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Adaptive Optics Development Program (AODP)

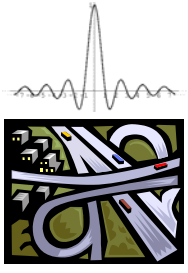
Fiscal Year 2003 Announcement and Proposal Solicitation

Issued May 2003
Revised September 2003

PROPOSAL DEADLINES

July 3, 2003 ..... **Letters of Intent to Propose** (required) are due by July 3, 2003.

October 3, 2003..... **Full proposals** are due by October 3, 2003.



The Adaptive Optics Development Program is administered by the National Optical Astronomy Observatory (NOAO, which is operated by the Association of Universities for Research in Astronomy(AURA) under a cooperative agreement with the National Science Foundation

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Announcement of Opportunity FY 2003

INTRODUCTION

A. OVERVIEW OF THE ADAPTIVE OPTICS DEVELOPMENT PROGRAM (AODP)

1. Background

In 2000, the Astronomy and Astrophysics Survey Committee panel on Optical and Infrared Astronomy from the Ground (*Astronomy and Astrophysics in the New Millennium*, National Research Council, 2001) stated that an adaptive optics (AO) effort associated with the development of a Giant Segmented Mirror Telescope (GSMT) should be supported by funding on the order of $5M per year for the next ten years. The panel also noted that AO development work will enhance dramatically the power of existing large telescopes, allowing them to work at the diffraction limit at shorter wavelengths, thereby greatly increasing their scientific power. In a recent position paper on adaptive optics (http://www.auraastronomy.org/g/ ag.asp?gid=68), the members of the AURA Coordinating Council of Observatory Research Directors (ACCORD) are unanimous in the view that implementation of reliable, high performance AO systems is of critical importance to the future of U.S. ground-based astronomy. Specifically, ACCORD reviewed and gave its general support to the document entitled "A Road Map for the Development of Astronomical Adaptive Optics." (see http://www.noao.edu/dir/ao/) The challenge now is to achieve the technical goals set out in the road map.

2. The AO Imperative

AO on large ground-based telescopes will revolutionize infrared and optical astronomy. Originally proposed and developed in the U.S., AO will permit diffraction-limited imaging on ground-based telescopes using state-of-the-art electro-optical technology to correct the wave front distortion and hence image blurring caused by the Earth's atmosphere. Since in many applications the effectiveness of a telescope is proportional both to its collecting area and the inverse square image size, adaptive optics on large aperture telescopes offers enormous gains in capability. Furthermore, these gains can be achieved at costs that are relatively modest compared to the investment (more than $500 million) already made in the current generation of 6-12-m class telescopes. Major efforts in AO are well underway in Europe, with strong governmental financial support. If U.S. astronomy is to maintain its competitive position, it is essential that a program be put in place to exploit the potential of AO.

3. Current AO Status

While the basic concept of AO correction has been understood for decades, it is only relatively recently that practical implementations have become possible. These are still very much in the nature of prototypes, using many different approaches to achieve similar goals. There are thus multiple technologies for such critical AO elements as adaptive mirrors, wave front sensing, and laser guide stars. The current prototype systems are generally complex, and are not yet sufficiently reliable that they can be considered routine components of observatory equipment. This is natural to a technology that is still in its infancy. The potential rewards of AO are so great, however, that a means must be found to realize that potential at the major U.S. observatories. The need now is for about a five-year period of second-generation AO development, followed by a roughly five-year period of implementation of robust AO systems at least at the major U.S. optical/infrared astronomical observatories.

4. Program Outlook

The Adaptive Optics Development Program is structured into two components: development awards and implementation awards. Development funds will be awarded on the basis of technical promise, with a goal of demonstrating the viability of approaches that offer prospectively significant advances in performance, robustness, and cost-effectiveness for extremely large telescopes (ELTs), such as the GSMT. The AODP is also intended to make implementation awards to observatories operating large telescopes. The present plan

is that a ten-year period be devoted to development, prototype demonstrations, and implementation, with the transitions between them dependent on progress. All results, findings, and documentation obtained from the AODP will be available to the entire U.S. community to ensure that all can benefit from the experience gained by individual groups.

5. Program Administration

The AODP is administered by the NSF Division of Astronomical Sciences through the National Optical Astronomy Observatory (NOAO). An administrative model similar to that of the recent NSF-funded Telescope System Instrumentation Program (TSIP) has been adopted for AODP. In this model, NOAO will solicit proposals for AO development and implementation from the community, organize and provide administrative support for peer review meetings, and—subject to final NSF approval—make awards and disburse monies to successful proposers. To eliminate any conflicts of interest, NOAO is not eligible for funds under the AODP program. (This does not preclude university-led partnerships with NOAO from proposing and receiving AODP awards, but NOAO may not be a party to such proposals.) The NOAO effort in administering the program will, like TSIP, require only modest resources.

6. Community Benefit from the AODP Awards

The AODP, like the TSIP program, achieves its maximum impact when AO is implemented on large telescopes. As such, the implementation will be of benefit principally to the operators/users of such large systems. In order that the community, as a whole, can derive benefit from the proposed AODP investment, the following arrangements have been adopted. AODP development awards will require the recipients to provide detailed technical reports on the results achieved and these will be made available to the entire U.S. community. Development studies should be verified (where practical) on the sky, either through prototype examples or otherwise. AODP implementation awards to observatories operating large telescopes will require the observatory receiving the funds to make observing time available to the community on the same basis as in the TSIP program.

7. Relationship to Other Programs

The AODP is established as a new and specialized program, independent of TSIP.

B. TWO TYPES OF AODP PROPOSALS

There are two types of AODP proposals: development proposals and implementation proposals. (Implementation proposals are *not* solicited in FY 2003.) AODP proposals may request funding for up to five years of effort. Funding will be provided in annual increments, contingent on satisfactory progress as evaluated by an annual progress review conducted by NOAO and reported to NSF.

1. Development proposals are proposals for the development and demonstration of the new technology identified in the "Adaptive Optics Road Map." Examples called out in the road map include

- **High power lasers**: reliable, affordable sodium wavelength lasers with power levels of order 20 to 50 watts, and appropriate optical characteristics. Laser guide stars are essential for providing scientifically useful sky coverage for conventional single-conjugate adaptive optics systems. They also enable multi-conjugate adaptive optics (MCAO) systems, and ground-layer turbulence compensation. Examples of promising technologies include reliable and efficient solid-state sum frequency lasers and fiber lasers, and lasers used to produce Rayleigh beacons, which might be integrated into systems for ground-layer turbulence compensation.

- **Fast, low noise optical and near infrared detectors**: faster, more sensitive, lower noise detectors with more pixels and better wavelength coverage, as well as detectors capable of taking fast movies

of pulsed Rayleigh beacons. Rapid detection and characterization of wave front aberrations requires panoramic detectors with a number of picture elements (pixels) large enough to sense high-order distortions, with a sensitivity, frame rate, and noise level consistent with rapid updates to the deformable mirror. Efficient, fast detectors with low readout noise enable better performance for fixed natural guide star (NGS) brightness or laser power. The needs of extreme AO (ExAO, the high Strehl ratio extremum of the technique) are similar, with an emphasis on the higher frame rates and lower read noise levels. Infrared detectors with background-limited read noise and dark current, and QE > 0.8 are needed to enable tip-tilt corrections over all regions of the sky—including optically opaque molecular clouds, where the only available NGS for tip-tilt corrections is optically-invisible but IR bright.

- **Deformable mirrors:** prototyping and testing of advanced wave front correction elements, including curved optics, telescope M1/2/3 mirrors, transmissive optics, closer actuator spacing, and higher order deformable mirrors (both regular grid and curvature style). Deformable mirrors are essential components of AO systems. Achieving enhanced image quality on ELTs will require significant advances in DM performance from today's systems, presently restricted to 10-1000 degrees of freedom, to systems with many thousands of actuators. DMs of a variety of scales and strokes will be needed for a range of AO modes of operation. These could range from devices with small stroke, and centimeter pupil diameter to meter-scale adaptive secondaries with large stroke and ~1000 actuators. Prototypes would be systems which include DM drive electronics.

- **Wave Front Reconstructor Processors and Algorithms**: new AO systems will require the processing of thousands to many ten of thousands of WFS measurements at frame rates of 1-2 KHz. Current processors and processing algorithms have computational complexities that scale with the product of the number of WFS measurements, the number of DM actuators, and the AO loop update rate. New reconstruction algorithms have been proposed with significantly reduced computational scaling, but more work is needed to develop processor implementations that will provide near-optimal wave front reconstruction accuracy at reasonable cost. The AODP encourages design studies to define and evaluate these processing architectures. Even if these designs benefit from anticipated future electronics capabilities, innovative wave front reconstruction algorithms are still expected to be necessary. Early availability may enable advanced wave front reconstruction concepts for ExAO systems on 8-10 meter class telescopes.

Development proposals must have clear staffing and budgeting profiles and schedules for development of the proposed technology. A management plan with clear milestones must be well defined. Multi-year proposals should be clearly divided into a concept and design phase, and a development and test phase. Staffing and budgeting profiles for the two phases should be distinct. Proposals should contain full costs for both phases, and sources of uncertainty or needs for contingency should be clearly explained. Proposals should also contain a science justification explaining how the proposed development fits into the overall context of the adaptive optics road map developed by the U.S. astronomical community. Proposals may reference scientific priorities and needs as stated in various community studies or workshops.

2. **Implementation proposals** are proposals for implementation of AO systems on existing large telescopes. Such proposals are *not* solicited in FY 2003.

    - Proposals for AO implementation on telescopes should provide community observing time equivalent in value to 50% of the NSF-supplied cost of the improvements.

    - Implementation proposals must contain a description of the amount, scheduling, and nature of observing time to be made available to the U.S. community as a consequence of the requested funding. This observing time will be allocated by NOAO through the same mechanisms of merit review of observing proposals used to allocate time on the NOAO telescopes.

Implementation proposals must show clearly what improvements in capabilities will be a consequence of the requested funding. A management plan with clear milestones against which progress can be

measured must be well defined. Requests for funding that are simply substitutes for existing operations funds for telescopes are not appropriate for AODP funding.

For implementation proposals, the value of community observing time to be allocated as a consequence of the requested funding must be described and justified in the proposal. Determination and justification of the value of observing time is the sole responsibility of the proposer. Further details are given in Section E below.

C. ELIGIBILITY INFORMATION

This program is open to U.S. institutions with the capability to undertake research and development in adaptive optics. For implementation proposals, proposing institutions should have a mechanism for providing observing time on a telescope through the NOAO time allocation process.

D. AWARD INFORMATION

Subject to the availability of funds, it is anticipated that $3 million will be available in FY 2003 for the AODP program. According to the AO road map, these funds should rise in later years to $5M – 7M per year.

Awards will be fixed price grants administered to institutions as sub-awards from NOAO. Any award in excess of $250,000 will be subject to the approval of the NSF Program Officer. Proposals will be funded annually in advance, subject to satisfactory progress reviews.

E. COMMUNITY ACCESS TO TELESCOPES

Each implementation proposal must include a commitment of observing time on the telescope for which the instrument or improvement has been proposed. For implementation proposals, the value must be equal to 50% of the NSF-supplied funds. The value of community observing time is to be described by an explicit calculation in the proposal. Determination and justification of the value of observing time is the sole responsibility of the proposer. Following each annual selection and awards, a description of the successful proposals and the costing of the observing time will be published on the NOAO System Project Office web site (http://www.noao.edu/syspo/). The TSIP web site http://www.noao.edu/system/tsip/ currently presents the accepted calculation of the cost of a night on one of the W.M. Keck telescopes resulting from the FY 2002 proposals and subsequent negotiations.

Proposers must specify in their proposal any conditions they wish to impose on the community access they are offering. NOAO is willing to provide interface and support services for community access, and the details of such arrangements can be negotiated following the successful review of an AODP implementation proposal. Proposers may specify particular modes of access, including limits on observing run lengths or their intent to carry out surveys on behalf of community-based teams.

PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. LETTERS OF INTENT (REQUIRED)

The deadline for Letters of Intent is July 3, 2003.

Letters of Intent for AODP proposals are required. Letters of Intent may be submitted in electronic version, paper copy, or both. Acceptable formats for the electronic versions are plain ASCII text, MS Word, Adobe PDF, or Postscript formats. If submitted electronically, send by e-mail attachment to syspo@noao.edu.

If submitted by mail, Letters of Intent should be sent to:

Adaptive Optics Development Program Office
c/o NOAO Director's Office
National Optical Astronomy Observatory
P.O. Box 26732
Tucson, AZ 85726

1. Required Content of Letters of Intent

Letters of Intent should include (a) designation of the proposal as either a development or implementation proposal, (b) names and institutions of the PI and Co-I's, (c) general description of the planned AO technology development, (d) anticipated award period, (e) anticipated total funding or other resources sought through proposal, (f) description of facilities to which community access will be given, in the case of implementation proposals. The purpose of obtaining Letters of Intent is to assemble a peer review panel without conflicts of interest and with expertise appropriate to the anticipated proposals.

Questions that arise during the period preceding the due date for Letters of Intent may be sent to syspo@noao.edu. Collected questions and answers will be displayed on the system web site: http://www.noao.edu/system/.

B. FULL PROPOSALS

The deadline for full proposals is October 3, 2003.

All proposals *must* be submitted electronically to syspo@noao.edu. In addition to the required electronic version, hard copies of the proposal may also be submitted. Acceptable file formats for the electronic version are MS Word, Adobe PDF, or Postscript.

1. Required Sections and Page Limits of Full Proposals

Each proposal must contain five sections: (1) Science, (2) Technical, (3) Management, (4) Budget, and, for implementation proposals only, (5) Community Access. The length of the proposal *without* the Budget section should not exceed 30 pages. There are no page limitations on the Budget section.

a. The **Science** section must describe the scientific capability that the proposed development provides or enables. It may refer to scientific motivations for particular capabilities derived from community meetings or workshops (e.g., The Adaptive Optics Road Map; see: http://www.noao.edu/dir/ao/). Specific scientific goals for the instrument or improvement and/or generally described studies that could be undertaken with community time may be stated.

b. The **Technical** section must describe the technical approach that will be used in order to provide the proposed capability. *The intent of this section is to convince the evaluation committee that the technical approach is viable and that the proposing team has the resources and the expertise to carry it out.* This section should include an overview of the AO development or implementation, including optics, mechanical design, electronics, and software. It should present a discussion of the technical issues or concerns, and strategies for addressing them. It should also describe the flow down from scientific goals to functional performance requirements, and should provide evidence that the proposed instrument will satisfy these requirements.

c. The **Management** section must describe the management approach to be used on the proposed project, including:

(i) Overall project structure and organization, including an organization chart

(ii) Project risks and key challenges and strategies for addressing these

(iii) Procedures and process to be used to manage the project, including:

- Procedures to assign tasks and to control project personnel
- Metrics to monitor and assess progress
- Procedures and tools to plan and organize the project work
- Plant and equipment
- Personnel or subcontractors
- Dependencies among aspects of development, design, or fabrication
- Project management documentation to be generated
- Summary of any effort requested from NOAO personnel resources

(iv) A Work Breakdown Structure and schedule based on the WBS showing timeline of major tasks, resource loading, task durations, and task costs built up to the overall project cost

(v) Dates of planned meetings and reviews and other critical milestones

(vi) Quality assessment and control

(vii) Proposed mechanisms to facilitate NOAO oversight activities (see section on Award Administration and Program Oversight)

d. The **Budget** section will give the total cost of the project, and an annual payment schedule or funding profile for the funds requested from AODP. The payment schedule should be justified on the basis of the work breakdown structure and planned commitments for large capital items. The budget should explicitly identify payroll, benefits, non-payroll, and agency-agreed overhead costs as they would be determined in a proposal to NSF. Summary budgets should be given using formats and categories similar to those used for NSF Fast Lane proposals.

e. The **Community Access** section must detail the manner in which telescope time is to be made available, including the total number of nights and their distribution over time, constraints on their use, the facilities to be made available, and so forth.

This section must include an explicit calculation of the value of community observing time used to determine the nights available to the community if the proposal is funded. This value should be calculated using such items as total construction cost, together with annual costs for operations and instruments. To provide accountability to the community, the calculation and explanation of the value of nights provided for successful TSIP proposals is published on the System web site: http://www.noao.edu/system/

In addition, the **Community Access** section should include a thorough description of instruments available to visitors, services for visitors, data quality, data analysis capabilities, and any other factors that affect the judgment of the value of observing time on a particular telescope. Proposals should state a clear schedule and any contingency planning for providing the allocated community observing time.

Questions that arise during the period following the due date for Letters of Intent may be sent to syspo@noao.edu. Submitted questions and answers will be distributed to all potential proposers from whom letters of intent were received.

PROPOSAL REVIEW

A. REVIEW CRITERIA

Review and ranking of all AODP proposals will be carried out by a peer review panel assembled by NOAO and approved by NSF. (NOAO staff are excluded from membership on the review panel.) The reviewers will meet late in 2003 to conduct their review. Comments will be returned to all proposers following the review panel meeting. The merit review for AODP proposals will include the same criteria as for proposals submitted to NSF. These criteria are:

1. **What is the intellectual merit of the proposed activity?**

   How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

2. **What are the broader impacts of the proposed activity?**

   How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

3. **Additional criteria** for AODP proposals include the following:

   - Likelihood that the proposed work will advance AO technology towards milestones identified on the AO road map
   - For implementation proposals, the overall value of the proposed amount of time to the U.S. astronomical community
   - Overall quality of the management and technical plans for accomplishing the goals
   - Broader impacts of the proposed effort on, for example, the improvement of infrastructure for education through involvement of students in the proposed efforts, or the improvement of research infrastructure through the training of instrumentalists

Based on the panel rankings and available funding, NOAO will request NSF approval of sub-awards to fund successful proposals.

AWARD ADMINISTRATION AND PROGRAM OVERSIGHT

A. NOAO ADAPTIVE OPTICS DEVELOPMENT PROGRAM OFFICE OVERSIGHT

Following NSF approval of the sub-awards, the NOAO contracts office will negotiate contracts with the selected proposers. Each contract will include the following elements:

- Description of the adaptive optics development
- Timeline, including milestones and payments
- Telescope time to be provided, where relevant, together with contingencies and limitations
- Management plan
- Reporting and review schedule

NOAO's role is an oversight responsibility. Listed below are examples of oversight activities. The actual reports and meetings agreed upon in each case will be negotiated to minimize impact on the awardee's management approaches and mechanisms already in place.

1. Approval of Management Plan

The AODP Technical Project Manager of the NOAO System Project Office will review and approve the management plan for the work. This is to ensure that sufficient project management is being provided by the proposing institution, that sufficient resources are identified to carry out the work, and that the budget and schedule are credible. An acceptable management plan is required before a sub-award can be recommended to NSF for approval.

2. Regular Periodic Reports

During the course of the awarded program, the PI or Project Manager will be required to submit monthly reports to keep the System Project Office informed of progress and problems. These reports will summarize work completed, equipment or parts purchased, issues identified, and progress relative to the accepted management plan. All reports and review results will be publicly available on the NOAO System web site.

3. Semi-annual Reviews for Development Projects

It is expected that development projects will have formal management and will include regular reviews, typically every three months. These will be attended by the Adaptive Optics Development Program Technical Manager and any associated technical personnel who might provide needed expertise. The review documentation and response to the review will be publicly available.

4. Annual Status Reports

At each annual AODP review, the panel will review the ongoing AODP-funded projects in addition to new proposals. These reports, which must be submitted to the AODP Office by each proposal deadline, will describe work completed in the past year, work planned for the next year, progress relative to the original proposal, and problems encountered.

5. Review of Progress on Implementation Proposals

It is expected that implementation projects will also have regular reviews similar in nature to the semi-annual reviews for development projects. Review materials and reports will be publicly available. The generic criteria to be used in annual evaluation for continuation of funding are successful completion of the work according to the original plan, and the improvement in performance of the facility described in the technical proposal. If improvements are not being made as proposed, the NOAO System Project Office will convene a panel to evaluate the project in context of other existing or proposed AODP projects and determine whether the project should be continued. A revised sub-award would require NSF approval.