

REPORT of the COMMITTEE OF VISITORS
Division of Astronomical Sciences
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GPRA FY 2002 Core Questions: Report Template

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I. INTRODUCTION

The Committee of Visitors (COV) to the Division of Astronomical Sciences (AST) met at NSF on 2-4 April 2002. The charge to the COV was given by Dr. Robert Eisenstein, Assistant Director for Mathematical and Physical Sciences (MPS), and included the following topics to be addressed:

- 1) The integrity and efficiency of the processes used to solicit, review, recommend and document proposal actions, including such factors as
 - a) The quality and effectiveness of merit review procedures;
 - b) Selection of an adequate number of highly qualified, bias-free and conflict-free reviewers;
 - c) The quality of the research and/or educational projects supported and their balance in terms of subject matter, size and duration of awards, and age, experience diversity and geographic distribution of principal investigators; and
 - d) The overall technical management of the program.
- 2) Balance among activities such as funding for the National Centers, the University Radio Observatories, and awards to individuals.
- 3) Responsiveness of the Division operations and organization to evolving research trends.
- 4) The degree to which the award process supports the long-range goals and core strategies of the NSF as described in its FY2001-2006 Strategic Plan that addresses the Government Performance and Results Act of 1993 (GPRA).
- 5) Any other issues the COV feels are relevant to the review.

Dr. Morris Aizenman (Senior Science Associate, MPS) introduced the COV to the GPRA requirements and reporting, and Dr. Eileen Friel (Executive Officer, AST) outlined the COV procedures. This was followed by an overview of the AST Division programs and organization by Dr. Wayne Van Citters (AST Division Director).

The AST Grants Program was described by Dr. Vernon Pankonin (Unit Coordinator). The COV was then divided into three subgroups that reviewed the six elements of the grants program in two consecutive sessions. Each session started with a brief introduction by the cognizant Program Director. The six grant programs included

- * Extragalactic Astronomy and Cosmology – Dr. Richard Barvainis,
- * Stellar Astronomy and Astrophysics – Dr. Phillip Ianna,
- * Planetary Astronomy and Particle Astrophysics – Dr. Vernon Pankonin,
- * Galactic Astronomy – Dr. Vernon Pankonin,
- * Education and Special Programs – Dr. Kathleen Eastwood and Dr. Eileen Friel,
- * Advanced Technology and Instrumentation – Dr. James Breckinridge.

The review covered all proposal actions made during FY1999, 2000 and 2001. A sample of proposal ‘jackets’ for each of the AST program elements was examined by the subgroups. The jackets had been screened by the Executive Officer to avoid conflicts of interest amongst COV members. A total of 322 jackets were reviewed, representing 24% of the proposal actions. Notes were taken by appointed leaders of each subgroup, and were summarized to the full COV and discussed in an executive session.

Dr. Van Citters presented the AST strategic planning that is currently underway in the AST Division. He outlined the various projects that have been recommended by the recent NRC 'Survey of Astronomy and Astrophysics in the New Millennium', and reviewed their support requirements. He emphasized the need for a different process to implement the strategic plan than had been used in the past due to the large financial demands for these projects and the constraints of the AST budget.

On the second day, an overview of the Radio Astronomy Unit was presented by Dr. Robert Dickman (Unit Coordinator), and was followed by detailed descriptions of the unit elements by the cognizant Program Directors. This included:

- * University Radio Observatories – Dr. Richard Barvainis,
- * National Astronomy and Ionosphere Center – Dr. Richard Barvainis,
- * National Radio Astronomy Observatory – Dr. James Breckinridge,
- * Atacama Large Millimeter Array – Dr. Robert Dickman,
- * Electromagnetic Spectrum Management – Dr. Tomas Gergely.

In the afternoon, an overview of the Optical/Infrared Unit was presented by Dr. Van Citters (Unit Coordinator), and was followed by detailed descriptions of the sub-elements of the unit by the responsible Program Directors. This included:

- * National Optical Astronomy Observatories – Dr. Daniel Weedman,
- * National Solar Observatory – Dr. Daniel Weedman,
- * Gemini Observatories – Dr. Wayne Van Citters.

The quality of all the presentations by the AST staff was uniformly excellent, and much care and attention were exercised by the staff in the preparations of the materials for the COV. The presentations showed a truly impressive array of accomplishments in scientific discoveries, innovative instrumentation development, and student education and training, as well as public outreach. The discussions between the COV and the Program Directors were open and frank, and all responses to questions asked by the COV were direct and unambiguous.

While the COV commends the AST staff for their professionalism and sound management, we were astonished to see the extent that each of the staff is spread amongst several major responsibilities in the Division. This can be readily deduced from the repetition of Program Director names amongst the various elements of the programs listed above.

The remainder of the COV meeting was spent in executive session, summarizing our observations and developing recommendations. Key inputs for the GPRA template were identified, and preparations of the report to the MPS Advisory Committee were initiated. A meeting with Dr. Eisenstein concluded our visit where our initial feedback on the COV primary observations and recommendations were outlined. It should be noted that all COV members were duly impressed with the openness of the NSF COV process and its value to both the NSF and the science community.

The following sections summarize the observations and recommendations from the COV review of the AST Division. The appended document contains the responses to the FY 2002 GPRA core questions and the COV evaluation according to the required GPRA template.

II. EXPANDING OUR UNIVERSE: HIGHLIGHTS FOR 1999-2001

In the last three years, the frontiers of the exploration of the universe have been greatly expanded through the advent of new instrumentation, observations, and theory. Remarkable discoveries have been made and they have changed and challenged our conventional views of the universe. These discoveries have further enriched our appreciation of astronomy, and have been fostered through various collaborative research and educational efforts. We summarize some of these highlights here under the broad themes of the NSF goals: *Ideas*, *Tools*, and *People*. Details of these and other examples are included in Part B of the GPRA template.

IDEAS: Scientific discoveries and advances

- ◆ A large number of new planets were detected orbiting around other stars using innovative techniques that measure the small gravitational effects that the planets exert on the star (*Butler, Carnegie Institution of Washington, Marcy and Fischer, UC Berkeley, Vogt, Lick Observatory, AST-9988087; Cochran and Hatzes, U. Texas, AST-9808980*).
- ◆ The surface and atmosphere of Jupiter's moon Europa were observed and investigated (*Brown, California Institute of Technology, AST-9973151*), and a satellite was discovered around an asteroid (*Merline, Southwest Research Institute, AST-9802030*).
- ◆ Images of the emission from the cosmic microwave background were created using a variety of experimental techniques, and constraints on the density parameter and cosmological constant were established based on the data (*Readhead, Caltech, AST-982989 and AST-0098734; Ruhl, UCSB, AST-9813920; Jaffe, UC Berkeley, AST-9872979; Carlstrom, Univ. Chicago, AST-0096913*).
- ◆ Advances were made in computational models to trace the evolution of the cosmic structure in the universe to its current lumpy state (*Loeb and Hernquist, Harvard, AST-0071019*).
- ◆ Constraints on the jets of energy released during gamma ray bursts were set based on observations at the Very Large Array (*Kulkarni, Caltech, AST-0098676 and AST-9803157*).
- ◆ Precise measurements of the velocities of stars near the center of the Milky Way resulted in the first detection of accelerations and provided the strongest evidence for the existence of a black hole at the center of our Galaxy with a mass of $2.6 \times 10^6 M_{\text{sun}}$ (*Ghez, UCLA, AST-9988397*).
- ◆ The structure of the molecular gas in the inner Milky Way was mapped with high resolution at the FCRAO radio telescope (*Jackson, Clemens, Heyer, and Bania, Boston U., AST-9800334*).
- ◆ Advances were made in our understanding of the physical processes such as magnetic fields associated with the formation of stars (*Boss, Carnegie Institution, AST-9983530*), and of stellar evolution including processes of supernovae explosions (*Mezzacappa, U. Tennessee, AST-9877130*).
- ◆ White dwarfs were detected in the Galactic halo, accounting for 2% of the dark matter (*Saumon, Vanderbilt U., AST-9731438*).
- ◆ Synoptic seismic imaging of active regions on the far side of the Sun was achieved using SOHO (*Braun & Lindsey, Solar Physics Research Corp. & Northwest Research Assoc., AST-9987286*).

TOOLS: Major Instrumentation

- ◆ Construction of the 8-meter Gemini North (Hawaii) and South (Chile) telescopes was completed. The telescopes saw ‘first light’ in early 1999 and 2000 respectively, and are currently operational.
- ◆ Construction of the 100-m Green Bank Telescope was completed at the National Radio Astronomy Observatory, and is being commissioned through early science operations.
- ◆ The Arecibo Telescope returned to full operation following completion of the Gregorian upgrade.
- ◆ The design and development phase of the Atacama Large Millimeter Array (ALMA) was completed through an international partnership between the U.S. and Europe, and this has led to the approval of the start of the construction phase in FY 2002 under the MRE program.

PEOPLE: Education, training and outreach

- ◆ The Astronomy & Astrophysics Postdoctoral Fellowship Program (AAPF) was initiated in 2001 to provide outstanding recent PhD recipients with 3 years of support to pursue a coordinated research and educational program at the institution of their choice. Ten fellowship awards out of 51 applications were made (*AST Divisional Report, FY2001, pg 2*).
- ◆ Graduate student education in astronomy is vibrant. A total of ~300 students are supported annually by the AST Division, primarily under research grants to individuals at colleges and universities. Training opportunities in instrumentation at national and university facilities serve to develop technological expertise and represent an important investment in future leadership.
- ◆ Integration of education and research at the undergraduate level is promoted through a highly-successful REU program in astronomy at 14 sites, supporting ~125 students annually. Roughly 50% of these students are women, and 15% are from under-represented minorities. Examples:
 - ◆ Students participating in the REU program at NRAO carried out a collaborative observing project using the Very Large Array in which they discovered the first radio emission ever detected from a brown dwarf. The students’ paper was published in *Nature*, and is forcing experts to rethink their theories about brown dwarfs (*Giacconi, AUI, REU AST-9731795*).
 - ◆ Students participating in the REU program at Cal State L.A. found that a recently-discovered asteroid is actually a new comet. This program, dedicated to providing research opportunities to minority students, is arguably the AST Division’s most successful initiative towards creating a workforce that reflects America’s diversity. (*Gregorich, Cal State LA, AST- 9820546*).
- ◆ Excellent public outreach efforts were supported by the AST Division and have been tremendously successful. A major new exhibit ‘*Exploring the Universe*’ opened in September 2001 at the Smithsonian Institution’s National Air and Space Museum (*DeVorkin, AST-0083463*). An interactive exhibit called ‘*Astroflow*’ was installed at the Strasenburgh Planetarium in Rochester, NY. It has allowed users to interactively control, visualize and explore simulations of cosmic events such as exploding stars, comets diving into the atmosphere, and jets of gas driving through interstellar clouds (*Frank, U. Rochester, AST-9702484 – a CAREER award*).

III. AST DIVISION MANAGEMENT

The COV is pleased to report that the management of the AST Division is presently in excellent hands. The COV members were impressed with the Division Director and his vision, as well as the exceptional efficiency and organizational skills of the Executive Officer. The COV recognized that the AST Division has undergone a change in management in the past year, and has had to satisfy various demands that are marked with substantial national visibility. These include the

- NRC decadal survey of ‘Astronomy and Astrophysics in the New Millenium’,
- OMB-mandated review of NASA and NSF astronomy management: Committee on Management of Research in Astronomy and Astrophysics (COMRAA),
- Recompensation of the management of the National Optical Astronomy Observatory and the National Solar Observatory, and
- Initiation of the Atacama Large Millimeter Array – a complex international project under the Major Research Equipment (MRE) program.

The AST Division is handling the complex issues associated with the above initiatives with foresight and sound planning.

We are also pleased to note the excellent work of the Program Directors within the AST Division, and the vitality of the overall Division. This should enhance the community’s trust and confidence in the NSF stewardship of the ground-based astronomy resources in the U.S. But we found that all the Program Directors and managers are fulfilling many simultaneous tasks and carry multiple responsibilities, as already mentioned in Section 1 of this report. While the proposal handling workload is heavy and the reporting requirements are sizable and growing as at all MPS Divisions, the launch of major astronomical projects such as ALMA and the EVLA, the planning for the large projects recommended by the decadal survey, the enhanced interactions with other Federal agencies, and the initiative to strengthen community relations, are all adding major responsibilities and stresses on the Division and its staff. The AST Division is severely undermanned.

- **Our first and most urgent recommendation is to increase the staff in the AST Division**

The urgency is driven by the critical need to dedicate close attention and oversight to the large projects that are being started. There is substantial risk if the management of these large projects is not handled properly.

The recommendation for additional staffing also appeared in the previous COV review, but unfortunately has not been achieved. Apart from the need to add new staff positions, several existing positions are presently unfilled and this is exacerbating the situation and stressing the current staff in the Division. In order to respond to the difficulty of attracting rotators to AST, the Division has developed an innovative plan through the competitive award of Senior Fellowships in Science and Public Policy. The award would allow mid-career scientists to spend two years at NSF in public service, to be followed by two years at the home institution to reestablish or broaden their research programs. The COV strongly endorses this program and commends the AST Division for this original idea. It is hoped that this action as well as others, together with the enhanced vitality within the Division that would make it more attractive for scientists to come to NSF, will help resolve the staffing problem.

A related recommendation is the provision of an adequate travel budget for the Program Directors. This will serve to enhance their contacts with the community, maintain up-to-date knowledge of new developments and scientific results, and bring more satisfaction to their challenging work.

IV. STRATEGIES AND IMPLEMENTATION PLANS

One of the major challenges currently confronting the AST Division is the development of a sound response to the initiatives for ground-based astronomy identified by the U.S. astronomical community in the NRC Survey of Astronomy and Astrophysics for this decade. The survey has set the community's priorities for various projects based on scientific merits and on the technological developments required to maintain U.S. leadership in astronomy.

The AST Division Director has recognized that the current process for determining how best to implement the recommended initiatives, namely through unsolicited, unmanaged proposals, is not adequate, and a new process needs to be identified. Various possible approaches were presented and discussed with the COV, and the benefits of each were reviewed. It was clear that no single approach would be applicable to all projects, and a mix of different approaches would provide the best response to the various initiatives on both the large and moderate scale. We commend the AST management for its recognition of the need to prepare a plan at the earliest possible time for the implementation of the decadal initiatives in order to maximize progress across the various disciplines in astronomy. We also commend the AST Division for initiating preliminary design studies in the community for several of the new projects, and for encouraging the community to take advantage of various NSF-wide initiatives such as ITR, MRI and other programs to support some of these studies.

- **The COV recommends that the AST Division develop an implementation plan with funding requirements to the end of the decade to support the various initiatives that have been identified and prioritized by the community in the NRC Decadal Survey. The Division needs to actively engage the community on a continuing basis in the planning effort.**

There are two classes of projects within the decadal initiatives. Large telescopes with costs over \$80M clearly belong to the MRE category and need to be developed sufficiently so they can compete within that budget category. Moderate projects in the \$10M class are currently difficult to plan since there is no process to handle them within the constrained AST budget. A careful phasing of these projects based on their readiness needs to be prepared.

Initial funding requirements over the next decade for both the large and moderate projects have been estimated. The profile indicates a need for a steady enhancement of the AST Division budget by about \$40M over the next 6 years to support the moderate initiatives. Such an increase would not be inconsistent with the desired enhancement of the overall NSF research budget.

The AST implementation plan when completed can set the budget goals clearly, and the MPS Directorate can hopefully use this plan to justify the requests for the out-year budgets. The COV inquired about the budgeting process within NSF, and although the details of the budget build-up for a particular year remained unclear, the COV encourages that the implementation plan be seriously considered in setting the future budget requests for the AST Division.

V. PROGRAMS

RESEARCH GRANTS

The COV subpanels considered each of the proposal categories in the research grants to individuals, namely Planetary Astronomy (PLA), Stellar Astronomy and Astrophysics (SAA), Galactic Astronomy (GAL), Extragalactic Astronomy and Cosmology (EXC), Advanced Technology and Instrumentation (ATI), and Education and Special Programs (ESP). Overall, 322 proposal ‘jackets’ in the FY1999-2001 period were reviewed, providing an adequate sample for assessment (24% of all proposal actions). We note that the AST Division has implemented a review process primarily based on expert panels in order to allow a ranked comparison amongst proposals in the different subfields. We present below some general observations and recommendations, and then summarize each of the subpanel reviews and comments for the various AST programs.

As a whole, the COV was impressed with the extensive documentation, appropriate review panel composition, and fairness of the awards. Because of the relatively small size of the AST community, arranging for panels is a challenge for the Program Directors, and we commend them for their efforts in seeking and constructing these panels. The COV found that the review process is fundamentally strong and efficient, and possesses the necessary integrity.

The COV also examined how well the AST community is responding to the ‘broader impact’ criterion and how well the review panels value this criterion. It was found that most proposers at least mention the broader impact of their research in general terms, although most do not identify it specifically in a special section of the proposal. Many of the NSF-supported programs in the research grants involve students, both at the graduate and undergraduate level, and are therefore helping in the general scientific education of the workforce and in the training of future generations of scientists. The COV did note an improving trend between FY2000 and FY2001 where the importance of specifically discussing the broad impact of the research work is being more widely appreciated by the community. On the other hand, it appeared as though only a minority of the panel reviewers have so far actually used the broader impact criterion in their assessments. Although it is recognized that this criterion may not apply to all researchers, the COV expects that it would be a relatively easy criterion to fulfill by the astronomy community if it were better understood. It should be recognized for example that the criterion extends to education at all levels, beyond K-12 outreach.

- **The COV recommends that the AST Division explore new ways to enhance the AST community’s response to the ‘broader impact criterion’ in the review process by emphasizing its importance, clarifying its meaning and usefulness, and illustrating its application. Review panels should also be encouraged to pay closer attention to this criterion and to give credit to investigators who fulfill it well.**

One general concern was shared by the COV. The future of astronomical research rests on the shoulders of the youngest members of the profession. However, many institutions have rules that prohibit all but permanent members from becoming Principal Investigators for grants. This has fostered a system where junior researchers often have their work submitted for funding by more senior colleagues. While the senior colleagues will generally mention the contribution of the junior researchers in the proposal, there is no official recognition of their contribution. NASA has created a title of "Science PI" to recognize this problem. The normal PI still has overall and fiduciary responsibility for the grant but the contribution of the junior researcher is officially enunciated and

tracked. This approach is very beneficial for the future careers of junior researchers and formally recognizes their important contributions, while meeting institutional rules. We realize that the NSF proposal forms need to apply to all divisions, and suggest that NSF consider incorporating a similar mechanism of Science PI for NSF grant proposals to encourage our future scientific leaders.

1. Planetary Astronomy (PLA)

The Planetary Astronomy Program provides funding for U.S. astronomers carrying out theoretical and observational studies of the detailed structure and composition of planetary surfaces, interiors, atmospheres, and satellites; the nature of small bodies (asteroids and comets); the origin and development of the solar system, and related laboratory studies.

Planetary Astronomy is unique amongst disciplines of astronomical research because, though NASA does not in general fund ground-based astronomy, ground-based planetary astronomy is funded through both NSF and NASA. However, the NASA funding is generally tied to mission-specific science. The NSF Planetary Astronomy Grants Program offers a funding source that is not tied to specific mission goals and is very complementary to the NASA funding. The NSF Planetary Astronomy Program Director appears to maintain excellent communications with his counterparts at NASA, thus avoiding program overlap.

The Planetary Astronomy program offers a special challenge for proposal review because of the breadth of the discipline. Proposals can range from observational to theoretical to laboratory projects, and from solid surfaces to atmospheres to icy bodies. Thus, in a review panel of only 4 or 5 members, it is quite likely that the breadth of the proposals will exceed the expertise of the panel members. Recognizing this, it is important to consider soliciting external (*ad hoc*) reviews when the research base of the panel experts does not adequately cover the PLA subfield for the particular proposals under review.

2. Stellar Astronomy (SAA)

The program encompasses a broad range of observational and theoretical studies of stars. In particular, these studies involve the formation of stars, the fundamental physical parameters, structure and evolution of the Sun and normal stars, the characteristics of stars in the Milky Way Galaxy as probes of stellar age and composition, the processes by which stars return material to the interstellar medium via winds, large scale mass loss and supernova explosions, and the end stages of stellar evolution such as white dwarfs, neutron stars and black holes.

The COV subpanel concluded that the proposal review process for the SAA section is working well, and was impressed with the strengths of the review panels assembled. In all cases examined, the panels had sufficient experts to evaluate the wide-ranging variety of proposals.

There was much discussion of a few cases where proposals fell on the borderline for funding. It eventually became clear why they were or were not funded; most of these were programmatic decisions made by the Program Director. Some members of the subcommittee inquired whether the panels might be able to help the Program Director in setting priorities for those borderline cases. Without attempting to infringe on the discretion of the Program Director, it was suggested that perhaps the panels might at least give some opinions or advice to the Program Director about the

weight to be ascribed to those borderline proposals in terms of scientific diversity, gender equity, geographic concentrations, new investigators, etc.

3. Galactic Astronomy (GAL)

The Galactic Astronomy program, in response to the rapidly changing scope of the Extragalactic Astronomy and Cosmology program, expanded in 2001 to include galaxies beyond the Milky Way to the Local Group galaxies, and further added in 2002 nearby galaxies at distances up to a few Mpc. This change is appropriate because the increasing resolution and sensitivity of modern observational facilities has made it possible to study nearby galaxies in similar detail to conventional studies of the Milky Way.

Care must continue to be taken to ensure that review panels cover the wide variety of fields appropriate to the expanded scope of GAL proposals. In 2001, the proposal review process carefully divided the proposals into panels with emphasis on interstellar medium, stellar populations, and fundamental astronomy and processes. The results of the proposal review appear to be fair.

4. Extragalactic Astronomy and Cosmology (EXC)

The COV subpanel for this section was uniformly impressed not only by the completeness of the reviews written by the panel, but also by the fairness and sensitivity of the overall action provided by the Program Director both in written and verbal feedback to the PI. The COV noted that individual reviews, while clearly providing a useful independent assessment of a proposal, were often reconsidered during the panel discussion where the panelists had the benefit of being able to compare the merits of one proposal against all of the others under consideration and were able to hear from other experts with different perspectives. The COV found that the overall review benefited from the 'give-and-take' during the panel discussions, and that the summary provided by the NSF program officer presented a fair and comprehensive picture of the total review process.

The EXC section continues to be the largest of the four research programs within the Astronomy Research Grants unit. The COV noted that the 'funding rate' of EXC proposals increased from 27% to 31% between FY1999 and FY2001, but was slightly below that of the other three research grants programs. Perhaps this was a reflection of a conscious effort not to fund larger numbers of proposals with smaller dollar awards. Given that the average dollar amount awarded over all AST research grants is already too small (~\$75,000) to adequately fund even a single postdoctoral researcher, and that the pressure to fund many meritorious proposals is great, the COV understands that difficult choices need to be made when considering the number of proposals to accept. We agree that the mean dollar awards should not be allowed to dip much further below current levels.

In considering the future health of the program, the COV expressed a few concerns about the increasing scope of the EXC program. The COV cautioned that the proposal pressure on the EXC program may become even more severe with the continued growth of the numbers of proposals to study new and exciting phenomena associated with the very early Universe. The COV noted a continued shift in proposals submitted to the EXC program away from studies of individual, nearby galaxies and AGN to studies of large-scale structure, gamma-ray bursts, and other high-z phenomena. Members of the COV were concerned that meritorious studies of nearby galaxies might be shortchanged, either by assigning them to the Galactic Astronomy program or by not having a sufficiently large subset of panel reviewers who were expert in studies of nearby galaxies. As has

been mentioned in section 3 above, the AST Division needs to be vigilant in finding expert reviewers to ensure that all topics covered by proposals assigned to the EXC program have adequate scientific representation on the EXC review panel.

5. Advanced Technologies and Instrumentation (ATI)

The ATI program supports the development of innovative instrumentation at all wavelength bands used in astronomical research. The ATI Program Director also administers the astronomical proposals submitted to the NSF-wide MRI program, and the Advanced Electro-Optical System (AEOS) program that provides access to the Air Force's 3.8m-telescope on Maui, Hawaii, in collaboration with AFOSR. Administratively, the ATI program is part the O/IR unit within AST.

Inspection of the proposal jackets by the COV indicated that the proposal review process was handled fairly for all of the above programs. The review panel recommendations were internally reasonably consistent, and the actions taken by the Program Director were generally compatible with those recommendations. In the few cases where the panel recommendations were not followed, the rationale seemed reasonably clear and justified. For example, in one case the Program Director funded a risky but highly innovative project, led by a powerful team, that had a very large potential payoff. This particular example illustrates what we perceive to be a wise use by the Program Director of his discretion to achieve an appropriate balance between reasonably assured and risky projects.

The COV noted an explicit recognition in the ATI program to support the training of the next generation of astronomy instrument builders. An interdisciplinary post-doctoral fellowship program competed across the MPS Directorate may be one solution. Because instrument development is fundamental to astronomy's continuing success, the COV suggests that an aggressive approach be pursued to making graduate and post-doctoral fellowships in instrumentation available outside of grants. For example, students and post-doctoral researchers could receive fellowships to train on, and contribute to, otherwise fully funded projects at national centers, observatories, or universities.

Finally, it is apparent that the ATI program is extremely diverse. Although the ATI program's website appears to have all the pertinent program information, the COV suggests that the ATI Program Director provide additional clarification of the distinctions among the various technology sub-programs (e.g. ATI, MRI, AEOS, TSIP) to further assist interested investigators in obtaining information about the program efficiently.

EDUCATION AND SPECIAL PROGRAMS (ESP)

The AST Division is well positioned to help advance science education within the United States through the captivating interest that astronomy provides and the broad appeal that it possesses. AST's ESP covers education and training at all levels, as well as public outreach. Its goals include supporting innovative new projects in education and outreach, and providing incentives to researchers in order to integrate education as part of their research programs.

The ESP core programs include faculty early career development (CAREER), Research Experiences for Undergraduates (REU) and for Teachers (RET), the Astronomy and Astrophysics Post-doctoral Fellowships (AAPF), and Research at Undergraduate Institutions (RUI). ESP also represents AST's involvement in NSF and MPS cross-cutting programs such as ADVANCE which aims at increasing the participation and advancement of women in science careers, and the MPS Distinguished Research

Fellowship Program (DRF). The COV was impressed with the management of the rather diverse ESP program. Examination of the jackets showed excellent proposal processing, including thoughtful reviews, appropriate allocation of awards, and sensitive communications between program officers and proposers.

The CAREER program is the most visible implementation of the strategy to provide incentives for researchers to be engaged in education. The COV commends the ESP Program Directors for their commitment to insuring that the CAREER program of the Astronomy Division accomplishes its goal of fostering both forefront research programs and advanced education initiatives in young faculty. Over the three years reviewed by the COV, there has been a notable improvement in the quality of the education components of the CAREER proposals. This change in the community response is a direct result of the resolve of the Program Directors to support excellence in all facets of the successful CAREER proposals and to broader expertise in the review panels.

Another commendable development in ESP is the initiation in 2001 of the Astronomy and Astrophysics Post-Doctoral Fellowships program which is a three-year fellowship portable to any institution, and which must include an educational component. The strong response of 51 proposals is a clear endorsement of a felt need fulfilled by the program. Equally important is the fact that 9 of the 10 initial offers were accepted, in some cases competing with prestigious Hubble Fellowships with similar benefits but solely a research mission. This is seen as a clear statement that young Ph.D.'s are at the vanguard of a broadening perspective on the roles of forefront scientists. In addition, the COV was particularly pleased with the number of awards in astronomy (6) for the first year of the MPS DRF program.

The REU site programs in astronomy have been most effective in training students and attracting them to science, and students have enjoyed the discovery aspects of astronomy through observations at various radio and optical telescopes. There are currently 14 active REU sites in astronomy, and the number appears to be limited by community interest in supporting sites rather than by NSF funding. This was of concern to the COV, particularly as there also appears to be some turnover in REU sites. REU sites are often initiated enthusiastically by a researcher, but the program is not generally institutionalized possibly due to the lack of adequate funding support for infrastructure at some sites. In other words, when an REU site director moves on, the cost of program maintenance is too high to be attractive for replacement by new leaders.

We commend the AST Division for pursuing and encouraging outreach activities to bring the excitement of astronomy to the public. The support provided for the exhibit at the National Air and Space Museum when EHR was unable to jointly support it for administrative reasons is an excellent investment. Encouragement of the visitor centers at NAIC, NOAO, NSO, and NRAO, is laudable and will amplify the message to the public about the importance of investments in science and in the education of the next generation of scientists in the U.S.

More broadly, the COV feels that it is essential that efficiencies in ESP be gained through more active collaboration by the Program Director with other MPS divisions, and preferably with divisions in other Directorates such as EHR. The similarities of education initiatives across research divisions are far greater than the disciplinary differences; it makes little sense for each to innovate and evolve independently. The COV was pleased to hear about the Education Working Group organized by the OMA Director within MPS, and to see the Internships in Public Science Education (IPSE) program

arise from this collaboration. This Working Group is well poised to develop a strong strategy for education and public outreach across all the MPS divisions.

NATIONAL CENTERS AND OBSERVATORIES

The COV heard comprehensive presentations from the Program Directors responsible for oversight of the astronomy national centers. This included the operations of the national facilities and some of the new major projects that are being undertaken in AST. The presentations covered the radio astronomy unit and its facilities – the National Astronomy and Ionosphere Center (NAIC), the National Radio Astronomy Observatory and the ALMA project, and the University Radio Observatories (URO). A most interesting presentation on Electromagnetic Spectrum Management (ESM) was also provided. Presentations on the optical/IR unit covered the National Optical Astronomy Observatories (NOAO), the National Solar Observatory (NSO), and the Gemini telescopes. We summarize our evaluations of each of these Centers and Observatories below.

1. Radio Astronomy Facilities Unit

The Radio Astronomy Facilities Unit consists basically of three parts: (1) the National Centers of NRAO and NAIC, (2) the University Radio Observatories (UROs), and (3) the Electromagnetic Spectrum Management (ESM). These are three parts of a coherent whole with the National Centers providing unique major instruments that are beyond the scope of any single university or consortium of universities; the UROs providing unique and productive, but smaller scale, instruments which are available as training platforms for students in addition to their forefront research activities; and the ESM coordinating protection and sharing on a national and international scale primarily for the heavily oversubscribed radio frequency spectrum. These three components help to maintain and improve the strength of US radio astronomy in particular and its contribution to astrophysics in general. Oversight of these facilities by the NSF appears strong and is directed towards the need to maintain diversity, quality, and balance among these facilities. Maintaining balance between a center as large as NRAO with a budget of ~\$40M/year, and a small URO such as the CMVA with a budget of ~\$0.4M/year, while phasing out older facilities and establishing newer ones, is very challenging. However, the AST Division appears well aware of the difficulties and is establishing mechanisms to maintain and, to the greatest extent possible, increase the vitality and diversity of the Radio Astronomy Facilities Unit.

(a) NAIC

An extensive upgrade of the Arecibo radio telescope has been completed, and this facility – the largest in the world – remains an important tool for astronomical research. This fact is demonstrated by a number of scientific highlights that resulted from Arecibo observations, including continuation of a long history of discovery and study of Galactic pulsars, discovery and investigations of low-surface-brightness, dark-matter dominated galaxies in the local Universe, spatially resolved studies of Galactic and Local Group High-Velocity Clouds, and high-resolution radar maps of the surface of Venus and of near-Earth and main-belt asteroids. The radar observations are supported by NASA.

NAIC has for many years been one of the leaders in the area of education and public outreach. The Visitor and Education Facility has an astonishing 120,000 visitors per year. A new Science Teacher

Training Course is an example of Arecibo leading the way in this area, and this activity could provide a model in pre-college science education for other national centers.

The committee's concerns for NAIC in the longer-term involve the potentially redundant capability between Arecibo and the newly commissioned Green Bank Telescope (GBT), and the relatively lower demand for observations at Arecibo (oversubscription ratio of 1.8) compared with some of the other NSF AST facilities. The track record of excellent science based on Arecibo data strongly suggests that it is currently a vital and well-utilized facility. The demand for Arecibo capabilities in the GBT era will need to be monitored.

(b) NRAO

NRAO is a very well-managed and highly productive national center. It offers instrumentation which is unique in the world and which has kept US radio astronomy at the forefront. NRAO's facilities attract scientists from many other countries, and some 30% of the institutions making use of NRAO telescopes are foreign. NRAO annually provides about 20,000 observing hours to 950 different observers. As of 2001, it is operating only three facilities – the VLA, the VLBA, and the GBT – all world-class. In 2000, the 12-m radio telescope at Kitt Peak was closed, and its key staff are now supporting the development of ALMA.

The three facilities operated by NRAO offer an excellent balance of sensitivity and resolution. Although it is now 20 years old, the VLA continues to be highly productive. NRAO's plan to upgrade the VLA (the EVLA-1 program), leading to an increase of a factor of 10 in sensitivity, is well-considered and is a high pay-off investment for the future. The GBT is only now coming into full-time operation and will be the premier single-dish radio telescope in the world. Although the larger NAIC Arecibo telescope has higher sensitivity for some applications than the GBT, the full sky coverage of the GBT, allowing long integration times and larger source samples, gives it a significant net advantage.

NRAO's Central Development Laboratory deserves special mention for its leadership in developing state-of-the-art high frequency receiver technology. It is not widely known, but the recent explosion in observational cosmology based on measuring structure in the Cosmic Microwave Background is largely owed to technologies produced by the CDL. NRAO detectors are, for instance, the heart of the ongoing NASA MAP mission. This, in fact, is an area where both NSF and NRAO could have done more to publicize a unique contribution to a highly conspicuous scientific frontier.

(c) ALMA

The Atacama Large Millimeter Array (ALMA) is one of the most anticipated new facilities in astronomy. It has undergone an extended planning and development period, with what appears to be unusually careful attention to cost containment. NSF and NRAO are to be congratulated for having secured initial construction funds for FY 2002. Nonetheless, ALMA is a complex project, not only because of the technology involved but also because of the challenge of construction at high altitude, and the project's international structure. NSF current staffing in support of ALMA is not thought to be sufficient, and we recommend that one additional full-time position be assigned to the project. Since ALMA is funded through the MRE program, it may be appropriate that additional management personnel be supported from MRE resources, if such funds could be used for this purpose.

(d) URO

The University Radio Observatories (UROs) play a vital role in the training of students and providing the sort of direct contact with instrumentation which is not possible at the large national centers. In addition to their training role, the UROs are expected to provide unique facilities and to be world leaders in their research areas. There are currently five UROs supported by NSF: (1) the Caltech Submillimeter Observatory (CSO), (2) the Five College Radio Astronomy Observatory (FCRAO), (3) the Owens Valley Radio Observatory Millimeter Array (OVRO), (4) the Berkeley-Illinois-Maryland Array (BIMA), and (5) the Coordinated Millimeter VLBI Array (CMVA) at the MIT Haystack Observatory. These are powerful instruments which carry out research in unique areas of radio astronomy, provide access to the broader community of U.S. and world astronomers, and have a long record of successful research and training of high quality astrophysics and instrumental students. Currently the UROs support approximately 500 users per year, have more than 80 PhD students and postdocs working at the observatories, and publish ~190 scientific papers per year. They have produced approximately 90 PhDs over the past 10 years.

As is appropriate, and in spite of such a record of success, there is continual review and transition of the UROs to insure that they remain forefront instruments while still providing the vital student training function. CSO is the youngest of the UROs and will continue to develop, upgrade, and improve its facilities on Mauna Kea, Hawaii. FCRAO is expected to transition to the joint US/Mexico Large Millimeter Telescope (LMT) over the next few years after its completion in 2005. The OVRO and BIMA arrays are planned to be combined at a new, higher elevation site in 2004-2005 to form the Combined Array for Research in Millimeter Astronomy (CARMA). The CMVA, which uses a global array of radio telescopes for its observations, will phase out in FY2003 as the Very Long Baseline Array (VLBA) is upgraded for operations at 3mm-wavelength. Such changes and transitions are proper for maintaining the UROs as forefront research and training facilities. To insure proper coordination, uniqueness, and challenging goals for the UROs, simultaneous competitive reviewing of all of the URO proposals is planned in Summer 2002 for requested FY2003 funding.

In summary, the URO program appears to be active, unique, and vital to the health of US science and technology development. If there is a concern, it is that the planned improvement and expansion of some existing facilities and closing of others may lead to an over-consolidation of UROs and a potential decrease in their collective capability to allow student training. Consideration should be given to establishing new UROs in the future as the closing of older facilities provides new funding opportunities, but without impacting the support for research grants to individuals.

(e) ESM

The work in the AST Division regarding electromagnetic spectrum management and the concerns about the threats to the electromagnetic spectrum for radio astronomy was presented, and was indeed an 'eye-opener' for the COV. The 1999 CD movie by NSF on "*Radio Astronomy: Observing the Invisible Universe*" is an excellent presentation of the challenges facing ESM. There are tremendous commercial pressures threatening the small percentage of the EM spectrum available to radio astronomy. As the technology is becoming available to make exciting observations in the atmospheric windows between 70 and 300 GHz, it is imperative that the efforts of the NSF, in particular the NSF responsibilities to safeguard the ESM for astronomy be given full support. The COV is concerned that these efforts require more than the one FTE position devoted to this issue.

2. Optical/IR Unit

The Optical/Infrared Facilities Unit oversees the operations of several independent programs, including NOAO, NSO, the U.S. Gemini Project, and the recently-initiated Telescope System Instrumentation Program (TSIP), managed by NOAO. The ATI program is administered as part of the O/IR unit, but has been covered earlier. Except for a small increase in the past three years due almost entirely to the Gemini project, the budgets for the Unit were pretty flat in the nineties. The individual components of the Unit will be described in more detail below.

The major concern with such a diverse O/IR program is the challenging development of an optimum "investment" strategy not only for the near-term, but also for the next decade. One must balance the sometimes conflicting needs to provide telescope access, research support, development of next generation instruments, training of new scientists, and broader education and outreach goals. The O/IR Facilities Unit plays a different role in the community than the Radio Unit, owing to the proliferation of private optical observatories. The committee applauds initiatives, such as the Telescope System Instrumentation Program (TSIP), that are designed to provide access to the private facilities by the general community. This would help counteract to some extent the decline in access to NOAO telescopes, where facility closures and transfers to private groups are being traded for the development of future initiatives, such as the Large-aperture Synoptic Survey Telescope (LSST) and the Giant Segmented Mirror Telescope (GSMT) recommended by the NRC Decadal Survey.

(a) NOAO

The COV recognizes the important role of NOAO in the maintenance and growth of optical and infrared astronomy and astrophysics. State-of-the-art ground-based optical and infrared observatories have made significant contributions to scientific discoveries and play an essential complementary role to space-based observatories and space missions. NOAO facilities provide astronomers from all institutions access to premier telescopes, and for many astronomers, the only access to such facilities. NOAO observatories also serve the important function of providing the opportunity and facility for development of new instrumentation and the training of astronomers and instrument builders of the future. NOAO is faced with difficult choices in fulfilling its mission to provide advanced facilities and continuing maintenance and upgrade of existing observatories in view of necessary fiscal constraints and current uncertainty in the NOAO management contract. NOAO is managed by AURA, and its management contract has been recently recompeted, with results to be released soon.

The COV is pleased to see that reforms in the technical management at NOAO Tucson recommended by the previous COV have been addressed. We also recognize the decision to shut down NOAO operation of most telescopes smaller than 4-m and transfer most to private institutions. We commend the NOAO for taking proactive steps to strengthen the program and provide the resources and opportunities for growth of new facilities and technologies.

At the same time, the COV expressed concern, echoed by the 1999 Portfolio Allocation Review and the general community, about reduced public access to NSF-supported national nighttime optical facilities. NOAO has restructured its KPNO and CTIO operations and has added part-time access to the Gemini, WIYN, and SOAR telescopes. However, in 2003 the number of observing nights NOAO will be able to offer to the general US community will be a factor of 2.5 smaller than in 1990. Partly as a cost-saving measure, significant amounts of 4-m time have also been dedicated for specialized observing campaigns and surveys, further limiting access by the general user. This reduction in

access seems likely to have a negative impact on exploratory or risky programs, instrument development, student training, PhD thesis projects, and access to public telescopes by smaller college and university faculty and students.

The COV does not believe that the new large (8-m class) facilities alone can provide adequate time to address these goals. We recommend that NSF provide sufficient support to NOAO such that no further reduction in public access to first class optical/IR facilities becomes necessary. One specific concern was the potential elimination of support for instrument development at the remaining 4-m telescopes and even the possible closure of the facilities themselves. The COV believes the continued support of the 4-m class facilities and continued support for instrumentation for these facilities must be maintained. The plan to eliminate support for such instrumentation developments on 4-m telescopes needs to be reexamined.

- **The COV recommends that a vital instrumentation program be maintained for the 4m class telescopes to which the national community has access.**

The COV further suggests that NSF/AST and NOAO need to present a clearer vision of the role of the remaining suite of NOAO telescopes and how their mission to train a new generation of optical and infrared astronomers will be accomplished. The use of the TSIP and creation of a program analogous to the highly successful radio astronomy UROs may be one approach. The NOAO should also consider a mechanism for at least partial support for facilities transferred to universities such that they can be made accessible to the entire astronomical community.

The COV also recommends the NSF/AST and NOAO examine the possibility of establishing observing travel support for observers granted time on NOAO facilities. A long-standing successful program at the NRAO can be used as an example, and will help build a stronger community of users.

(b) GEMINI

The COV is pleased with the progress in the Gemini program. Gemini is an excellent example of a successful large international project managed in the AST Division. Now that the construction phase has been completed, there is some concern regarding adequate funding for instrumentation and upgrades. AST should examine the instrument and operations budget to optimize Gemini capabilities. Unique approaches, such as currently proposed, involve trading of Gemini time for NASA time on Keck telescopes to enable access to a broader instrument complement. Additional leveraging of NASA, DOE and DOD development can also enhance Gemini capabilities. Particular use could be made of the enhanced NSF/NASA partnership, as recommended by the Committee on Management of Research in Astronomy and Astrophysics (COMRAA).

(c) NSO

The National Solar Observatory (NSO) operates solar instrumentation at two major sites---Kitt Peak and Sacramento Peak--for the benefit of the astronomical community. Formerly part of NOAO, NSO now is an administratively separate entity, although still managed by AURA under a cooperative agreement with NSF that includes NOAO. Solar Physics is an area of astronomy that has particular relevance to society and commerce, as for example the rapid growth in "space weather" activities over the past decade can attest.

NSO runs the two workhorse US solar telescopes: the 76-cm Dunn Solar Telescope at Sac Peak and the 150-cm McMath-Pierce (largest in the solar world) at Kitt Peak. NSO scientists have developed an adaptive optics system for the Dunn, making it one of the premier solar imaging instruments, despite its continental mountain site. The McMath-Pierce, with its all-reflecting unobscured design, is well suited for infrared work, particularly in the thermal IR beyond 3 microns. In addition to the major facilities, NSO operates the GONG project, to study global solar oscillations by means of a world-wide network of semi-autonomous monitors. NSO is also building SOLIS, an instrument cluster to provide high-precision synoptic solar measurements for research and space weather applications. Finally, NSO is designing the next generation solar facility – the Advanced Technology Solar Telescope (ATST), a 4-m off-axis system with adaptive optics yielding unprecedented resolution and sensitivity.

The committee commends NSO for its forward-looking program to provide new tools for the solar community. At the same time, NSO is faced with enormous technological challenges in the design of ATST, while constrained budgets have depleted the staff leaving fewer people to shoulder the burden. In addition, the crucial site selection process for ATST could become politicized, with potentially negative impacts to the current momentum of the project. Site consolidation represents an additional future complication that NSO will have to face after ATST is built. If these issues can be solved, solar physics faces a bright new future, indeed.

It also was noted that the new visitor center at Sac Peak has become a valuable education and public outreach tool not only for NSO, but also for the nearby Apache Peak Observatory where the Sloan Survey is being conducted.

VI. BALANCE OF PROGRAMS

Within the confines of a finite budget, it is imperative that the AST Division maintain an appropriate balance of its programs. The Portfolio Allocation Review (PAR) Committee, assembled as a result of the previous COV review, addressed this issue in its report of December 1999. Many of the PAR recommendations have been addressed by the AST Division. Based on the PAR report and on the presentations and documents presented at the COV meeting, the COV believes that, overall, the AST Division is currently allocating its resources in a productive way, but pressures will continue from various directions to adjust the balance as new demands and opportunities arise. The AST Division must maintain its flexibility and sustain a well-balanced program.

The AST Division has implemented a good organizational change for its Research Grants program. It created one research unit allowing for the funds within the four research subfields (PLA, SAA, GAL, and EXC) to adjust to the community's demands and pressures. We have noted that such adjustments have already occurred, but found that the SAA and PLA funded awards remain on average at a lower level than the other subfields thus needing some further attention in the future.

We were pleased to find that the overall level of support to individual researchers under the Research Grants Program increased steadily by about 20% over the past three years. The success rate for AST proposals has also improved and reached ~33% in FY2001. But we continue to be concerned that the funding level of AST research grants (~\$75,000) remains much lower than the overall NSF level.

Our concern about the core support stems from another aspect. NSF now has many directed programs and in some of these, AST has difficulty competing (e.g. biocomplexity and nanoscale

technology). The special initiatives, while important to the overall NSF program, appear to represent an increasing fraction of the total AST budget and will reduce flexibility for budget management if they continue to grow. The COV emphasizes the importance of strengthening the core research programs in NSF/MPS, and discourages further proliferation of directed initiatives.

The COV recognizes that the AST community has had some success in a few of the directed initiatives such as the Information Technology Research (ITR) and Major Research Instrumentation (MRI) programs. For example, the National Virtual Observatory (NVO), initiated through an AST Small Grant for Exploratory Research (SGER) award (*Szalay, Johns Hopkins, AST-9876645*), has been funded by ITR at a \$10M level for the next five years. However, based on a sampling of the COV members, it appears that the characteristics of the various NSF-wide initiatives relevant to astronomy are not well understood by the AST community and not many astronomers are taking advantage of these opportunities to the extent that the COV believes is possible. As long as these special programs continue to exist, the AST Division's help is needed to clarify them for the astronomical community.

Similarly, the COV noted the surprisingly low number of grant proposals (20) to the RUI program, and suggests that the RUI, ROA, and ADVANCE programs need to be better publicized among colleges. The AST Division could take better advantage of the opportunities afforded by the MRPG, MCAA, and DRF/IPSE programs if there were greater awareness of these programs. We acknowledge that these opportunities are publicized at AAS meetings, and but more effort is needed.

- **The COV recommends that the AST Division should help clarify the information disseminated to the astronomical community about various NSF-wide opportunities such as MRI, RUI and other similar programs, by providing simplified descriptions of goals and requirements for these programs. The Division should also encourage additional proposals for these programs from the community.**

The COV discussed the balance of funding between the radio and optical observatories. The COV recognizes that the NSF's emphasis on radio facilities is a product of the different histories of radio and optical astronomy and the traditional availability of private or state support for optical observatories. Nonetheless, the success and high productivity of the URO program over the last 15 years in developing mm-wave technology that has culminated in the ALMA project is an excellent model to emulate for the optical/IR community. A university-centered optical/IR program could similarly be valuable in exploring technology for the large ground-based optical/IR telescopes planned for the next decades.

As previously noted, the COV is concerned that the national optical observatories continue to provide access to all astronomers, as stated in the charter of the NOAO. The COV recognizes that the emphasis on producing forefront science is the proper guiding principle in building larger telescopes at the expense of smaller ones. Nonetheless, there is some concern that privatizing the smaller telescopes, perhaps eventually including the 4-m, will restrict public access to observatories and therefore diminish opportunities for training graduate students in instrumentation and for observing by astronomers from institutions that cannot afford their own telescopes. The COV recommendation in this regard has been expressed under the NOAO program (section 5.2.a).

The ongoing travel funding to the Infrared Telescope Facility (IRTF) and to NRAO facilities prompted the implicit question of uniformity in travel support across all national observatories. The COV believes that the possibility of providing NSF funds to travel to observatories when observing

time has been awarded should be reconsidered by all national centers, particularly in such cases where the travel is not supported by other funding. A careful set of criteria should be developed to decide such support in an equitable manner.

The COV applauds the efforts of various programs within AST to seek national and international cooperation in planning and building new large telescopes. We commend the implementation of partnerships that have resulted in the Gemini and ALMA international projects, and endorse further efforts along these lines. Such joint cooperation is essential to produce the most scientifically productive and cost-effective telescopes of the future, to be usefully accessed by all astronomers.

The COV was pleased to learn of coordinated programs within AST with NASA, DOE, and AFOSR. In particular, COV endorses the recent COMRAA report and recommendations. Since NSF and NASA fund most of the major astronomical projects, we believe that the joint NASA/NSF advisory committee suggested in the COMRAA report is absolutely critical for program coordination and for development of an integrated strategy for astronomy and astrophysics. We were pleased to hear that interactions between NSF and NASA staff have been initiated, and that efforts are under way to charter a National Advisory Committee for Astronomy and Astrophysics. Enhanced communications between NASA and NSF will strengthen the overall U.S. astronomical research program. However, we also recognize that NASA and NSF are very different types of agencies. NSF responds to research driven by individual or group initiatives, while NASA supports mission-oriented research – both of which are needed in our overall national program. We caution, however, that the enhanced interactions with NASA will stress the AST Division staff if additional positions are not available.

VII. SUMMARY OF PRIMARY RECOMMENDATIONS

1. An increase in the staff of the AST Division is urgently needed in order to handle the new initiatives, as well as the large number of proposals and awards. The COV endorses the proposed idea of the ‘Senior Fellowships in Science and Public Policy’ to attract rotators to the Division, and recommends additional travel support for Division staff to interact with the community.
2. The AST Division should develop an implementation plan with funding requirements to the end of the decade to support the various initiatives that have been identified and prioritized by the community in the NRC Decadal Survey. The Division needs to actively engage the community on a continuing basis in the planning effort.
3. The AST Division should explore new ways to enhance the AST community’s response to the ‘broader impact criterion’ in the review process by emphasizing its importance, clarifying its meaning and usefulness, and illustrating its application. Review panels should also be encouraged to pay closer attention to this criterion and to give credit to investigators who fulfill it well.
4. The AST Division is urged to maintain a vital instrumentation program for the 4-m class telescopes to which the national community has access.
5. The AST Division should help clarify the information disseminated to the astronomical community about various NSF-wide opportunities, such as MRI, RUI and other similar programs, by providing simplified descriptions of goals and requirements for these programs. The Division should also encourage additional proposals for these programs from the community.