additional sheet in the same format as Section C.

Section C. Business References

Section D. Representations and Certifications

The Contractor is requested to check the appropriate boxes making the Representations and Certifications of the project a formal part of its pre-qualification. Failure to provide this information will prevent your company from being pre-qualified.

9. Small Business and Small Disadvantaged Business Contracting Program. AURA/NSO maintains a Small Business and Small Disadvantaged Business Contracting Program. Check Business Size as Small or Large as defined. Check as many that apply under the Business Classification. Check one under Business Status, for IRS reporting requirements.

10. Identification Numbers. Enter appropriate D-U-N-S Number and Federal Employee Identification Number and (Central Contractor Registration Number) (or Social Security Number, if
appropriate).

Section E. Debarment/Suspension Status

The Contractor is required to read and certify the understanding of the debarment procedure and process.

11-12. Signature and Date: Signature and Date of an authorized representative attests that the information provided is current and factual.

13-15. Name, Title, and Address.

Section F. Byrd Anti-Lobbying Amendment Certification

The Contractor is required to read and certify that it has not used federal appropriated funds to pay anyone for influencing an agency or a member or employee of Congress in connection with the award of any federal contracts, grants, loans or agreements.

16-19. Signature, Date and Title: Signature and title of an authorized representative who certifies to the truthfulness of the statements set forth therein.

Section G. Qualifications of Corporate Signature

Signature of the qualified person authorized, empowered, and directed on behalf of the Contractor to make and execute Proposals, offers, and contracts is required.

20-21. Signature and Date: Signature and Date of Contractor's officer to attest that the officer signing the Proposal Documents is authorized to make and execute Proposals, offers, and contracts binding upon this corporation for the offer and sale of goods and/or services by this corporation in the course of its business in an amount specified in the Contractor's Proposal Document.

22-24. Name, Title, and Address.

Section H. Qualifications of Limited Liability Company Signature

Signature of the qualified person authorized, empowered, and directed on behalf of the Contractor to make and execute Proposals, offers, and contracts is required.

25-26. Signature and Date: Signature and Date: Signature and Date of Contractor's member/manager/officer to attest that the individual signing the Proposal Documents is authorized to make and execute Proposals, offers, and contracts binding upon this limited liability company for the offer and sale of goods and/or services by this limited liability company in the course of its business in an amount specified in the Contractor's Proposal Document.

27-29. Name, Title, and Address.

Section I. Certification of no Conflict of Interest

The Contractor is required to read and certify that no organizational conflict of interest exists as defined in the certification form.

30-33. Signature of authorized representative, date and printed name of authorized representative and title of authorized representative.

Section J. Additional Information

Use this section to provide additional information specifically requested or to address selection criteria not covered by the information provided.

Section K. Declarations

34-37. Signature and Date: Signature and Date of Contractor's officer to attest that the information contained in the Proposal Documents is true and correct and to confirm that the Contractor understands its statements in the Proposal Documents are subject to investigation and that dishonest answers may be grounds for disqualification and may subject the Contractor and its representative to criminal and civil liability.

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Section A. Contract Information

Contractor Point of Contact

1. Name and Title: _____

2. Name of company: _____

3. Telephone number: _____

4. Fax number: _____

5. E-mail address: _____

Section B. Sub-contractor (ONLY if applicable)

Sub-contractor Point of Contact

6. Company Name: _____

7. Address: _____

8. Role in this contract: _____

Section C. BUSINESS REFERENCES:

On a separate sheet of paper, list five customers for whom your business is currently providing the same or similar services as those covered in the scope of work/technical specifications described in Section III of this RFP. Include all information requested below.

Please provide: the name of the business, the point of contact name and email contact information, the address, their phone and fax numbers and the type of project completed for the references:

You may include any other information or documentation that may assist AURA in evaluating your qualifications.

Section D. Representations and Certifications

The Contractor, by checking the appropriate boxes, makes the following representations and certifications:

The Offeror is (check all that apply):

- ☐ a regular Dealer/Distributor of the item(s) offered.
- ☐ a regular Manufacturer of the item(s) offered.

9. Small Business/Small Disadvantaged Business Contracting Program

Pursuant to the terms of our Agreement with the Government and applicable Federal Procurement Regulations 1-1.701, AURA is required to maintain a Small Business and Small Disadvantaged Business Subcontracting Program. You are therefore requested to check the appropriate blocks below:

Business Size (Check One)

☐ Small	A domestic concern that is independently owned and operated, is not dominant in the field of its operations, qualifies under the criteria covering annual receipts set forth in Section 3 of the Small Business Act and does not employ more than 500 employees.
☐ Large	A domestic concern which, including domestic and foreign divisions and affiliates, normally employs 500 or more persons, is independently or publicly owned or controlled and operated, and which may be a division of another domestic or foreign concern.

Business Classification (Check as many as are applicable)

☐ Minority	51% of business or stock is owned by one or more socially and economically disadvantaged individuals and whose management and daily business operations are controlled by one more of such individuals. Socially and economically disadvantaged individuals including Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Asian-Indian Americans and other minorities, or any other individual found to be disadvantaged pursuant to Section 8(a) of the Small Business Act. Native Americans include American Indians, Eskimos, Aleuts, and native Hawaiians. Asian-Pacific Americans includes U. S. citizens whose origins are Guam, the U. S. Trust Territories of the Pacific, Northern Marianas, Laos, Cambodia and Taiwan. For assistance in determining your business size and socially and economically disadvantaged status, contact the nearest office of the Small Business Administration.

☐ Women-Owned A business that is at least 51% owned, controlled and operated by a woman or women.

Note: Controlled is defined as exercising the power to make policy decisions. Operated is defined as actively involved in the day-to-day management.

☐ Non-Profit A business or organization that has received non-profit status under IRS Regulation 501(c)(3).

☐ Public An agency of the Federal or State Government Sector or a municipality.

☐ Sheltered A sheltered workshop or other equivalent business basically employing the handicapped.

☐ Handicapped A business that is owned, controlled and operated by a handicapped person(s).

☐ Foreign A concern which is not incorporated in the United States or an unincorporated concern having its principal place of business outside the United States.

Business Status (Check One) - For IRS Reporting Requirements

☐ Corporation A business entity that is registered with a state in the United States as a corporation, including non-profit corporations but excluding professional corporations.

☐ Other An individual, or other business entity that is not a registered corporation. This includes corporations, independent contractors, partnerships, and the like.

10. Indicate Your:

SAM Unique Entity Identifier (UEI): _____

Federal Employer ID (EIN): _____

SAM.gov Registration? (Check one): ☐ Yes ☐ No

WARNING: Failure to provide this information may require that we withhold 20% of your payments and may result in fines imposed by the IRS.

Section E. Debarment/Suspension Status

Contractor certifies to the best of its knowledge and belief that it and its principals:

(a) are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from a covered transaction by any Federal department or agency;

(b) have not within a three year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, state or local) transaction or contract under a public transaction; violation of Federal or state antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (federal, State or local) with commission of any of the offenses enumerated in paragraph b of this certification; and

(d) have not within a three-year period preceding this proposal for Proposal had one or more public transactions (Federal, state or local) terminated for cause or default. The Contractor agrees to provide immediate notice to the AURA/NSO Contracting Officer in the event of being suspended, debarred, or declared ineligible by any department or Federal Agency, or upon receipt of a notice of proposed debarment that is received after the submission of the Proposal or offer, but prior to the award of the purchase order or contract.

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CERTIFICATION

The Contractor hereby certifies that he or she has read the above Debarment/Suspension Status requirements and that he or she understands and will comply with these requirements. Please advise this facility as soon as possible when the status of your company changes from that indicated above.

11. SIGNATURE OF AUTHORIZED REPRESENTATIVE:

_____

12. DATE SIGNED:

_____

13. NAME OF SIGNER (PRINT OR TYPE):

_____

14. TITLE OF SIGNER

_____

15. ADDRESS:

_____

_____

_____

SECTION F. BYRD ANTI-LOBBYING AMENDMENT CERTIFICATION (31 U.S.C. §1352)

(To be signed with each Proposal or offer exceeding $100,000.00)

Contractor certifies, to the best of its knowledge and belief that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of congress, or an employee of a Member of congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form LLL, "Disclosure of Lobbying Activities," in accordance with its instructions to the [as amended by "Government wide Guidance for New Restrictions on Lobbying, "61 Fed. Reg. 1413 (1/19/96). Note Language in paragraph (2) herein has been modified in accordance with Section 10 of the lobbying disclosure Act of 1995 (P.L. 104-65, to be codified at 2 U.S. C. 1601 *et seq*.)].

(3) Contractor shall require that the language of this certification be included in the award documents for all sub-awards at all tiers including subcontracts, sub-grants, and contracts under grants, loans, and cooperative agreements and that all sub-recipients shall certify and disclose accordingly. This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by 31 U.S.C. § 1352 (as amended by the Lobbying Disclosure Act of 1995). Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such expenditure or failure.

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CERTIFICATION

Contractor certifies or affirms the truthfulness and accuracy of each statement of its certification and disclosure, if any. In addition, contractor understands and agrees that the provisions of 31 U.S.C. A 3801 *et seq*., apply to this certification and disclosure, if any.

16. SIGNATURE OF AUTHORIZED OFFICER/MEMBER/REPRESENTATIVE:

_____

17. DATE SIGNED:

_____

18. NAME OF SIGNER (PRINT OR TYPE):

_____

19. TITLE OF SIGNER

_____

Section G. Qualifications of Corporate Signature

(To be completed if Contractor is a corporation)

_____, incorporated in the
(Name of Corporation)

State of _____.

RESOLVED THAT:

_____, _____
(Name) (Title)

of this corporation is hereby authorized, empowered, and directed, for and on behalf of this corporation and its corporate name, to make and execute Proposals, offers, and contracts binding upon this corporation for the offer and sale of goods and/or services by this corporation in the course of its business in an amount up to:

_____ DOLLARS ($_____)

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CERTIFICATION

I hereby certify that I am a/the duly elected and qualified _____, of the above named corporation, that the forgoing is a true and correct statement of a resolution adopted at a meeting of the Board of Directors of said corporation, and that the foregoing resolution is in full force and effect, and has not been withdrawn, repealed, amended, or canceled.

IN WITNESS WHEREOF I have hereto set my hand on behalf of said corporation.

20. SIGNATURE OF OFFICER:

_____

21. DATE SIGNED:

_____

22. NAME OF SIGNER (PRINT OR TYPE):

_____

23. TITLE OF SIGNER

_____

24. ADDRESS:

_____

_____

_____

SECTION H. QUALIFICATION OF LIMITED LIABILITY COMPANY SIGNATURE

(To be completed if Contractor is a Limited Liability company)

_____, organized in the

(Name of Limited Liability Company)

State of _____.

RESOLVED THAT:

_____, _____

(Name) (Title)

of this limited liability company is hereby authorized, empowered, and directed, for and on behalf of this limited liability company and its limited liability name, to make and execute Proposals, offers, and contracts binding upon this limited liability company for the offer and sale of goods and/or services by this limited liability company in the course of its business in an amount up to:

_____ DOLLARS ($_____)

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CERTIFICATION

I hereby certify that I am (i) a member or (ii) a/the duly elected and qualified/appointed _____, of the above named limited liability company, that the forgoing is a true and correct statement of a resolution adopted at a meeting of the members/managers of said limited liability company, and that the foregoing resolution is in full force and effect, and has not been withdrawn, repealed, amended, or canceled.

IN WITNESS WHEREOF, I have hereto set my hand on behalf of said limited liability company.

25. SIGNATURE OF AUTHORIZED OFFICER/MEMBER/REPRESENTATIVE:

_____

26. DATE SIGNED:

_____

27. NAME OF SIGNER (PRINT OR TYPE):

_____

28. TITLE OF SIGNER

_____

29. ADDRESS:

_____

_____

_____

SECTION I. CONFLICTS OF INTEREST CERTIFICATION

(a) Contractor warrants that to the best of its knowledge and belief, and except as otherwise disclosed, it does not have any organizational conflict of interest which is defined as a situation in which the nature of work under a proposed contract and the prospective contractor's organizational, financial, contractual or other interest are such that:

(i) award of the contract may result in or be the result of an unfair competitive advantage;

(ii) the Contractor's objectivity in performing the contract work may be impaired; or

(iii) that the Contractor has disclosed all relevant information and requested AURA to make a determination with respect to this Contract.

(b) Contractor agrees that if, after award, it discovers an organizational conflict of interest with respect to this Contract, it shall make an immediate and full disclosure in writing to the AURA Contracts Officer which shall include a description of the action which the Contractor has taken or intends to take to eliminate or neutralize the conflict. The AURA Contracts Officer may, however, terminate the contract for the convenience of AURA, if it would be in the best interests of AURA to do so.

(c) In the event the Contractor was aware of an organizational conflict of interest before the award of this contract and intentionally did not disclose the conflict to the AURA Contracts Officer, the Contracts Officer may terminate the Contract for default.

(d) Contractor shall require a conflict of interest disclosure or representation from subcontractors and consultants who may be in a position to influence the advice or assistance rendered to AURA and shall include any necessary provisions to eliminate or neutralize conflicts of interest in such consultant agreements or subcontracts involving performance or work under this Contract.

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CERTIFICATION

I declare under penalty of perjury that all statements and information contained in this document and any accompanying documents are true and correct, with full knowledge that all statements made in this document and any accompanying documents are subject to investigation and that any false or dishonest answer to any question may be grounds for disqualification from this solicitation or termination of any award and expose me and the represented organization to both civil and criminal liability.

30. SIGNATURE OF AUTHORIZED OFFICER/MEMBER/REPRESENTATIVE:

_____

31. DATE SIGNED:

_____

32. NAME OF SIGNER (PRINT OR TYPE):

_____

33. TITLE OF SIGNER

_____

SECTION J. ADDITIONAL INFORMATION

Provide any additional information as requested. Attach additional sheets as needed. Offeror not to exceed 30 pages.

SECTION K. DECLARATION

I declare under penalty of perjury that all statements and information contained in this document and any accompanying documents are true and correct, with full knowledge that all statements made in this document any accompanying documents are subject to investigation and that any false or dishonest answer to any question may be grounds for disqualification from this solicitation and expose me and the represented organization to both civil and criminal liability.

34. SIGNATURE OF AUTHORIZED OFFICER/MEMBER/REPRESENTATIVE:

_____

35. DATE SIGNED:

_____

36. NAME OF SIGNER (PRINT OR TYPE):

_____

37. TITLE OF SIGNER

_____

APPENDIX 1

11km Deformable Mirror Design Study
Statement of Work

Luke Johnson, Dirk Schmidt
MCAO Group

April 28, 2025

REVISION SUMMARY:

1. Date: April 28, 2025
   Revision: A
   Changes: Initial draft

Table of Contents

1. DEFINITIONS

- AURA – Association of Universities for Research in Astronomy, Inc.
- CAD – Computer-aided design
- CIDL – Configuration Item Data List
- CO – Contracts Officer
- COTR – Contract Officer's Technical Representative
- DKIST – Daniel K. Inouye Solar Telescope
- DM – Deformable Mirror
- DM11KM – 11 Kilometer Deformable Mirror
- DR – Design Review
- Electronic format – the computerized format of a deliverable document or software program file (e.g., Microsoft word format document)
- ICD – Interface Control Document
- MCAO – Multi-Conjugate Adaptive Optics
- NSO – National Solar Observatory
- PDR – Preliminary Design Review
- Phase – a distinct stage or segment of the Work
- RFW – Request for Waiver
- Site – the set aside location for the DKIST Observatory on the Institute for Astronomy's Haleakalā High Altitude Observatory on the summit of Haleakalā, which is on the island of Maui, Hawai'i, USA.
- SOW – Statement of Work
- TD – Technical Directive
- TBR – To be Reviewed
- WBS – Work Breakdown Structure

2. SCOPE & OVERVIEW OF DELIVERABLES

2.1 SCOPE

This Statement of Work (SOW) defines the tasks, deliverables, and timelines that shall be performed and provided by Contractor as part of AURA/NSO Contract **N00051392C** for a design study into the fabrication of the 11km Deformable Mirror System (DM11km).

2.2 CONTRACTOR RESPONSIBILITIES

The Work is defined as the development, design, and analysis of the 11km Deformable Mirror System and all included components as specified by MCAO.DM11KM.MIRROR.STUDY.SPEC (hereafter "Specification") and as required by this document. Note that the Work detailed in this SOW does not include any prototype fabrication. If any sort of prototype fabrication or other work beyond modeling and analysis is necessary to ensure the success of the DM11km final design and fabrication, Contractor shall propose a Risk Reduction Study following this design study, as described in section 6.4.

Contractor shall be responsible for all aspects of the Work.

The DM11km System is composed of the following:

- A deformable mirror device (referred to as "the DM" herein)
- A mount that interfaces to the deformable mirror device
- Driver electronics (referred to as "the DM Driver" herein) with a digital interface to control the actuators in the deformable mirror device
- Analysis of DM performance under expected operating conditions
- Detailed Design Documentation

2.3 PROJECT PHASE, MAJOR MILESTONES, AND DELIVERABLES

The Work shall be subdivided into three (3) Phases, as shown in Table 1. The deliverables for each Phase shall include the items shown in the table. Specific information on the Phases and deliverables is included in Sections 4 through 5 of this SOW.

Phase	Deliverable	Month	Milestone Payment
Phase 1: Planning and Development	Kick-off Meeting Project Plan	1	25%
Phase 2: Mid-Progress Report	Mid-progress Report Mid-progress Meeting	4	25%
Phase 3: Final Report	Final Report Final Meeting Proposal for Risk Reduction Study (optional)	8	50%

	Proposal for DM11km final design and fabrication		

Table 1: Phase deliverables

3. PROJECT ORGANIZATION & CONTROL

3.1 KEY PERSONNEL

Contractor shall establish and maintain an effective project organization to accomplish the objectives of this Contract and to carry out the Work in an efficient manner. This project organization shall have effective control and support from appropriate senior company management.

Contractor's project management office shall coordinate and control all technical and commercial activities, project resources, and manage all disciplines required to successfully complete the Work.

Contractor shall assign a Project Manager with authority over all personnel and resources of the project organization as well as those of other members of their industrial team. The Project Manager shall be assigned authority to negotiate and conclude with AURA/NSO for all issues related to the Contract to the extent consistent with the Contractor's organizational structure. The Project Manager shall be the single point of contact with AURA/NSO for all technical and contractual matters to the extent consistent with the Contractor's organizational structure.

AURA/NSO will appoint a Contracts Officer (CO) and a Contracts Officer's Technical Representative (COTR) who will be the single point of technical contact with Contractor via the Project Manager.

3.2 DOCUMENTATION OF CHANGES AND COMMUNICATIONS

No aspect of the Work may be modified by verbal or informal email communications. In order to be binding on the parties, a modification to the Work must be formally documented by the proper AURA/NSO representative (either AURA Contracts Manager or COTR) as provided in this Contract.

When Contractor requires technical information from AURA/NSO, the COTR will provide the information using a standard Technical Directive form and shall sign the form. All Technical Directives will be numbered in sequential order.

Staff from AURA/NSO and Contractor may informally communicate in order to explore issues and ideas related to the Work, provided, however, that:

- The Program Manager and the COTR shall be copied on all substantive email communications between AURA/NSO and Contractor personnel and be provided with summaries of all meeting and discussions where they were not present.
- Once informal communications have converged on a solution to an issue the COTR will either document the agreed solution using a Technical Directive (TD) or may ask the AURA/NSO Contracts Officer to prepare a Contract Amendment to jointly modify the terms of the Contract.

3.3 MEETINGS

In addition to the Kick-Off Meeting, the Mid-Progress Meeting, and the Final Meeting, Contractor shall meet regularly with AURA/NSO personnel upon request to update them on the status of the Work and discuss any matter related to the Work. All such meetings shall be held

either at NSO Boulder, CO site, at Contractor's facility, or via telephone/videoconferencing link with AURA/NSO personnel as determined in this document or revised as agreed upon by Contractor and AURA prior to the meeting. All meetings shall include the option for remote participation via telephone/videoconferencing

3.4 ACCESS TO WORK AND INFORMATION

Subject to the security requirements for entry to the facility and upon reasonable advance notice, Contractor shall grant AURA/NSO personnel and representatives escorted access during working hours to Contractor's own facility where contracted testing of the Work is being performed. Contractor will work to obtain similar access for AURA/NSO personnel to visit subcontractors' facilities alongside Contractor personnel, subject to the restrictions of intellectual property and security protections.

Upon request, Contractor shall allow AURA/NSO personnel to view, copy, and retain deliverable design documentation produced under this Contract. AURA/NSO will make the request for the information not less than three (3) working days in advance of the desired time of receipt.

3.5 DELAYS

If an event or events occur that may cause an impact to the schedule, Contractor shall evaluate all reasonable methods to avoid a schedule slip or a delay of achieving critical milestones. These methods may include utilization of additional Contractor manpower and facilities. AURA/NSO shall be notified within three (3) days of such events; notification shall include a description of schedule impact.

4. PHASE 1: PLANNING AND DEVELOPMENT

4.1 KICK-OFF MEETING

By the date provided in the Project Plan, Contractor shall meet in a video conference call with AURA/NSO for a Kick-Off Meeting. The Kick-Off Meeting shall include:

1) A presentation by Contractor of the designs proposed by Contractor in its bid proposal and as modified during contract negotiations;
2) A discussion of the preliminary project plan detailing the Work and all milestones; and
3) Initial discussions regarding the commencement of the Work.
4) Contractor's staff to be present at the Kick-Off Meeting shall include at least the Program Manager and lead engineers.

During the course of the Work, Contractor shall give AURA/NSO the opportunity to review the general concepts of the designs as early as possible. At the time of the Kick-Off Meeting, Contractor shall present a brief but informal report showing how the Contractor intends to apply best engineering practices during the design of the DM11km. This report shall focus on all specific areas of the Work that Contractor believes represents potentially elevated risk to the project, including price, schedule, or future required changes to the DM11km and their requirements.

Contractor shall provide Kick-Off documentation, their presentation, and any unresolved questions and issues prior to the Kick-Off meeting. This documentation shall be submitted to AURA/NSO five (5) calendar days in advance of the Kick-Off meeting. Contractor shall submit to AURA/NSO a summary of the Kick-Off meeting discussions and a list of action items within ten (10) calendar days after the Kick-Off meeting. Contractor shall include their responses to items raised by AURA/NSO staff in this summary. AURA/NSO will provide Contractor with a list of comments for response within five (5) calendar days after the Kick-Off meeting.

4.2 KICK-OFF DOCUMENTATION

4.2.1 Project Plan

Contractor shall submit a Project Plan to AURA/NSO. The Project Plan shall consist of:

1) A Work Breakdown Structure (WBS) of all of the tasks necessary to complete the Work, including but not limited to the development, design, and analysis, including duration, manpower, and resources required for each task;
2) A schedule based upon the task list which shows when each task will be started and completed. This schedule shall include the milestones and key dates specified above in section 2.3 of this SOW; and

4.2.2 Compliance Matrix

Contractor shall submit to the COTR a Compliance Matrix, in Contractor preferred format listing all of the Specifications. The Compliance Matrix shall be accompanied by a report detailing any noncompliance noted, or any other technical or interface issues that will need to be resolved

during the design effort and describing proposed methods of resolving these issues. The content of the Compliance Matrix shall at a minimum include the following information:

- The source document and requirement number.
- Title or description of the requirement.
- The verification method. Choices of verification method are: Design, Inspection, Analysis, and/or Test. Multiple verification methods may be used. The verification method for each requirement is documented in the Specifications.
- Compliance. This cell is marked with the word "OK" if the requirement is met by the Work and the word "Fails" if the requirement is not met by the Work.
- Notes on the compliance if other than "OK".

5. PHASE 2: MID-PROGRESS REPORT

5.1 GENERAL

Contractor shall call a mid-progress meeting when they estimate that the Work is approximately 50% complete.

5.2 MID-PROGRESS REPORT WORK

The Work necessary for the Mid-Progress Report is the same as that required for the Final Report

5.3 MID-PROGRESS REPORT DOCUMENTATION

At a minimum, the Mid-Progress Report Documentation shall consist of the following:

1) An updated Project Plan, including a schedule for the remainder of the Work;
2) An updated Compliance Matrix, including all potential requirements that have a risk of not being met;
3) A report, consisting of a written document or set of slides, that summarizes:
   a) Progress made to date on all major tasks.
   b) Any significant areas where design tradeoffs need to be made.
   c) Requirements or aspects of the design that are likely to incur significant cost or risk to design and fabricate.

5.4 MID-PROGRESS REVIEW

Contractor shall meet in a video conference call with AURA/NSO for a Mid-Progress Meeting. At the Mid-Progress Meeting, Contractor shall present the progress of the DM11km System design per the following:

1) Contractor's staff to be present at all reviews shall include at least the Program Manager and lead engineers with additional staff as needed.
4) Contractor shall notify AURA/NSO of the date it will be ready for the Mid-Progress Review at least two (2) weeks before such date. Contractor shall provide AURA/NSO with all Design Documentation at least one (1) week to prior to the review meeting.
5) AURA/NSO will call and conduct the PDR on or near the date specified by Contractor. AURA/NSO will select the review committee members. The total number of review committee members will not exceed five (5).
6) The Mid-Progress Review is advisory and shall not relieve Contractor of any responsibility for the successful completion of the Work in conformity with the Requirements. Similarly, comments or discussions during the design review shall not be construed as modifying or waiving any of the Requirements or relieving Contractor of any obligations under this Contract. As provided in the Contract or Sub-award, the Requirements may only be modified by means of a written amendment or change order to the Contract.

6. PHASE 2: FINAL REPORT

6.1 GENERAL

Contractor shall perform the Final Report Work, prepare the Final Report Documentation for the DM11km design, and deliver the same to AURA/NSO by the dates provided in the Project Plan. A Final Meeting to review this documentation shall be held by the date provided in the Project Plan.

The Final Report Phase shall be complete when Contractor has completed all actions identified during the Final Meeting as necessary for completion of the Work, per agreement with AURA/NSO.

6.2 FINAL REPORT WORK

Contractor shall perform the Work required to complete the Final Report. Contractor shall perform the following Work to meet the Specifications:

1) Mirror Modeling, base line design
   a) Contractor shall design a deformable mirror that meets all requirements in the Specification.
   b) Contractor shall create a finite element model of the full mirror including the mounting points. Contractor shall determine the number and location of the mounting points.
   c) Contractor shall specify the number of actuators in the active area and their layout.
   d) Contractor shall estimate the expected maximum surface deformation of each actuator at maximum stroke.
   e) Contractor shall model the resonant frequencies of the DM and identify resonant modes that are likely to be excited by actuation of the active area actuators.
   f) Contractor shall analyze whether additional actuators or other modifications are needed outside of the active area to achieve the active area flatness and clear aperture flatness requirements.
   g) Contractor shall model the temporal response of the DM and optimize for step response to a 30 nm step command to a single actuator. Contractor shall consult with AURA/NSO how best to optimize the frequency response of the DM.
   h) Contractor shall optimize the design for maximum stroke and maximum resonant frequency beyond the minimal requirements. If trade-offs between stroke and resonant frequencies need to be made, AURA/NSO shall advise the priorities based on the performance of the latest design.
   i) Contractor shall provide models of all influence functions over the entire mirror surface. Influence functions shall be provided as 2-dimensional surface maps in a file format agreed to between AURA/NSO and Contractor, the units being meters of surface deflection per stroke unit of the underlying actuator.
   j) Contractor shall provide models over the entire mirror surface of all resonant modes with resonant frequencies below 2000 hertz as 2-dimensional surface maps in a file format

agreed to between AURA/NSO and Contractor. Contractor shall provide the resonant frequency for each mode. Contractor shall include models of resonant modes higher than 2000 hertz, if such analysis was made.

k) Contractor shall perform thermal modelling and analysis to understand how the proposed design will respond to expected DKIST flux energy density at M7 location in terms of optical surface temperature and actuator performance. This analysis shall also consider fluctuation of ambient temperature within the Operational range defined in SPEC-0149 Rev E. This analysis shall include the change of the optical surface shape under small temperature changes and the correctability thereof with the actuators.

2) Mirror Mount

a) Contractor shall produce a preliminary design for the mirror mount showing how the mirror will be supported and housed within the space envelope required by DKIST.

b) Contractor shall perform an analysis of mirror support/package as deployed at 45 degrees (facing up).

3) Contractor shall identify all key subcontractors needed for fabrication of the DM11km System, including mirror substrate, mirror polishing, drive electronics, and any other subcontractors that would be required to deliver highly specialized or costly (>250,000 USD) components of the DM11km system. Contractor is not required to establish formal agreements with these key subcontractors but should confirm that the identified subcontractors are capable of completing the required tasks and obtain accurate cost estimates from the subcontractors. If possible, Contractor shall also identify backup subcontractors that could be used for these components.

4) Contractor shall identify any aspects of the design and fabrication of the DM11km System that carry significant technical risk or are outside the demonstrated capabilities of Contractor or any of the key subcontractors they have identified.

5) Produce all Final Report Documentation.

6.3 FINAL REPORT DOCUMENTATION

At a minimum, the Final Report Documentation shall consist of the following:

1) A proposal for the design and fabrication of the DM11km System including:

a) A Project Plan, containing all major tasks required to design and fabrication the DM11km System.

b) Estimated schedule for completion of all major tasks from start date of a design and build contract.

c) Estimated cost to complete design and fabrication of the DM11km System

d) References to other projects completed by Contractor that demonstrate their ability to deliver systems with similar requirements.

2) An updated Compliance Matrix, including all potential requirements that have a risk of not being met.

3) A design of the DM11 System, including but not limited to:

a) A preliminary mechanical design with 3D models and 2D drawings of the structure and mounting, optical, electrical, and thermal interfaces.

b) A description of component manufacturability, including preliminary plans for fabrication.

c) A report of preliminary design considerations and trades as called for in the Final Report phase Work, including reference to any impacted requirements.

d) A list of requirements that need to be reviewed and finalized before proceeding to a final design and fabrication of the DM11km System.

7) A list of key subcontractors who will be used to complete the design and fabrication of the DM11km System.

8) A summary of any significant risks to the design and fabrication of the DM11km system

6.4 OPTION FOR RISK REDUCTION STUDY PROPOSAL

If AURA/NSO or Contractor find that any of the risks identified in section 6.2 number 4) are of a large enough magnitude to threaten the success of the DM11km final design and fabrication, Contractor shall propose a Risk Reduction Study to take place before the contract for final design and fabrication is to be negotiated. The Risk Reduction Study may involve prototype construction, more thorough subcontractor validation, or any other activities that would reduce the DM11km fabrication risks to manageable levels. In the case such a Risk Reduction Study is necessary, the proposal for the design and fabrication of the DM11km in section 6.3 number 1) shall be considered a rough order of magnitude (ROM) proposal and one of the deliverables for the Risk Reduction Study shall be an updated and final proposal for the design and fabrication of the DM11km.

6.5 FINAL MEETING

Contractor shall present the design for the DM11km at a Final Meeting per the following:

1) The Final Meeting will be held over a videoconference call or at or near Contractor's facility. Contractor shall be responsible for providing the meeting space, meeting equipment (e.g., projectors) during the meeting.

2) Contractor's staff to be present at the meeting shall include at least the Program Manager and lead engineers with additional staff as needed.

2) Contractor shall notify AURA/NSO of the date it will be ready for the Final Meeting at least two (2) weeks before such date. Contractor shall provide AURA/NSO with all Design Documentation at least two (2) weeks to prior to the meeting.

3) AURA/NSO will call and conduct the Final Meeting on or near the date specified by Contractor. AURA/NSO will select the review committee members. The total number of review committee members will not exceed five (5). Contractor will not be responsible for any travel expenses of the review committee members.

4) Within fifteen (15) working days after the Final Meeting, the COTR will send to Contractor Final Meeting Report based on the committee recommendations, questions and comments. In this report, the COTR may direct Contractor, in writing, to make changes to the design documentation that are required in order to make it consistent with the Requirements and this

SOW. Contractor shall promptly contact the AURA Contracts Officer if it feels that any requested changes are beyond the scope of the Requirements and request a formal contract modification. Within fifteen (15) working days after receipt of the Final Meeting Report, Contractor shall submit a Response to the Final Meeting Report with point by point responses to each of the recommendations, questions and comments. Contractor shall promptly comply with all directions to make changes to the design documentation and submit the revised documents for approval. Once all requested changes have been implemented to AURA/NSO's satisfaction, the COTR will notify Contractor in writing that the Final Report Documentation is approved.

5) The Final Meeting is advisory and shall not relieve Contractor of any responsibility for the successful completion of the Work in conformity with the Requirements. Similarly, comments or discussions during the design review shall not be construed as modifying or waiving any of the Requirements or relieving Contractor of any obligations under this Contract. As provided in the Contract or Sub-award, the Requirements may only be modified by means of a written amendment or change order to the Contract.

APPENDIX 2

11km Deformable Mirror Design Study Specification

D. Schmidt, L. Johnson
MCAO Group

April 28, 2025

REVISION SUMMARY:

1. Date: April 28, 2025
   Revision: A
   Changes: Initial draft

Table of Contents

1. SPECIFICATIONS OVERVIEW

1.1 SCOPE OF THE DOCUMENT

This document contains the specifications and design requirements for an initial design of the DKIST 11 km Deformable Mirror System (DM11km) that is comprised of the Deformable Mirror (DM) and the DM Driver. The DM11km will be part of the DKIST Multi-conjugate Adaptive Optics (MCAO) system. Top-level configuration and performance requirements for the DM11km are defined in this document. Drawings and specifications for other related subassemblies or subsystems are also referenced where applicable.

1.2 RELATED DOCUMENTS

1.2.1 DKIST Project Specification and Design Documents

The following DKIST documents are reference documents that contain information applicable to the design of the 11 km Deformable Mirror System. However, requirements in this document, MCAO.DM11KM.MIRROR.STUDY.SPEC, take precedence.

- SPEC-0027 DKIST Coordinate System
- SPEC-0029 DKIST Optical Prescription
- SPEC-0063 Interconnects and Services Specification Document
- SPEC-0149 Haleakala Environmental Specification
- TN-0094 Environmental Conditions on Haleakalā

1.3 VERIFICATION METHODS

Included in each major numbered specification listed herein this document is a requirement verification method. These verification methods specify the minimum standards of verification required by AURA/NSO to ensure that the individual requirements and specifications are met.

All verification activities are the responsibility of the Contractor; i.e., the Contractor shall be solely responsible for providing any and all test equipment, analyses, inspections, and other means necessary to verify that the specifications and requirements have been met.

Examples of verification methods include:

Design Review. Verification by design review shall mean that the Contractor demonstrates to AURA/NSO during the appropriate design review that the equipment shall meet the specification by way of its intrinsic layout and configuration.

Analysis. Verification by analysis shall mean that the Contractor analytically demonstrates that the design meets the specification. Such analyses may include finite element methods, ray-tracing analysis, closed form analyses, etc. All analyses shall be provided to AURA/NSO in written report form, in electronic (e.g., MS Word or pdf) format.

Inspection. Verification by inspection shall mean that the Contractor visually demonstrates to AURA/NSO personnel that the specification has been achieved on the as-built equipment during factory acceptance testing.

Test. Verification by test and/or measurement shall mean that the Contractor empirically demonstrates that the as-built equipment meets the specification. Testing may be required in the factory during factory acceptance testing.

At a minimum, the specification compliance matrix provided by the Contractor as part of the Work shall use the verification method(s) listed in each of the requirements below.

All analyses, test results (with test error analysis), and other verification reports shall be provided to AURA/NSO in written report form, in electronic (e.g., PDF, Matlab, FITS, HDF5, Microsoft Word or Excel) format. For each Test method used for acceptance testing, the Contractor shall perform a test error analysis. All potential errors affecting the measurement shall be listed and their influence on the test results evaluated. The required measurement value shall be adjusted so that the Test shall yield a 99% or greater certainty that the specification has been met after taking the test error analysis into account.

2. DESCRIPTION, DEFINITIONS AND ACRONYMS

2.1 11KM DEFORMABLE MIRROR SYSTEM DESCRIPTION

The DM11km is comprised of a Deformable Mirror (DM) containing actuators and all ancillary driver/control electronics and cabling necessary to modify the surface shape of the DM in order to correct wavefront aberrations. The DM11km receives signals from the DKIST MCAO real time control system.

2.2 DEFINITIONS AND ACRONYMS

Actuator - An electrically driven component to deform the figure of the reflective optical surface in the deformable mirror

AURA – Association of Universities for Research in Astronomy

DKIST – Daniel K. Inouye Solar Telescope

DM – Deformable Mirror

LVDS – Low Voltage Differential Signaling

MCAO – Multi-Conjugate Adaptive Optics

NSO – National Solar Observatory

3. SPECIFICATIONS FOR THE DM11KM DEFORMABLE MIRROR SYSTEM

3.1 DM11KM COMPONENTS

REQ# DM11km-0001 DM System Components

The DM11km Deformable Mirror System shall include the following components:

1. A deformable mirror device (referred to as "the DM" herein) that consists of
    a. A reflective optical surface
    b. A number of electrically controllable actuators to modify the surface figure of the reflective surface
    c. Electrical connectors for the actuators
    d. Any additional components as provided by the vendor that make the deformable mirror device a complete package (e.g. a support structure or a housing that holds the base and the connectors, internal wiring)
2. An interface to mount the deformable mirror device
3. Driver electronics (referred to as "the DM Driver" herein) with a digital interface to control the actuators in the deformable mirror device, and cabling
4. Detailed design documentation of the system interfaces
5. Operational and maintenance manuals
6. Specialized handling equipment and tools
7. Shipping container and packaging

Verification: Design Review and Inspection

3.2 DM MECHANICAL, OPTICAL, AND PERFORMANCE SPECIFICATIONS

The DM will be a flat deformable mirror located in the coudé lab of DKIST at a position that is optically conjugate to 11.2 kilometers along the line of sight in front the primary mirror. The DM will replace the DKIST M7 mirror. The DM will be used under a 45° angle with the incident light. The DM will be mounted at an angle of 45° between the reflective surface and the gravity vector, with the reflecting surface facing upwards.

3.2.1 Mechanical Design

REQ# DM11km-0005 Clear aperture

The DM reflective optical surface shall have an elliptical clear aperture of 930 millimeters along the semi-major axis and 655 millimeters along the semi-minor axis. Any edge material shall be formed so as not to block or scatter any of the incident or reflected light.

Note: The shape of the edge of the mirror substrate beyond the clear aperture is not required to be elliptical, and other geometries (e.g. hexagonal) may be used upon approval by AURA/NSO. The vendor shall determine the actual size of the substrate in addition to the clear aperture that is needed for the manufacturing and polishing processes.

Verification: Design Review

REQ# DM11km-0010 Active area

The DM shall have an elliptical active area in the center of the clear aperture where the figure of the reflective surface can be modified with the actuators. The active area shall measure 315.5 millimeters along the semi-major axis and 223.1 millimeters along the semi-minor axis of the clear aperture.

Verification: Design Review

REQ# DM11km-0015 Actuator layout

Two actuator geometries shall be modeled for the purposes of a design study:

1. Actuators arranged in a 2-dimensional rectangular grid. The short sides of each rectangle shall have actuators spaced 16 mm apart and the long sides shall have actuators spaced 22.63 mm apart. The long sides of the rectangles shall align with the semi-major axis of the active area.
2. Actuators arranged in a “maximum density” packing. The vendor shall model an actuator layout that fits the maximum number of actuators possible in the active area of the DM.

NOTE: The influence functions from both DM geometries shall be modeled and presented to AURA/NSO for analysis. AURA/NSO will choose one of the actuator geometries to continue as the preferred geometry.

Verification: Design Review and Analysis

REQ# DM11km-0025 Surface Tilt

The DM shall produce no more than 1 micrometer surface tilt peak-to-valley (GOAL: 0.1 micrometer) within the active area when all actuators are at maximum range.

Verification: Design Review and Analysis

REQ# DM11km-0030 Envelope

The DM shall be contained within a rectangular volume of 1100 millimeters x 800 millimeters x 300 millimeters.

Verification: Design Review

REQ# DM11km-0035 Weight

The DM weight shall not exceed 155 kilograms.

Verification: Design Review

3.2.2 Performance

REQ# DM11km-0100 Orientation

All performance requirements must be achieved with the mirror surface mounted at 45 degrees with the gravity vector, with the optical surface facing up.

Verification: Design Review and Analysis

REQ# DM11km-0105 Optical flatness at bias, clear aperture

At bias voltage and at 20 °C ambient temperature, the optical surface of the DM shall be flat to less than 25 nanometers root-mean-square over its entire clear aperture.

Verification: Design Review and Analysis

REQ# DM11km-0110 Optical flatness at bias, active area

At bias voltage and at 20 °C ambient temperature, the optical surface of the DM shall be flat to less than 15 nanometers root-mean-square within its active area.

Verification: Design Review and Analysis

REQ# DM11km-0115 Optical flatness after flattening, active area

After performing the mirror flattening procedure at 20 °C ambient temperature, the optical surface of the DM shall be flat to less than 10 nanometers root-mean-square within its active area.

Verification: Design Review and Analysis

REQ# DM11km-0120 Optical flatness at bias, full clear aperture

After performing the mirror flattening procedure at 20 °C ambient temperature, the optical surface of the DM shall be flat over any 100-millimeter diameter circular region to less than 40 nanometers peak-to-valley.

Verification: Design Review and Analysis

REQ# DM11km-0125 Actuator stroke

Each actuator of the DM shall produce a surface deflection (actuation range) of at least ±2.5 micrometers about the calibrated position for making the mirror flat.

Verification: Design Review and Analysis

REQ# DM11km-0130 Interactuator stroke

Any two adjacent actuators shall be capable of producing a surface deflection of at least ±1.5 micrometers relative to each other.

Verification: Design Review and Analysis

REQ# DM11km-0135 DM actuation safety

The DM shall be able to accept full range of actuation commands to its actuators at the nominal update rate of 2 kHz without risking damage to any part of the DM. If this requirement is unable to be met, safety systems shall be implemented to prevent damage to the DM during normal use cases.

Verification: Design Review

REQ# DM11km-0140 Actuator step response

The vendor shall construct a dynamic model of the DM that is capable of modeling the actuator step response. The vendor shall work with AURA/NSO to optimize the step response parameters (rise time, settle time, overshoot, etc.) for DKIST MCAO.

Verification: Design Review and Analysis

REQ# DM11km-0145 Hysteresis

The DM shall have an actuator hysteresis of less than 5% within the minimum ranges in REQ# DM11km-0125. Beyond the minimum range, the hysteresis can be larger for the purpose of increasing the maximum available actuator stroke.

Verification: Design Review and Analysis

REQ# DM11km-0150 Linearity

The DM shall have an actuator non-linearity of less than 5% within the minimum ranges in REQ# DM11km-0125. Beyond the minimum range, the non-linearity can be larger for the purpose of increasing the maximum available actuator stroke.

Verification: Design Review and Analysis

REQ# DM11km-0155 Uniformity

The actuators in the DM shall have a non-uniformity of response of less than 5% before attached to the DM substrate.

Verification: Design Review and Analysis

REQ# DM11km-0160 Resonant frequency

Excluding rigid-body modes, the lowest resonant mode of the DM mirror, including the mount, shall have a resonant frequency greater than 500 Hertz.

Verification: Design Review and Analysis

REQ# DM11km-0165 Resonant modes

Excluding rigid-body modes, the DM mirror, including the mount, shall have fewer than 5 modes with resonant frequencies below 2000 Hertz that can be excited by driving the DM actuators.

Verification: Design Review and Analysis

REQ# DM11km-0170 Working actuators

The DM shall be delivered with all actuators working as specified.

Verification: Design Review

3.2.3 Optical Surface Specification

REQ# DM11km-0200 Surface roughness

The optical surface of the DM shall have a maximum root-mean-square roughness (micro roughness) of 2 nanometers over the entire surface, not just over the clear aperture.

Verification: Design Review

REQ# DM11km-0205 Surface defects

The optical surface of the DM shall meet the requirements of a 60/40 scratch dig per MIL-PRF-1383B over the entire surface, not just over the clear aperture.

Verification: Design Review

3.2.4 Reflective coating

REQ# DM11km-0300 Coating type

The optical surface of the DM shall be coated with a blue-enhanced protected silver coating, either one of the following coatings or an equivalent coating approved by AURA/NSO:

AG99 coating provided by EMF with Ravg >0.9 from 393-396 nm, and Ravg >0.97 from 0.380-5.0 um.

EAg1-420 coating provided by Infinite Optics

FSS-99-500 coating provided by Quantum Coatings

Verified by reflectance curve from 0.380-5.0 um

Verification: Design Review, Test

REQ# DM11km-0305 Recoating

The optical surface of the DM shall be able to be recoated.

Verification: Design Review

3.3 DM11KM DRIVER REQUIREMENTS

REQ# DM11km-0400 Driver digital interface

The vendor shall work with AURA/NSO to define the interface from the DKIST real-time computer to the DM Driver.

Goal: The DM Driver should use a Starfire Optical Range SOR-422 16-bit LVDS digital interface to receive actuator commands at a frequency of at least 20 megahertz.

Verification: Design Review

REQ# DM11km-0405 Driver chassis

The DM Driver shall be mountable in a 19-inch (482.6 millimeters) electronics rack using no more than 7 rack units (311.15 millimeters) in height (including any ventilation) and 600 millimeters in depth.

Verification: Design Review

REQ# DM11km-0410 DM cable length

The cable length from the DM Driver to the DM shall be 15 meters.

Note: This requirement will be finalized before start of fabrication based on final equipment placement and cable routing paths.

Verification: Design Review

3.4 THERMAL PERFORMANCE

REQ# DM11km-0500 Thermal response in active area

Throughout the Performance range defined in SPEC-0149 and the estimated heating based on modeling of the 2.8 arc minute solar beam, the optical surface within the active area of the DM shall deform by a maximum of 150 nanometers peak-to-valley from one end of the expected Performance range to the other.

NOTE: The 2.8 arc minute beam illuminates an elliptical area in the center of the DM of 571 millimeters along the semi-major axis and 404 millimeters along the semi-minor axis with an impinging heat load of 84 watts (0.46 milliwatts per square-millimeter).

Verification: Design Review and Analysis

REQ# DM11km-0510 Thermal response in clear aperture

Throughout the Performance range defined in SPEC-0149 and the estimated heating based on modeling of the 5 arcminute solar beam, the optical surface within the clear aperture of the DM shall deform by a maximum of 150 nanometers peak-to-valley from one end of the expected Performance range to the other.

If the DM does not meet this requirement with the actuators held in a static position, Contractor shall provide actuator lookup tables so that the above requirement can be met with lookup tables that track ambient temperature.

NOTE: The 5 arcminute beam illuminates an elliptical area in the center of the DM of 884 millimeters along the semi-major axis and 625 millimeters along the semi-minor axis with an impinging heat load of 268 watts (0.62 milliwatts per square-millimeter).

Verification: Design Review and Analysis

3.5 ENVIRONMENTAL REQUIREMENTS

3.5.1 Operating Environment

The DM11km Deformable Mirror System will operate at the DKIST observatory located at an elevation of approximately 3050 meters (approximately 10,000 feet). The specific conditions encountered are provided in SPEC-0149, Haleakala Environmental Specification. The DM11km Assembly will be located in the coudé lab, in conditions designated as Class A: Environmental. The DM Driver will be housed in a conditioned rack that meets ASHRAE Thermal Guidelines for Data Processing Environments.

Parameter	Survival Minimum	Operational Minimum	Performance Minimum	Performance Maximum	Operational Maximum	Survival Maximum
Temperature	0 °C	18 °C	19.5 °C	20.5 °C	22 °C	27 °C
Humidity	5 %	30 %	40 %	50 %	60 %	95 %
Air Flow	0 m/s	0 m/s	0.4 m/s	0.6 m/s	N/A	N/A
Dust	N/A	N/A	N/A	10^5 ppcf	10^6 ppcf	10^7 ppcf

Table 1: Summary of Class A: Environmental Specifications

REQ# DM11km-0600 DM Driver operating environment

The DM Driver shall remain fully operational, meeting all requirements of this specification throughout any combination of conditions that meet ASHRAE Thermal Guidelines for Data Processing Environments.

Verification: Design Review and Analysis

REQ# DM11km-0605 DM normal operating environment

The DM shall remain fully operational, meeting all requirements of this specification, throughout any combination of conditions specified as Class A: Environmental Performance Conditions, as described in SPEC-0149.

Note: For reference, the Performance conditions appear in this document in Table 1.

Verification: Design Review and Analysis

REQ# DM11km-0610 DM safe operating environment

The DM shall remain operational, without risk of damage, throughout all combinations of conditions specified as Class A: Environmental Operating conditions, as described in SPEC-0149. The strictest performance requirements may be impossible to meet outside of the Performance conditions.

Note: For reference, the Operating conditions appear in this document in Table 1.

Verification: Design Review and Analysis

REQ# DM11km-0615 DM survival environment

The DM shall survive in a powered-off state, without risk of damage, throughout all combinations of conditions specified as Class A: Environmental Survival conditions, as described in SPEC-0149. Contractor shall describe any procedures necessary to bring the DM back into operational and performance specification after exposure to the survival extremes.

Note: For reference, the Survival conditions appear in this document in Table 1.

Verification: Design Review and Analysis

REQ# DM11km-0620 Seismic survivability

The DM11km Deformable Mirror System (i.e., the DM, the DM Driver, the DM mount, and all additional components) shall survive and be capable of operation within specification, without repair or adjustment, after being subjected to seismic acceleration of 2 g (20 meters per second per second) in any direction while in either an operational or non-operational state.

Verification: Design Review and Analysis

3.5.2 Storage and Transportation Environment

REQ# DM11km-0700 Ways of transportation

The DM11km Deformable Mirror System shall survive shipping by air, land, or sea.

Verification: Design Review and Analysis

REQ# DM11km-0705 Shipping humidity

The DM11km Deformable Mirror System shall survive shipping and storage inside a shipping container that may be exposed to humidity of up to 100% condensing with salt spray. Contractor shall design and fabricate the shipping container.

Verification: Design Review and Analysis

REQ# DM11km-0710 Shipping temperatures

The DM11km Deformable Mirror System shall survive shipping and storage in a temperature range of −20 °C to +50 °C.

Verification: Design Review and Analysis

REQ# DM11km-0715 Shipping shocks and vibrations

The DM11km Deformable Mirror System shall survive shock and vibration during shipping of up to 50 g (500 meters per second per second) in any direction.

Verification: Design Review and Analysis

REQ# DM11km-0720 Shipping shock indicators

The DM11km Deformable Mirror System shall be shipped with shock indicators (impact indicators) on the exterior of the shipping containers that shall indicate if the package has undergone a shock greater than the designed survivability of the unit packaged inside the container.

Verification: Design Review

REQ# DM11km-0725 Shipping container

The shipping container for the DM11km Deformable Mirror System shall be designed to be reusable.

Verification: Design Review

3.6 HANDLING REQUIREMENTS

The following requirements are to provide ease and safety in the handling of the DM for installation, removal, and storage.

REQ# DM11km-0800 Fixtures

The DM shall have handling fixtures to allow manual and overhead crane manipulation of the assembly for installation and removal from the optical bench.

Verification: Design Review

REQ# DM11km-0805 Cover

The DM shall have a cover to protect the Mirror and Actuators during handling and storage.

Verification: Design Review

REQ# DM11km-0810 Storage container

The DM11km Deformable Mirror System shall be delivered with reusable storage containers.

Note: The shipping container(s) may be designed to serve this purpose.

Verification: Design Review

3.7 ASSEMBLY AND MAINTENANCE

3.7.1 Reliability

The lifetime of the DKIST telescope is expected to be in excess of forty years. The objective of the facility is to allow maximum telescope availability and performance for the given weather conditions of any day of the year. The remote nature of the site puts a premium on having robust systems that are easily repaired.

REQ# DM11km-0900 Reliability

Wherever possible, all assemblies, subassemblies, components, parts, and mechanical systems shall be designed to exceed the lifetime of the facility. Contractor shall identify any items not designed to exceed this lifetime, and maintenance procedures and spares lists shall be provided for them.

Verification: Design Review

3.7.2 Tooling

REQ# DM11km-1000 Tooling

The DM11km Deformable Mirror System shall be designed to be set up, operated, and maintained using standard tools and test equipment. Contractor shall design any special tools or equipment required for setup, operation, and maintenance. Any such tools and equipment shall be provided as deliverables with the final DM11km Assembly, along with detailed instructions for their use.

Verification: Design Review

3.7.3 Maintainability

REQ# DM11km-1100 Maintainability

The DM11km Deformable Mirror System design shall ensure that all necessary maintenance operations can be effectively carried out without risk to personnel or hardware. Special care must be taken in the design of any hardware that would require maintenance personnel to work around the DM11km Deformable Mirror System to avoid risk to the DM optical surface.

Verification: Design Review

REQ# DM11km-1105 Maintenance Schedule

Contractor shall provide maintenance, replacement and repair schedules for all components of the DM11km Deformable Mirror System, listing frequency and type of maintenance required.

Verification: Design Review

3.8 GENERAL REQUIREMENTS

3.8.1 Mechanical Design

REQ# DM11km-1200 Drawing standard

All detail design drawings shall conform to AMSE Y14.5M-2009.

Verification: Design Review and Inspection

REQ# DM11km-1205 Drawing units

All deliverable detail design drawings of external envelope and interfaces shall be in System International (metric) units with Imperial (inch) secondary units shown in parentheses as required. All analyses shall be performed in the System International system (metric).

Verification: Design Review and Inspection

REQ# DM11km-1210 Drawing copies and digital format

All deliverable detail design drawings of external envelope and interfaces shall be generated in or transferable to SolidWorks. These drawings, along with printed hard copies, shall be provided to AURA/NSO upon completion of the Work. Detailed drawings of internal components that are proprietary in nature are not required to be provided.

Verification: Design Review and Inspection

REQ# DM11km-1215 Digital 3-dimensional models

All computer aided design (CAD) 3-dimensional solid models of the DM11km Deformable Mirror System external envelope and interfaces shall be provided to AURA/NSO in SolidWorks or either IGES format (.igs) or STEP format (.stp) or other format compatible for transfer to SolidWorks for the design review and revised models upon completion of the Work. Detailed 3-dimensional- solid models of internal components that are proprietary in nature are not required to be provided.

Verification: Design Review and Inspection

3.8.2 Electrical Design

110 and 220 VAC 60 Hz power to the DM11km Deformable Mirror System is provided by DKIST at each major subsystem location.

REQ# DM11km-1400 Over-current protection

All electronic/electrical equipment shall have over-current protection (thermal breakers, fuses, lightning arresters, ground-fault interrupts, surge protection, etc.).

Verification: Design Review and Inspection

REQ# DM11km-1410 US National Electrical Code

All electrical/electronic installations must comply with US National Electrical Code where applicable.

Verification: Design Review and Inspection

REQ# DM11km-1420 Grounding

All electronic/electrical equipment in the DM11km Deformable Mirror System shall have safety grounds.

Verification: Design Review and Inspection

REQ# DM11km-1430 Connector/Cable Quality

Contractor shall define and provide electrical connectors, cabling, and tubing consistent with high reliability operation and electromagnetic compatibility constraints.

Verification: Design Review and Inspection

REQ# DM11km-1435 Connector/Cable labeling

Wherever multiple connectors of the same type are used, connections shall be uniquely labeled on both ends using a labeling method approved by AURA/NSO.

Verification: Design Review and Inspection

REQ# DM11km-1440 Strain relief

Proper and appropriate strain relief shall be provided to ensure reliability and to minimize effect of cabling loads on the DM11km Deformable Mirror System. All connections shall use high-quality rough-service connectors.

Verification: Design Review and Inspection

REQ# DM11km-1445 Power cables

Cables designated for power shall also meet the specifications for voltage and amperage capacities as per the U.S. National Electric Code.

Verification: Design Review and Inspection

3.8.3 Materials and Workmanship

REQ# DM11km-1500 Quality of materials

All materials used in the Work shall be new and of high-grade commercial quality. They shall be sound and free from defects, both internal and external, such as cracks, laminations, inclusions, blow holes or porosity.

Verification: Design Review and Inspection

REQ# DM11km-1505 Material Defects

All manufacturing processes, such as plating, welding or heat treatment, shall be specified and performed in such a manner as to achieve the strength and properties required without introducing any material defects such as hydrogen embrittlement, excessive grain growth, or residual stress concentrations.

Verification: Design Review and Inspection

REQ# DM11km-1510 Metal edges

All metal edges shall be free of burrs and sharp corners. No sharp edges that might constitute a hazard to personnel or equipment (e.g., cabling) shall remain on the finished components.

Verification: Design Review and Inspection

REQ# DM11km-1515 Selected Materials

Materials used by Contractor shall be consistent with all requirements including life cycle, reliability, and maintainability. Substitution (e.g., to obtain improved performance or reduced cost) is subject to written approval by AURA/NSO.

Verification: Design Review and Inspection

3.8.4 Surface Finish, Coatings, and Paint

REQ# DM11km-1600 Machined surface finish

All exposed machined surfaces, unless specified otherwise, shall have a surface finish of 64-microinches or better.

Verification: Design Review and Inspection

REQ# DM11km-1605 Surface finish approval

Surface finishes shall be approved by AURA/NSO as suiting the location and function of each member. These finishes shall not adversely affect the functioning of the telescope, nor require additional maintenance during the life of the telescope.

Verification: Design Review and Inspection

REQ# DM11km-1610 Corrosion protection

All non-optical metallic surfaces, other than mating machined surfaces, shall be painted or otherwise permanently protected against atmospheric corrosion.

Verification: Design Review and Inspection

REQ# DM11km-1615 DM non-optical surface finish

All exterior surfaces of the DM shall be finished with a hard black anodize or other AURA/NSO-approved surface finish.

Verification: Design Review and Inspection