Report of the 2014 Committee of Visitors for the Division of Astronomical Sciences of the National Science Foundation

December 17-19, 2014

Committee Membership

Katelyn Allers, Bucknell University
Nancy Brickhouse, Harvard-Smithsonian Ctr. for Astrophysics
Mike Briley, Appalachian State University
Robert Brown, Cornell University (retired) [1]
Lynn Cominsky, Vice Chair, Sonoma State University
Kelle Cruz, City University of New York, Hunter College
Kelly Holley-Bockelmann Vanderbilt University
Mark Krumholz, University of California at Santa Cruz
Charles McGruder, Western Kentucky University
Windsor Morgan, Dickinson College
Tim Paglione City University of New York, York College
Lawrence Ramsey, Chair, The Pennsylvania State University
Lou Strolger, Space Telescope Science Institute
Hugh Van Horn, University of Rochester (retired)
William Zajc, Columbia University

[1] Deceased 20 December 2014

Table of Contents

1 Executive Summary

The Committee of Visitors met with the Director and staff of the Astronomy Division (AST) during 17-19 December, 2014. The report below summarizes our key findings and recommendations in the following areas: 1) the organization and management of AST; 2) the integrity and efficiency of the processes related to AST proposal reviews; 3) the management of a wide variety of astronomical facilities; 4) the management processes for the electromagnetic spectrum frequency allocations; 5) the management of two new Major Research Equipment and Facilities Construction (MREFC) projects; and 6) other areas that need improvement.

This Executive Summary provides an overview of our key *commendations* and **recommendations**. Additional detail and discussion is provided in the sections that follow.

1.1 Organization and Management of AST

The 2015 COV commends Division Director James Ulvestad and the entire AST staff for their outstanding efforts during the last four years since the last COV review in 2011. During this period, this outstanding team has succeeded in starting two new MREFC projects (Large Synoptic Survey Telescope [LSST] and Daniel K. Inouye Solar Telescope [DKIST]), has instituted procedures and managed mandated recompetitions for cooperative agreements for three major research facilities (National Optical Astronomy Observatory [NOAO], National Radio Astronomy Observatory [NRAO] and Gemini), has responded to a series of recommendations for portfolio rebalance by instituting the Mid-Scale Innovation Program (MSIP), and has handled a 25% increase in research grant proposal pressure in a fair and broadly inclusive manner.

We find that AST has addressed the recommendations of the 2011 COV to the extent that its human and financial resources have allowed. That said, the staffing level remains the same as at the time of the 2011 COV, which recommended "a thorough review of the staffing level needed to adequately support its base program while playing a leadership role in the complex, international development of the next generation of world-class observatories." In a partial response, AST management has converted two rotator Program Officer (PO) positions to permanent PO positions. In addition, the COV appreciates the effort this past year to mentor a new NSO/DKIST PO and urges that resources be made available to institute similar processes for other POs. The COV is pleased that these modest staffing adjustments have allowed AST to continue to serve the community in an exemplary fashion (thus far). However, expected continually increasing proposal pressure, the loss of key expertise in optical instrumentation and facility oversight, and the ongoing facility restructuring of the AST portfolio will place unsustainable demands on both budget and staff in the future. Proactive management of future staff turnover is critical to avoid interruptions in the oversight of AST facilities and programs. We therefore underscore the urgency of the increased staffing recommendations from the 2011 (and 2008) COV reports:

> **Recommendation 1: Rapidly recruiting additional AST POs and replacements for key AST staff must be a high priority for NSF.**

The COV highly commends AST staff for their hard work in endeavoring to meet the needs of the US astronomical community, as expressed in the 2010 Decadal Survey New Worlds, New Horizons

(NWNH), the 2011 Committee of Visitors report (2011 COV), and the 2011 Portfolio Review (2011 PR). AST has used these reports to guide their most important strategic endeavors in this period. The 2011 PR was conducted with transparency and clarity. The resulting prioritization and divestment decisions were clearly and appropriately communicated to both agency and external stakeholders in the astronomical community. AST is making the hard decisions necessary to divest lower-priority projects and facilities—which are nevertheless passionately defended by their user communities—in order to support projects and facilities with higher-priority recommendations. Decommissioning facilities is likely to be very costly in some cases, far exceeding the capability of AST to fund without devastating the Divisional program balance. While some of these facilities may be taken over by other institutions or consortia, some may be approaching the end of their useful lives in the context of science return *vs.* cost to operate. Thus the implications of de-commissioning must be fully understood. There does not seem to be a Foundation-level strategy at NSF for this inevitable and unprecedented situation.

> **Recommendation 2: We recommend that MPS work with NSF high-level management, the National Science Board (NSB), and—if appropriate—the Office of Management and Budget (OMB) to identify funding mechanisms for de-commissioning facilities. This is not an over-the-horizon issue, as funding for decommissioning may be needed prior to the next COV.**

We understand that NSF is proud of its long record of laudably low operating costs, but increases in the government programmatic and regulatory requirements has a significant impact, especially when resources have not increased. AST is very experienced in facility management; however MREFCs, cooperative agreement recompetitions and facility divestments have large and contractual project-management aspects. It was not clear to the COV if existing NSF structures such as the Large Facility Office have the potential to help alleviate some of these contractually-oriented workload concerns.

> **Recommendation 3: We strongly encourage MPS to work with NSF management to enhance the Large Facility Office by recruiting and retaining a cadre of skilled professionals with expertise as scientific project managers so that they can be available to work with POs in times of increased contractually-based workload, such as MREFC starts, recompetitions, and facility divestments.**

1.2 Research Grants Programs and Proposal Review Processes

The COV appreciates the support and responsiveness of the AST management and staff during the entire review process. We were pleased to have the opportunity to review the proposal eJackets for individual investigator programs (IIPs) before the committee's face-to-face meeting, as was suggested by the 2011 COV. *We commend AST for providing the eJacket review materials as well as important facilities documents in a timely, organized and internet-accessible format. The COV commends the Division for this very effective use of technology to streamline the review process and to provide the Committee with a clear and detailed picture of AST's functioning during the review period*. The COV was able to conduct an in-depth review of a representative fraction (247) of approximately 3900 submitted IIPs. The project documents allowed the COV to review management processes for the three existing major research facility cooperative agreements that are being recompeted, and for the two new MREFCs that are in progress.

Overall, the COV members thought that the review process for the Astronomy and Astrophysics Research Grants (AAG) programs was working well. Review panels were well-chosen in terms of balance of expertise and institution type, and the POs' recommendations and summaries generally provided faithful reflections of the panel recommendations. *The committee commends the Division for its handling of its review panels during this period of increasing proposal pressure.*

AST is justifiably proud of continuing to meet the NSF goal of processing 70% of received proposals within six months. *The COV commends AST for its efforts to fund as many awards as possible, especially given the appallingly small fraction of proposals (currently about 16%) for which the Division is able to provide support.* This historically-low and decreasing acceptance rate of grants within the IIPs is a major concern. We recognize that AST will need to implement several significant changes to IIP peer review and award administration, both to maintain the integrity of the merit review process and to ensure a fair balance of the science and broader impacts in the portfolio. The committee encourages continued efforts to find efficiencies in the review process while maintaining these high standards.

> **Recommendation 4: We recommend that AST be given broad latitude to test and implement changes in IIP review and award administration processes, and to do so as quickly as feasible.**

An increasing fraction of IIP proposals involve significant computational astrophysics elements. Evaluating the feasibility and technical merits of these proposals requires specialized knowledge, and constructing review panels to ensure that such knowledge is present is becoming increasingly difficult. Some COV members raised a concern about a few cases where it was felt that the assembled panels lacked the requisite knowledge to assess the technical feasibility of some of the proposed computational projects. However, for the most part, AST is doing a very good job in meeting this challenge, and has demonstrated flexibility in response to shifts in community interests.

> **Recommendation 5: We recommend that AST pay particular attention to ensuring that sufficient computational astrophysics and/or astroinformatics expertise is present on all future review panels, or that it is provided *via* outside *ad hoc* reviews.**

This COV period covered the rollout of the AST Mid-Scale Innovations Program (MSIP) initiative suggested by NWNH. The first solicitation in alternating-year opportunities was in mid-2013, and the first awards under the program were issued just before this committee met. Despite a high over-subscription rate (commensurate with the corresponding AAG rate), the results of this first round appear to be encouraging. AST established a two-stage proposal process, utilizing a strict prioritization protocol. The three fully-funded projects clearly emphasized student training and were aligned with 2011 PR recommendations. In addition, seed funding was provided for three additional projects. As this is early in the MSIP implementation phase, we encourage NSF to experiment with the process in order to ensure appropriate balance in the future MSIP portfolio.

> **Recommendation 6: We recommend that solicitations for MSIP proposals alternate between solicitation cycles either by proposal category or by requested funding level.**

Some COV members expressed concerns that NSF operations funding for smaller radio facilities such as the Combined Array for Research in Millimeter-wave Astronomy (CARMA) and the Caltech Submillimeter Observatory *(*CSO) is being phased out and that these mostly open-access facilities are finding it necessary to obtain funding from other sources to maintain operations. This

is not unlike the situation for small optical observatories years ago, which triggered similar concerns as to the potential loss of student training and community access. The COV highlights this as a potential future problem, particularly in the context of the *Principles of Access*[2] as recommended by the2014 Astronomy and Astrophysics Advisory Committee (AAAC). US astronomers would like NSF involvement to ensure more reciprocity from international partners for access to their facilities, while we continue to maintain global access to ours.

The COV looked closely at AST's efforts to broaden participation. The Division Director (DD/AST) has been very proactive in involving early-career scientists on panels and critical committees, including this COV. *The COV commends AST for the breadth and depth of their efforts to increase participation by a diverse population of current and future scientists*. AST goes to great efforts to ensure diverse representation with respect to gender, institutional type, and years since Ph.D. in review panels (and of course scientific specialty). Important AST programs such as Partnerships in Astronomy and Astrophysics Research and Education (PAARE) and bridge programs go to even greater lengths to ensure the diversity of the future work force. Broadening community awareness of NSF processes and procedures is a significant benefit for the future.

The information that Principal Investigators (PIs) receive in proposal reviews is being increasingly used for tenure and promotion considerations affecting junior faculty. As AAG success rates continue to plunge below 15%, panel summaries may have a wider audience than anticipated by the reviewers or the POs. We suggest that POs be made aware of this trend in order to encourage reviewers to write panel summaries that provide useful information about competitive (yet unfunded) proposals. As low success rates are becoming more pervasive in all science disciplines, a broader agency-wide approach to this matter should be considered.

1.3 Facilities Management

We have already addressed the impact of the management of large facilities on AST staffing. These facilities also consume the majority (~60%) of the AST budget. Oversight of these facilities is mission-critical for AST, as much of the research funded by the IIPs depends upon access to the facilities funded by NSF. The COV feels that *AST is doing an excellent job in working with the management organizations to assure that all facilities are serving their communities effectively*. We note that this has been a particularly challenging task in the context of implementing the 2011 PR within an essentially flat budget.

Additional challenges to AST facilities oversight include the effects of the three simultaneous recompetitions mandated by the NSB for NOAO, NRAO and Gemini; and the impact of two ongoing MREFC projects. The COV finds that the simultaneity and short-duration cooperative agreements envisioned by the recompetition mandate are likely to damage the science mission of NSF. While the COV understands the power of competition, we feel that current management teams for these facilities are being diverted for a year or more from focusing on ensuring that their facility best serves their science community. In addition, the uncertainty about future management creates an environment in which some of the best staff may be lost.

[2] http://www.nsf.gov/mps/ast/aaac/aaac_2014_principles_for_access.pdf

Recommendation 7: We strongly recommend that the circumstances and period of any future re-competitions be strongly guided by a comprehensive cost-benefit analysis with delivered science being the main criterion.

AST is now overseeing two MREFC projects: DKIST and LSST. AST management of the National Solar Observatory (NSO) and DKIST is in transition, as retiring DKIST PO Craig Foltz hands off to new PO David Boboltz. *The COV was especially impressed in the deliberate planning and mentoring that went into this transition and commends Dr. Foltz and AST management for enabling this process.*

The COV is also very impressed that AST was able to undertake a new MREFC project for LSST in 2014. This took extraordinary effort in working with the LSST project, AURA, DOE, the NSB, and several internal NSF offices. *The Division Director and the LSST facility Program Officer, Nigel Sharp, are to be especially commended for their considerable strategic planning* that allowed them to circumvent the roadblock of the 2013 government shutdown that threatened to delay the project start by at least a year.

1.4 Other Issues

The essentially flat AST budgets will continue to present a challenge to AST and its stakeholders. The prioritizations and divestments identified in the 2011 PR will help to allow investment in new facilities such as LSST. *We also commend AST for pursuing promising approaches to leveraging AST facilities with partnerships such as the WIYN telescope with NASA and the 4-m Mayall telescope on Kitt Peak with DOE for the Dark Energy Spectroscopic Instrument (DESI).*

Building a Solar Community. Under construction now, DKIST is an exciting new facility that will enable huge strides in solar physics. The NSF decision to operate DKIST within the AST Division is a testament to the vast experience in facilities operations within the Division. Currently, however, individual investigator grants for solar research comprise a small fraction of AST awards, out of proportion to the Division's investments in NSO and DKIST. This is because solar proposals to the NSF are split between space weather proposals, which go to the AGS Division, and a relatively small number of solar physics proposals, which go to AST. (Research by the solar physics community is also supported by a large number of primarily space-mission-oriented proposals funded through NASA's Heliophysics Division.)

With an eye toward building a strong user community for DKIST, NSO is in the process of relocating to Boulder to take advantage of efforts at the University of Colorado, the High Altitude Observatory (HAO), and the National Oceanic and Atmospheric Administration (NOAA). This consolidation may encourage workshops and other training opportunities that are essential to develop junior researchers in this area. Broader participation in instrument development by the solar and stellar community may also be important to the future growth of this community.

Recommendation 8: We recommend that AST continue to work with AGS, NASA's Heliophysics Division, and the solar research scientists to build a cohesive community that will become the future users for DKIST.

Improving NSF's Computational Astrophysics Programs. The COV notes with concern that access to NSF computational facilities is failing to keep pace with demand, and that the proposal process for access to available time has become extremely cumbersome. NSF's computational resources are currently provided primarily through the Extreme Science and Engineering Discovery

Environment (XSEDE) partnership, overseen by the Advanced CyberInfrastructure (ACI) Division, within the Directorate for Computer and Information Science and Engineering. While a review of this Division is not within the COV's purview, the increasing dependence of US astronomy on NSF-provided computational resources makes it impossible to assess the performance of the AST Division—and its relationship to the larger US astronomy community—without considering these issues.

The current proposal process creates a significant administrative burden on both the NSF and on PIs. At present, requests for computer time require full 10-page proposals in the standard NSF format, covering both the science goals and the computational methods, and these must be submitted annually. This means that a standard 3-year AAG award for a computational project that requires NSF computing resources would require, over the lifetime of the proposal, four full-size NSF proposals. In addition, the high oversubscription rate for NSF XSEDE resources leads to fractional-time (typically 1/3) awards which make it difficult to accomplish research goals.

> **Recommendation 9: The COV recommends that AST personnel continue to try to improve the interface with XSEDE with the goal of reducing the proposal burden. One way to do this would be to allow simultaneous proposals for funding and computer time.**

In sections 2 through 10 below there are some minor suggestions that AST might consider and these are in ***bold italicized text***.

2 Committee of Visitors (COV) Review Process

The 2014 COV review process began with the formation of the committee starting after the chair was appointed and charged in late September. The committee was completed in November and an introductory webinar was held on 21 Nov 2014. The key webinar elements were presentation of Confidentiality and Conflict of Interest issues relevant to the COV mission and its members and the types of documentation to be available for COV review, including information that goes beyond what the PIs and public can see. The webinar also included a tutorial on access to the eJacket website where the proposal materials were compiled and to the SharePoint website where documents related to the facilities and other information were deposited. On 1 December, COV members were notified of the preliminary agenda for the 17-19 December review, and each member was assigned a group of Individual Investigator Program (IIP) proposal eJackets to review. On 8 December, information about the AST facilities was posted on the SharePoint website. At this time, the committee was able to review most of the large volume of materials in advance of the face-to-face meeting. This was the first COV to have the opportunity to do this part of the review before the meeting, and it contributed greatly to efficient use of the time we had in Arlington. *Access to the eJackets before the in-person meeting was an issue raised by the 2011 COV, and AST should be commended for implementing it for this meeting.*

The COV meeting was held at NSF in Arlington during 17-19 December 2014. The morning of the first day was devoted to presentations by staff from the Mathematical and Physical Sciences (MPS) Directorate and from the Division of Astronomical Sciences (AST) on the review procedures. During the brief organizational-matters session conducted by the COV chair, Lynn Cominsky agreed to serve as COV vice chair to conduct the meeting when the chair was conflicted. That was followed by an overview presentation by the Deputy Division Director (DDD/AST), Paticia Knezek, on the AST division. Division Director (DD/AST) Jim Ulvestad then gave an extensive update on Division activities since the 2011 COV, focusing on AST's response to *New Worlds, New Horizons in Astronomy & Astrophysics* (NWNH) and to the 2011 Portfolio Review (2011 PR). After lunch, Dan Evans presented an extensive overview of AST's Individual Investigator Programs (IIPs), which detailed issues such as budgets for 2014, the steady increase in proposal workload from 1990 through 2015, the annual proposal lifecycle, and reviewer recruitment issues. Evans also presented extensive charts illustrating the demographics of proposal submissions, awards and reviewers. The proposal review process was described in detail, including the role of the Program Officer (PO). Decline and award statistics, as well as statistics on the participation of women and minorities, were also presented. The AST proposal success rate has declined from between 25 to 30% during 2000 to 2009 to between 15-20% so far this decade, and it will likely continue to decrease to around 10% if flat budgets continue. This has already led to an increase in multiple submissions per Principal Investigator (PI), which further increases the proposal pressure. Following Evans' presentation, Joan Schmelz provided an overview of AST's efforts to broaden participation.

The afternoon of 17 December was spent in breakout sessions with POs for the IIPs. The first session reviewed the Astronomy & Astrophysics Grants (AAG) Program. COV members were divided among the following panels based on their eJacket assignments. The PO who attended each session to address concerns is indicated below in parentheses.

- EXC: Extragalactic Astronomy and Cosmology (Richard Barvanis)
- SSA: Stellar Astronomy and Astrophysics (James Neff)

- GAL: Galactic Astronomy (Glen Langston)
- PLA: Planetary Astronomy (Maria Womack)

This was followed by a second session to review other, non-AAG, IIPs. Again the COV members were distributed according to prior eJacket review assignments, with POs present.

- Education & Special Programs (Dan Evans)
- Astronomy & Astrophysics Postdoctoral Fellowships (Joan Schmelz)
- NSF-wide programs, special projects (Nigel Sharp)
- Instrumentation Programs (Gary Schmidt)

The opportunity to review eJackets electronically prior to these sessions allowed more informed interchanges between COV members and the POs. As noted above, this was a substantial benefit compared to the process used by 2011 COV, which recommended the change.

The day ended with a COV executive session where the COV formulated a list of questions and requests for follow-up information to AST. Writing assignments were also made for short summaries of the eJacket review breakout sessions.

The second day, 18 December, was largely devoted to presentations and discussions on Mid-Scale Projects, infrastructure such as Electromagnetic Spectrum Management (ESM), and the oversight of the very extensive AST facilities as well as ongoing Major Research Equipment and Facilities Construction (MREFC) projects in AST, including the Atacama Large Millimeter Array (ALMA, now transitioning to operations), the Daniel K. Inouye Solar Telescope (DKIST) and the Large Synoptic Survey Telescope (LSST).

The day ended with a discussion with the DD/AST and DDD/AST about emerging concerns. This was followed by an executive session to discuss issues and develop a report outline.

On the third day, 19 December, Dan Evans responded to a COV request with an update on the participation rates of various types of institutions (Ph.D.-granting, primarily undergraduate, *etc*.) as well as statistics on the participation and success of women and minorities. The committee spent the rest of the morning and early afternoon developing report items and focused on writing up recommendations as well as commendations to be presented at a meeting with MPS Assistant Director F. Fleming Crim. After the meeting with Dr. Crim, the committee discussed additional writing assignments and established a tentative schedule to draft and complete the report. The committee adjourned shortly after 3PM as planned.

This report was begun after the holiday break, with the first draft completed in the third week of January and the Final draft submitted was submitted on March 2, 2015.

3 AST Responses to Previous Recommendations

The COV commends AST for being able to respond to the conflicting recommendations of the 2010 Decadal Survey, New Worlds, New Horizons (NWNH), the 2011 Committee of Visitors report (2011 COV), and the 2011 Portfolio Review (2011 PR). These reports were written in times of very different budgeting assumptions, and they have presented considerable challenges to AST management. In the sections below, we review some of the key recommendations from each report, and present our findings with respect to the feasibility of their recommendations.

3.1 AST Responses to the 2011 COV Recommendations

This 2014 COV feels that AST has been responsive to the 2011 COV's nine recommendations as summarized in their report[3]. Below we repeat those recommendations and our assessment of the AST response.

Recommendation-1: NSF should thoroughly review the staffing requirements of AST to determine the level required for AST to adequately support its base program while playing a leadership role in the complex, international development of the next generation of world-class observatories.

The 2014 COV feels AST that has responded to the extent that their resources have allowed, given that the number of staff remains the same. See Section 4.1 below.

Recommendation-2: AST should conduct a thorough review of present and planned programs and activities across the division (a portfolio review) in order to establish a realistic fiscal baseline to accompany the community's scientific aspirations as enumerated in the Astro2010 decadal survey. MPS/AST management should seek community consultation prior to defining the makeup and charge of its portfolio review team.

The 2014 COV commends the conduct of the AST Portfolio Review (2011 PR) conducted expeditiously within one year, starting in September 2011. This was a complex process, with numerous conflicts of interest posing constraints on participation. Overall, however, it was as transparent as could be expected, and the committee met its difficult prioritization charge. The priority recommendations from 2011 PR have allowed AST to begin the series of painful divestments necessary to allow new programs and projects to be funded.

Recommendation-3: As it prepares for a portfolio review, AST should consider establishing a set of metrics to measure success – that is, to measure the relative return on investment – of various segments of its portfolio, such as the individual investigator program and major facilities.

AST feels that it is impossible to have uniform metrics across its portfolio, which range from individual AAGs at the $100K level to national and international observatories, funded at levels one hundred times greater. The overarching principle governing the AST portfolio balance has been, and will continue to be, the decadal surveys. The 2014 COV accepts this approach.

Recommendation-4: The Foundation should aggressively explore the innovative use of new technologies to facilitate effective and timely communication with the research community.

AST has interpreted this recommendation as one that applies to NSF as a whole, and not just to AST. Given the scarcity of staff resources, this COV understands that AST remains reliant on NSF's and the American Astronomical Society's resources to aid in its communication.

Recommendation-5: AST should consider options to significantly expand the pool of potential panelists, such as: (a) establishing the expectation that past recipients of grants should participate in the review process; (b) communicating the benefits of participation to new investigators or those who have been previously unsuccessful; (c) gathering data on the

[3] http://www.nsf.gov/mps/advisory/cov.jsp&#8203

pool of potential panelists earlier than the present practice; and (d) assembling review panels earlier and, perhaps, using a staggered distribution approach.

The 2014 COV remains concerned with the effort required by POs to assemble panels, and in discussion it was clear that AST has tried several of the suggestions in this recommendation. We commend AST for its expanded used of virtual participants in traditional panels as well as totally virtual panels, which have the advantage of broadening the potential participants to include those who have travel constraints. The DD/AST has been very proactive in involving early-career scientists on panels.

Recommendation-6: **ATST's ultimate "programmatic home" within NSF should be decided before AST conducts its portfolio review because the portfolio review team will need to know whether or not ATST's operations cost will be borne by the AST division.**

This issue has been firmly decided with ATST (Advanced Technology Solar Telescope, now known as DKIST) remaining within MPS/AST. The COV agrees that AST's strong experience in overseeing telescope construction projects strongly supports making AST the right place for DKIST. See additional discussion in Section 8.1.

Recommendation-7: **A decision regarding whether or not to invest in D&D costs for the Giant Segmented Mirror Telescope (GSMT) should await the results of the portfolio review.**

AST noted that the 2011 PR only recommended GSMT construction support in a budget scenario above that existing at present. AST also responded to a Congressional directive to conduct a competition for a GSMT planning award, which was made to the Thirty Meter Telescope project. This COV agrees that AST has done what it can on this recommendation and is following the 2011 PR guidance by not investing in Design and Development and making no commitment to construction or operations contributions.

Recommendation-8: **AST and, more broadly, MPS must develop a realistic plan for decommissioning instruments and phasing out the M&O costs of its current and planned facilities. In particular, AST/MPS should establish and implement finite lifetimes for major research facilities built with NSF funds.**

The 2014 COV feels that AST is doing what it can on this recommendation at this time. AST and NSF are looking at an environmental review for several of the facilities recommended for divestment by the 2011 PR. We strongly agree that any decommissioning costs are likely to be far beyond the ability of the AST budget to handle without dire consequences for other portions of the portfolio. As we address in more detail in Section 4.2 below, this is an ongoing and serious issue.

Recommendation-9: **Given the importance of ESM to the NSF and the growing external pressures that are being placed by international commerce on ESM, a decision needs to be made regarding the proper home for the ESM program. The home for ESM must be chosen to ensure that ESM retains a sufficiently high profile to protect scientifically significant parts of the electromagnetic spectrum for research purposes.**

This recommendation has been addressed with the ESM (Electromagnetic Spectrum Management) group remaining within AST while maintaining close contact with the growing remote sensing and nanosatellite communities in the Geosciences Directorate (GEO). In the time since the last COV, the ESM staff has suffered from major personnel turnover, and we commend the Division for recruiting capable early-career scientists as POs for this important program.

3.2 2010 Decadal Survey, *New Worlds, New Horizons* (NWNH)

AST has clearly made NWNH[4] the foundation of its strategic vision since the 2011 COV. At the time of that COV, it was already clear that the NWNH goals were out of line with budget reality, and this was a major reason for the recommendation to conduct the 2011 PR. That said, AST has done an outstanding job of getting ready and enabling the new MREFC start for the top NWNH ground-based initiative, the LSST. They have also issued funding resulting from an initial solicitation for MSIP. A funding profile well below that assumed in NWNH has prevented AST from fully implementing recommendations on the Giant Segmented Mirror Telescope (GSMT), Atmospheric Cerenkov Telescope Array (ACTA) and Cerro Chajnantor Atacama Telescope (CCAT). Both ACTA and CCAT have competed for funding from the new Mid-Scale Innovations Program (MSIP). While this COV is not charged with reviewing these and other decisions related to NWNH, it is apparent that the decadal survey is being used by AST as a very important guide in the strategic thinking and prioritization of AST's efforts. As such, the COV feels that AST is doing its best procedurally to comply with the prioritizations and recommendations of NWNH.

3.3 2011 Portfolio Review (2011 PR)

The 2011 PR was carried out in response to the 2011 COV. It was also effectively the Senior Review recommended in NWNH. The full report[5] and the committee charge[6] are both publicly available. The mismatch between budget reality and the expectations of NWNH clearly necessitated the further prioritization of resource expenditures in the AST portfolio that were put forward by the 2011 PR report. The COV feels that this difficult process was well executed. We are not charged with commenting on the specific recommendations, but the balance between unhappiness and relief points to a process that was perceived as evenhanded overall. The committee selection was done transparently, resulting in a committee with diversity along several demographic and expertise axes. The DD/AST communicated the purpose of the 2011 PR to the astronomy community in an open and direct way, including regular "Town Hall" presentations at meetings of the American Astronomical Society (AAS) and through electronic communications. The difficult prioritizations and divestment decisions were communicated internally to agency stakeholders before public roll out and individually to external stakeholders quickly after public rollout.

[4] http://www.nap.edu/catalog/12951/new-worlds-new-horizons-in-astronomy-and-astrophysics
[5] http://www.nsf.gov/mps/ast/portfolioreview/reports/ast_portfolio_review_report.pdf
[6] http://www.nsf.gov/mps/ast/portfolioreview/portfolio_review_charge.pdf

4 Organization and Management of AST

Deputy Division Director Patricia Knezek presented the overall structure of AST and placed it in the context of the rest of MPS. As well as presenting the programs within AST, and describing the AST budget allocations, she also discussed the long list of committees that provide strategic and implementation advice to AST. She described the AST personnel organization and staff changes since the 2011 COV. She also detailed the current responsibilities for each PO within the AST organization.

The 2015 COV commends Division Director James Ulvestad, Deputy Director Knezek and the entire AST staff for their outstanding efforts during the last four years since the previous COV review in 2011. During this period, this outstanding team has succeeded in starting two new MREFC projects (the Large Synoptic Survey Telescope [LSST] and the Daniel K. Inouye Solar Telescope [DKIST]); has instituted procedures and managed mandated recompetitions for cooperative agreements for three major research facilities (the National Optical Astronomy Observatory [NOAO], National Radio Astronomy Observatory [NRAO] and Gemini); has responded to a series of recommendations for portfolio rebalance by instituting the Mid-Scale Innovations Program (MSIP); and has handled a 25% increase in research grant proposal pressure in a fair and broadly inclusive manner.

4.1 Staffing

We find that AST has addressed the recommendations of the 2011 COV to the extent that its human and financial resources have allowed. That said, the staffing level remains at the same inadequate level as at the time of the 2011 COV, which recommended "a thorough review of the staffing level needed to adequately support its base program while playing a leadership role in the complex, international development of the next generation of world-class observatories."

Since the 2011 COV, there have been two retirements from the permanent staff and one departure. These positions have now all been refilled. AST management has also converted two rotator PO positions to permanent positions. Currently there are also four POs serving as Inter-government Personnel Act staff (IPAs or rotators) and one Visiting Scientist, Engineer and Educator (VSEE) position. We congratulate the Division for recruiting new DDD Pat Knezek in 2013. Craig Foltz, who manages the DKIST project, plans to retire in early 2015. Dr. Foltz has been working closely with Dr. David Boboltz, National Solar Observatory (NSO) PO, to mentor him effectively to take over as PO/DKIST. *AST is to be commended on the planning and mentoring that went into this PO transition*, which is clearly happening at an unusually critical time in the history of the National Solar Observatory (NSO).

The COV is pleased that these modest staffing adjustments have allowed AST to continue to serve the community in an exemplary fashion (thus far). However, expected continually increasing proposal pressure, the loss of key expertise in optical instrumentation and facility oversight, and the ongoing facility restructuring of the AST portfolio will place unsustainable demands on both budget and staff in the future. Proactive management of future staff turnover is critical to avoid interruptions in the oversight of AST facilities and programs. We therefore underscore the urgency of the increased staffing recommendations from the 2011 (and 2008) COV reports:

Recommendation 1: Rapidly recruiting additional AST POs and replacements for key AST staff must be a high priority for NSF.

4.2 Planning and Implementation

The COV highly commends AST staff for their hard work in endeavoring to meet the needs of the US astronomical community, as expressed in the 2010 Decadal Survey, New Worlds, New Horizons (NWNH); the 2011 Committee of Visitors report (2011 COV); and the 2011 Portfolio Review (2011 PR). AST has used these reports to guide their most important strategic endeavors during this period. The 2011 PR was conducted with transparency and clarity. The resulting prioritization and divestment decisions were clearly and appropriately communicated to both agency and external stakeholders in the astronomical community. AST is making the hard decisions necessary to divest lower-priority projects and facilities—which are nevertheless passionately defended by their user communities—in order to support projects and facilities with higher-priority recommendations. Decommissioning facilities is likely to be very costly in some cases, far exceeding the capability of AST to fund without devastating the Divisional program balance. While some of these facilities may be taken over by other institutions or consortia, some may be approaching the ends of their useful lives, in the context of science return *vs.* cost to operate. Thus the implications of decommissioning must be fully understood. There does not seem to be a Foundation-level strategy at NSF for this inevitable and unprecedented situation.

Recommendation 2: We recommend that MPS work with NSF high-level management, the National Science Board (NSB), and—if appropriate—the Office of Management and Budget (OMB) to identify funding mechanisms for de-commissioning facilities. This is not an over-the-horizon issue, as funding for decommissioning may be needed prior to the next COV.

We understand that NSF is proud of its long record of laudably low operating costs, but increases in the government programmatic and regulatory requirements has a significant impact, especially when resources have not increased. AST is very experienced in facility management; however MREFCs, cooperative agreement recompetitions and facility divestments have large and contractual project-management aspects. It was not clear to the COV whether existing NSF structures, such as the Large Facility Office, have the potential to help alleviate some of these contractually-oriented workload concerns.

Recommendation 3: We strongly encourage MPS to work with NSF management to enhance the Large Facility Office by recruiting and retaining a cadre of skilled professionals with expertise as scientific project managers so that they can be available to work with POs in times of increased contractually-based workload, such as MREFC starts, recompetitions, and facility divestments.

5 Research Grants Programs & Proposal Review Processes

During the four-year period covered by this COV report (FY 2011 through FY 2014) AST received and processed 3911 proposals, meeting the NSF-wide goal of completing 70% of all proposal activities within six months. In FY 2014, AST's budget was approximately $239 million. About

40% of this amount was used to support IIPs, with about half (~$40M) of the IIP funding allocated to Astronomy and Astrophysics Research Grants (AAGs).

Each IIP is submitted electronically *via* the FastLane system. Each proposal, together with independent reviews and, where appropriate, summaries of panel reviews, communications between the PO and the Principal Investigator (PI), and other details of the proposal processing, are collected together in an electronic file called an eJacket. In advance of the COV meeting AST provided COV members with secure electronic access to 247 eJackets spanning the Division's entire portfolio. The actions included in this sample resulted in 81 awards, 143 declinations, 15 that were returned without review because they were not in compliance with the requirements in NSF's *Grant Proposal Guide (GPG)*, and two that were withdrawn. Committee members were thus able to study in detail the processes followed by Program Officers. During the meeting, COV members were therefore able to focus on presentations highlighting the factors with which AST had to contend during this review period and to interact with individual POs. *The COV commends the Division for this very effective use of technology to streamline the review process and provide the Committee with a clear and detailed picture of AST's functioning during the review period.*

Since the 2011 COV, proposal volume has increased more than 25%, with over 650 individuals submitting proposals as PIs. With the success rate now averaging 15.6% from 2011-2014, there appears to be a significant rise in multiple submissions by a given PI. While multiple submissions remain a bit more than 100 proposals a year, the trend is as worrying as it is natural. To help ameliorate the low success rate, AST is currently requesting that each PI submit only a single AAG proposal per year. This request is not being honored, however, and the percentage of multiple proposers is still the same as in previous years. One clear action that could be taken is to limit a PI to one submission per year to the AAG programs. In the context of the NSF mission and the culture that has developed to support it, this is not an ideal solution.

> **Recommendation 4: We recommend that AST be given broad latitude to test and implement changes in IIP review and award administration processes, and to do so as quickly as feasible.**

In this section, we report on the COV review of the various IIPs. In 2014, Dr. Daniel Evans was AST's Coordinator for all of these programs.

5.1 Astronomy and Astrophysics Research Grants (AAG)

The AAG programs consist of Extragalactic Astronomy and Cosmology (EXC), Galactic Astronomy (GAL), Stellar Astronomy and Astrophysics (SAA), and Planetary Astronomy (PLA), which now also includes research on exoplanets. AAG does *not* include Advanced Technologies and Instrumentation (ATI), Education and Special Programs (ESP), Theoretical and Computational Astrophysics Networks (TCAN), or Directorate- or Foundation-wide programs, all of which are discussed elsewhere in this report. According to Dr. Evans, the budget for the AAG programs in FY 2014 was $43 million, and there has been about a 25% increase since FY 2011 in the number of proposals AST receives annually.

Overall the COV members thought that the review process for the AAG programs was working well. The panels were well-chosen in terms of balance of expertise and institution type, and the Program Officers' recommendations and summaries generally provided faithful reflections of the panel recommendations.

A general issue, which emerged in discussions with individual POs, was the question of why notifications about some awards and declinations were received by PIs so late in the year, especially when AST's goal is to complete 70% of proposal processing within six months—and when AST takes pride in actually meeting that goal. The DD/AST, James Ulvestad, explained that AST always saves a few proposals that are right on the cusp in case money becomes available to fund them near the end of the fiscal year. All NSF Division funds must be spent out in early August, and any unspent funds are then collected at the Mathematical and Physical Sciences (MPS) Directorate level. These funds may be used by any MPS division to make final awards for the year. *The COV commends AST for its efforts to fund as many awards as possible, especially given the appallingly small fraction of proposals (currently about 16%) for which the Division is able to provide support.*

The COV also asked whether a triage system might be useful in helping to deal with the substantial increase in proposal pressure. Is there a way to throw out the bottom tier of proposals at the beginning of the review process, like the Hubble Space Telescope (HST) does? COV members spent some time discussing the merits of the HST proposal selections, which are comparably oversubscribed. We concluded that this may not be possible at NSF, however, because NSF policy requires three independent reviews, two from individual panelists, with the Panel Summary counting as the third. Non-competitive proposals must undergo this same level of review.

The 2014 COV also suggests that AST consider additional ways to encourage successful PIs to serve as panelists. The 2011 COV recommended something similar, but the DD/AST mentioned that NSF is not allowed to require service from its awardees. Is there a way to improve the 30—35% average acceptance rate by potential reviewers? Can they be given a choice of dates, for example? Relying on recruiting volunteers at AAS meetings is not sufficient to broaden the pool of potential reviewers, because faculty from 4-year colleges and others often cannot attend. With the keyword and facility function in the Astrophysics Data System, it should be possible to objectively build a pool of experts straight from the literature.

5.1.1 Proposal Processing

Proposals arrive each year in November. They are first sorted into the relevant disciplinary programs and then further separated into groups of about 20—25 proposals for review by panels. A typical PO has responsibility for about 150 proposals, which she/he reviews using some 6—7 panels. AST runs about 45 panels each year for IIPs. Each panel consists of 5—8 panelists and reviews some 15—28 proposals. At least two written reviews of each proposal are required in advance of the panel meeting.

To carry out proposal review, AST uses face-to-face panels, virtual panels (everyone on line remotely), and mixed panels, as well as separate *ad hoc* written reviews where necessary or appropriate. Only about one-third of the panels met entirely in person during FY 2014; the rest included some online participation or *ad hoc* review. Panel review has now almost completely replaced *ad hoc* reviews and is generally regarded as providing superior results, especially when comparing proposals covering similar topics. For each proposal, the Review Analysis Part 1 provides the context for the program, the conditions for the panel, and states which type of panel was employed. The COV asked whether the acceptance rates for the different types of panels are similar. As no answers were readily available, ***the COV recommends that AST compile statistics and track acceptance rates of proposals in traditional, virtual and mixed panels for the next COV***.

Program Officers feel that virtual panel review actually works better than one might think. In fact, some people will only participate remotely. Conversely, others—especially those in early stages of their careers, who may not have private offices — will only participate in person. About 30—35% of people asked to serve as reviewers actually agree to serve.

There are occasionally very different interpretations of a particular proposal by members of a review panel, but these are generally settled during the panel discussions. When this does not happen, the PO has the authority to override the panel recommendation, and the COV saw occasional cases in which this was done. There are usually perceptible gaps between the proposals ranked as Highly Competitive and those ranked Competitive, as well as between Competitive and Non-Competitive proposals.

A small fraction of proposals were returned without review (about 15 of the roughly 800 proposals received by AST during FY 2014, and 15 of the 247 seen by this COV) during the three-year review period. While there are many criteria that can lead to this outcome, the most common are: (1) the lack of a description of the outcome of prior support and (2) proposals that are clearly not appropriate for the program. In FY 2011, Program Officers did their own compliance checking to ensure that each proposal meets the guidelines in the *GPG*. This has changed as part of the effort to streamline proposal processing, and support staff are now doing this, rather than program staff.

5.1.2 Broader Impacts

In FY 2014, NSF changed the definition of "Broader Impacts" (BIs). Under the previous definition, a PI was able to describe assistance to the astronomical community outside her/his own particular niche as a BI. The new definition disallows this, instead requiring a PI to address the impact of his/her work on society as a whole. Sometimes the reviewers did not fully understand this change. In particular, reviewers who had written up their reviews before the panel meeting were not in sync with the new rules. In addition, some reviewers did not address BIs at all. While the NSF tries hard to explain the review criteria to proposers, the changes evidently had not sunk in completely during the period covered by this review.

In addition, the COV notes that the NSF *Grant Proposal Guide (GPG)* has just been revised again, and the new *GPG* does not include examples of BIs. Many PIs apparently thought that the examples were the only types of things that could be counted as BIs, rather than just being examples. AST is still trying to solve this issue. The Division tries to do considerable outreach to the community, and they are working on a new communication plan to enable AST to communicate more effectively with the U.S. astronomical community. The AAAS Fellows at NSF have drafted a document identifying ways to communicate about BIs to the community at large, which the DD/AST thinks is a good document, but it needs to be approved before it can be released. The COV therefore was unable to review this document.

5.1.3 Broadening Participation

Statistics presented to the COV on the demographics of AAG proposals for FY2011 through 2014 indicate that AST has done a good job of broadening participation. Participation in the review process is enhanced by the increase in virtual panels since 2011 (when they were non-existent). In 2014 over 60% of the panels had some online participants; of these, ~20% were entirely virtual. Distribution maps of submitted proposals show that they originate broadly over the country and, more importantly, the distribution of submissions, awards and reviewers are similar. Proposal submission rates by women PIs climbed slightly during the review period and are now approaching 25%, with a success rate similar to that of the total population of PIs over the last decade. The

number of proposals from minority PIs remained at 4-5% level over the review period, consistent with rates from 2004. The success rates appear a bit lower than one would expect from the submitted population, but it is hard to tell due to limited statistics. ***AST should continue to follow this demographic to study the significance of this possible under-representation***. About 10% of proposals come from 4-year and Masters-granting institutions; these have the same success rates as those from Ph.D.-granting institutions. Scientists from 4-year and Masters-granting institutions comprise an even larger fraction of reviewers. Of those reviewers who self-identify (which is unfortunately a relatively small fraction of the total), about 28% are female. *The COV commends the AST Division Director for his increasing emphasis on inclusion of early-career scientists on AST review panels and oversight committees.* Broadening community awareness of NSF processes and procedures is a significant benefit for the future.

One additional question was whether or not the selected panelists represent the proportional fraction of PIs at research universities (R1 schools) as opposed to those at 4-year schools and at other types of institutions. AST provided statistics on proposals, reviewers and awards from Ph.D. and 4 Year + Masters-granting institutions which showed this was not the case. In addition, COV members also noted that several panels either were all-male or else were heavily-weighted toward research universities (R1s). The Committee wondered if this had made the panels biased against, say, undergraduate institutions. We learned that this was not the case; in fact, most panels made generous allowances for heavy teaching loads. In addition, we learned that 19 ± 2% of awards went to women PIs, essentially identical to the 19 ± 1% of proposals submitted by women. *The COV commends AST on its continuing efforts to make the peer review process as fair and even-handed as possible while simultaneously endeavoring to use scarce resources to support the highest quality of scientific research.*

5.1.4 Extragalactic Astronomy & Astronomy (EXC)

The COV reviewed eJackets for 34 EXC proposals, which resulted in 10 awards, as well as two supplement proposals, one of which was funded.

During a breakout session on 17 December 2014, COV members Allers, Cominsky, Cruz, and Morgan met with Dr. Richard Barvainis, the cognizant Program Officer for EXC (PO/EXC) to discuss this program. Part of this discussion focused on whether there may be ways to provide more constructive feedback to proposers. For example, can reviewers receive more training about ways to write more constructive reviews, especially to help those who are declined? It would be good if reviewers could provide advice to help unsuccessful PIs understand how they might have been able to improve their proposals.

One instance was discussed of an apparent inconsistency between the reasons given for declining a proposal by the PO as opposed to those given in the panel summary. The PO communicated his reasons in an email note to provide the PI with additional information.

The COV also considered whether or not it is useful for a PI to call his/her PO to learn about the status of a proposal and whether or not this makes any difference. For a proposal in a gray area, a call to the PO might perhaps provide the PI with a chance to modify budget so that it can be funded. PIs always are encouraged to call the POs, but it is up to the PIs to take the initiative. The COV felt that PIs should not have to know to call the PO to get the "inside scoop." The COV also noted that there is a significant difference in the culture at NSF *vs*. that at NASA. At NASA, having the PI call the PO makes no difference whatsoever and is not encouraged.

The COV observed that there are occasional blanks in reviews by panelists and asked why. The answer appears to be that some reviewers may have submitted their reviews to the wrong panel, and since the reviews cannot be removed, they can only be replaced by blanks. Also, reviewers sometimes grade more proposals than they review in detail. These also cannot be removed but can only be replaced with blanks. Such missing reviews are not usually due to flakiness on the part of the reviewer, however. If a review is marked as "unreleasable," this probably indicates a clerical error in the submission process rather than something inherently bad about the proposal. And if a particular reviewer does not provide reviews in a timely way, the PO nags him or her.

Panelist reviews sometimes are not consistent with NSF policy. The Panel Summary is supposed to summarize the essence of the discussion. The PO tries to improve the Panel Summary during the discussion – to expand on points, bring the panel to a consensus, add information, *etc.* The COV considered whether it might be helpful to encourage panelists to provide information in the final panel summary beyond just the strengths and weaknesses of the proposal. Some POs (including EXC) provide a template for the review, feeling that this makes for better review. But other Program Officers do not agree. ***The COV recommends that AST consider whether or not this should be a more uniform practice.***

Finally, the COV notes that EXC is a very large program, and we recommend that AST consider whether or not it may be useful to subdivide it. Possibilities that might be considered include separating it into Cosmology and Extragalactic Astronomy, or into EXC Theory/Computation and EXC Observation, or into Cosmology on its own, with galactic proposals sent to GAL or SAA, based upon the science, such as interstellar matter or stars.

5.1.5 Galactic Astronomy (GAL)

The COV reviewed eJackets for 24 GAL proposals, which resulted in 9 awards, and three proposals that were returned without review.

During a breakout session on 17 December 2014, COV members Briley, Krumholz, and Strolger met with Dr. Glen Langston, the cognizant Program Officer for GAL (PO/GAL) to discuss this program. Overall the COV members thought that the review process for GAL was working well. The panels were well-chosen in terms of balance of expertise and institution type, and the PO's recommendations and summaries generally provided a faithful reflection of the panel recommendations.

Some COV members raised a concern with two possible cases where it was felt that the assembled panels lacked the requisite knowledge to assess the technical feasibility of some of the proposed computational projects. In one of these cases, however, *ad-hoc* reviews did have the requisite expertise. As nearly half the proposal eJackets reviewed had numerical modeling or large data set analysis (aka astroinformatics) we suggest future vigilance in ensuring the selection of panel members or *ad-hoc* reviewers with the expertise to evaluate proposals with a heavy computational or astroinformatic focus.

> **Recommendation 5: We recommend that AST pay particular attention to ensuring that sufficient computational and/or astroinformatics expertise is present on all future review panels, or that it is provided *via* outside *ad hoc* reviews.**

Finally, the COV members noted that there were some technical problems with a few of the eJacket portfolios that were made available to the COV. In particular, we could not always see all the

information for each proposal. For example, COV members could not see the award/decline letters for some eJackets, which would have been helpful in assessing what was finally communicated to the proposers. In the future, it would be nice to have a concise summary for each decision to guide COV reviews, and ***the COV requests that AST consider the feasibility of this suggestion.***

5.1.7 Stellar Astronomy& Astrophysics (SAA)

The COV reviewed eJackets for 24 SAA proposals, which resulted in six awards, as well as one supplement proposal, which was declined.

During a breakout session on 17 December 2014, COV members Brickhouse, Holley-Bockelman, and Paglione met with Dr. James Neff, the cognizant Program Officer for SAA (PO/SAA) to discuss this program. The COV appreciated the panel summaries, which were mostly very thorough and helped to clarify what had happened in the panel meetings. Committee members noted several cases where the PO/SAA had disagreed with the panel rankings, and we thought there were excellent justifications for the PO recommending a different action than had been recommended by the panel. The PO also did a good job in some extreme cases where, for example, reviewers rated a proposal both Fair and Excellent. The PO managed to bring the panel to a consensus and explained clearly to the PI what had happened.

In addition, COV members noted that the success rates for PIs with prior awards was noticeably higher than the roughly 16% current average success rate for AST. This prompted the COV to wonder whether AST should consider limiting the number of awards per PI. However, we note that, since things like REU supplements count as separate awards, this probably boosts the apparent success rate for PIs with awards.

The COV noted that a few PIs have never received a single NSF award, despite having submitted NSF proposals for decades. Accordingly COV members wondered whether it might be possible for such PIs to receive a special call from the cognizant NSF PO with more detailed information. Another possibility might be to recruit such PIs to become panel reviewers, which would provide them with direct exposure to successful and unsuccessful proposals, which might help them to learn how improve their own proposals.

One other topic had to do with a proposal that was returned without review for not having addressed Broader Impacts of the proposed research. Even though the Broader Impacts were actually discussed in the proposal, this was not indicated on the front page. This problem was fixed in later years by requiring the PI to address explicitly both NSF review criteria by inserting text in a box on the Summary Form.

5.1.8 Planetary Astronomy (PLA)

The COV reviewed eJackets for 24 PLA proposals, which resulted in seven awards, as well as three proposals that were returned without review.

During a breakout session on 17 December 2014, COV members Brown, McGruder, and Van Horn met with Dr. Maria Womack, the cognizant Program Officer for PLA (PO/PLA) to discuss this program. There have been significant changes since the previous COV meeting in 2011. In particular, while PLA includes support for research on any topic within the Solar System except the Sun, the PO has also folded all of exoplanet research into PLA. In consequence, the budget for PLA has grown from about $3M in FY 2011 to about $6 M in FY 2014. Dr. Womack uses only panel review—running about 3 to 5 panels each year for PLA—unless for some reason it

proves absolutely necessary to employ *ad hoc* review. Some members do join the panel meetings remotely, although Dr. Womack would prefer to have them all together in one room for the review.

Because NASA provides the bulk of support for planetary science, a number of panelists come from NASA. Almost all panelists come from the U.S., although a few do come from Europe. Many early career astronomers are going abroad, and foreign scientists are much less likely to have conflicts of interest with the proposals than are U.S. astronomers. Even though NASA dominates support for planetary science, Dr. Womack highlighted two reasons why this sub-discipline *should* continue to be supported by NSF: (1) Otherwise NSF is missing support for an important component of astronomy and astrophysics; (2) NASA is a mission-based agency and in consequence NASA funding can potentially leave significant gaps in research coverage. ***The COV concurs with the view that PLA should continue to be supported by AST, especially given the recent dramatic increase in exoplanet research.***

Dr. Womack noted that many exoplanet proposals were returned without review in FY 2011 and FY 2012. She suspects this was caused by PIs submitting the same proposal to both NSF and NASA and not paying adequate attention to the requirements listed in the NSF *GPG.*

NSF POs are encouraged to employ prudent risk-taking in supporting proposals. Dr. Womack related a specific example in which the panel that reviewed a particular proposal ranked it as Competitive, but it was not ranked highly enough by the panel to have qualified for funding. Because she had concluded that the particular subfield needed the expertise in the area of this proposal, she nevertheless pushed to get it funded. In the past two years, Dr. Womack has also experienced good success in obtaining co-funding for PLA proposals from the MPS Office of Multidisciplinary Activities (OMA). This depends upon the OMA priorities in a given year, however. *The COV applauds these initiatives on the part of the PO/PLA.*

POs usually do not correspond with Principal Investigators (PIs) during the proposal review process. If PLA is seriously considering a highly ranked proposal for funding, however, the Program Officer contacts the PI to determine whether there have been changes in his or her support since the proposal was submitted. For this reason, Dr. Womack also talks with her NASA counterparts about twice a year to coordinate actions on proposals, seeking to ensure that the same proposal is not funded by both agencies. NSF does not usually co-fund proposals with NASA, but there is close coordination on funding actions, as there is a lot of overlap in proposals submitted to both agencies. And Dr. Womack noted that NSF and NASA are jointly supporting a new program to search for exoplanets—called "NASA-NSF Explore"—which is just about ready to be announced to the community.

Although the scientific scope of the planetary program has continued to expand over the period since the last COV—with even greater interest in exoplanets and Kuiper Belt Objects (KBOs), for example, and with a commensurate increase in proposal pressure—the PLA program remains manageable by a single Program Officer. Recruitment of a well-qualified replacement PO from the planetary research community is essential to ensure that this AST programmatic strength is maintained. ***The COV is concerned that the PLA program has had difficulty attracting Program Directors from the planetary science community.***

5.2 Advanced Technology Instrumentation (ATI)

In looking over the eJackets provided for awarded ATI proposals, the funded projects will develop technologies that are applicable across a broad range of scientific areas. Funded proposals

included: technologies for detecting exoplanets (a green laser comb); characterization of transients (a low-spectral-resolution Spectral Energy Distribution [SED] machine); and technologies that have applications across most scientific sub-fields (spherical Volume Phase Holographic [VPH] gratings). In addition, awarded ATI proposals will develop new technologies for large telescopes (*e.g.*, the Very Large Telescope [VLT]), as well as re-purposing smaller 1-3 m telescopes with new instrumentation. Overall, the COV found that the ATI program, in part, meets the goal of the AST portfolio to fund projects that are "innovative or potentially transformative."

The review process for ATI proposals is complicated by the fact that highly specialized knowledge is necessary to evaluate the technical feasibility of proposals. To facilitate a thorough review of ATI proposals, AST often requests *ad hoc* reviews of proposals in addition to panel reviews. These reviews are provided to the PI. The COV finds that the process for choosing panelists and soliciting *ad hoc* reviews is appropriate.

In reviewing the eJackets for ATI proposals, the COV had a couple of concerns. First, in reading the written reviews for proposals, some COV members were concerned that the program instructions to proposers may lack a clear description of how technological development and astronomical context will be reviewed. In particular, several written reviews would state, "in the context of the five review elements…" The COV did not find any indications that these review elements were provided to proposers. Secondly, the COV was concerned about the process involved in the review of one particular ATI proposal. The particular proposal (#1444409) was for a large supplement to an existing grant. The supplement requested a change in scope of the original grant. This proposal was approved for funding without documented input from the astronomical community. The COV recognizes that Program Officers have this latitude on supplementary funding, and the award was at the very end of the time limit to encumber funds. However, in this particular case, the COV felt that with the change in scope from the original grant as well as the dollar value of award—near a typical yearly IIP level—transparency would have been better served by noting in the Review Analysis why he felt a review could not be done.

5.3 Major Instrumentation (MRI)

The Major Research Instrumentation (MRI) program is designed to provide state-of-the-art scientific instruments that will be shared throughout a scientific/research community. Because of the potentially broad footprint of the user base, the program spans many Directorates, and the administration of these grants requires significant communication, coordination, and negotiation between POs throughout NSF. In addition, there is heterogeneity in the review process between Divisions, with some, like AST, conducting a panel supplemented by *ad hoc* reviews and others opting for panels alone; this places an additional challenge on all the NSF staff involved. Given the technical as well as science diversity in MRI proposals, it is challenging to constitute a panel with the breadth of expertise needed. *The COV appreciates AST's procedure of having additional ad-hoc reviews as needed to maintain an effective and high quality review process.* AST's MRI award rate of 19% compares to the NSF-wide MRI success rate of roughly 25%. While comparatively higher than AAG programs, the awarded proposals represent an appropriate balance between institution type, geographical location, and instrument type (*e.g.*, gamma-ray detector to supercomputer).

5.4 Education and Special Programs (ESP)

NSF's ESP category includes several different programs, and the participation by AST varies for each. In this report we focus on those for which the COV reviewed eJackets.

5.4.1 CAREER

The CAREER program is a key way in which the NSF promotes early-career tenure-track scientists by providing high-profile awards to kick-start innovative scientific initiatives with a broad impact. The COV found that the peer review process for this type of award was exceptionally well-done; the POs continue to do an excellent job in selecting and training the review panels so that close attention is paid to both the intellectual merit and the broader impacts of each proposal. As a result, the award quality continues to be high, and the awards made during this period were balanced in terms of project area, geographical location, and gender.

5.4.2 Astronomy and Astrophysics Postdoctoral Fellowship (AAPF)

Compared to the AAG programs, the Astronomy and Astrophysics Postdoctoral Fellowship (AAPF) program has very little difficulty recruiting panelists and getting quality feedback to proposers. Panelists, many AAPF alumni, appear to take their job very seriously and indicate a sense of obligation to mentor junior scientists *via* the panel comments. The vast majority of the jackets reviewed provided helpful and substantive comments.

There are several things about this program that contribute to the high panelist acceptance rate:

- The *espirit d'corps* of the alumni pool is high[7], and they are likely to respond favorably to a program by which they feel personally enriched.
- Since only graduate students and postdocs can apply, the likelihood of panelist conflicts of interest is quite low.
- The panel date is predictable, and the panelists can be recruited many months in advance, before their January schedules get too filled.

A major recommendation from our analysis and discussion with Joan Schmelz (the current PO who is a rotator) is that the PO for this program should be a full-time NSF employee and not a rotator. This program is very PO-intensive, due to the award being given directly to the investigator (and not to an institution) and to the junior standing of the awardees, many of whom are managing their own grant money for the first time. Some minor suggestions to improve the management and effectiveness of this program would be:

- Provide an "instruction" manual for the PO
- Build in grants management training into the program, possibly *via* the annual Fellows symposium
- Rekindle alumni network co-mentoring resources *via* the listserve.

5.4.3. Research Experiences for Undergraduates (REU)

The Research Experiences for Undergraduates (REU) program has evolved to be a relied-upon stepping stone for students planning to enter graduate school. A number of long-term sites have had great success, although the renewal process has become much more competitive lately. REU Supplements to existing awards are much less competitive than proposals to establish or maintain

[7] The AAPF Alumni run their own unofficial website http://aapf-fellows.org/

REU sites; supplements have an 80% success rate, while REU sites have a 30% success rate. Due to a decreasing funding rate, fewer REU sites are renewed than in the past; for example in FY14, only approximately 50% of the REU renewal proposals were funded.

5.4.4. Partnerships in Astronomy and Astrophysics Research and Education (PAARE)

The NSF Partnerships in Astronomy and Astrophysics Research and Education (PAARE) program provides large awards that are designed to enable formal and long-term programs to enhance diversity in astronomy through partnerships between Minority Serving Institutions (MSIs) and research institutions. It is now offered every two years, with the maximum award size of $1M per year. PAARE is a major way to fund both innovative new initiatives, like *AstroCom NYC*, as well as flagship programs, like the Fisk-Vanderbilt *Bridge to the Ph. D*. This innovative program grants the funding to the MSI, which is typically also a primarily undergraduate institution.

5.4.5. Unsolicited Proposals

ESP also accepts unsolicited proposals, and this flexibility allows the Division to fund programs that fall outside the purview of the standard solicitations. The COV noted that the POs put together *ad hoc* panels for this program very thoughtfully; pulling people from a broad range of institutions and with expertise that is particularly well-suited to review the proposals.

5.5. MPS- and NSF-wide Initiatives

MPS- and NSF-wide initiatives include such programs as Enhancing Access to the Radio Spectrum (EARS), Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE), Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) and Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21).

Since AST's participation in these multi-disciplinary initiatives varies widely, COV panel members found that there is no uniform way for PIs whose proposals are declined to get more information about the reasons for the declination. Some, but certainly not all, PIs contact the POs for more information beyond the individual panelist reviews and the panel summaries. That not all declined PIs ask for more information was surprising to at least one panelist; however, another panelist thought that such reticence could be due to cultural or gender reasons. Discussion of the PO-PI relationship occurred during at least one of the AAG panels as well.

Discussions of proposal reviews between PIs and POs do not seem to always be recorded in the eJackets' correspondence areas. Correspondence is not always automatically saved; newly appointed program directors may therefore have trouble getting up to speed because the data may not have all been saved in the eJackets.

Special programs that require an advocate, like INSPIRE, EAGER, and RAPID, are incredibly time-consuming. The "dollar allocated per hour spent by the Program Director" was greatly disproportionate compared to AAG, for example. A panel and PO might find a proposal worthy of funding, but the PO will then need to hunt either externally or internally within NSF for the money to fund it. PO success in the hunt for additional funding often depends on having personal contacts. ***Further discussion as to how to prioritize these programs and how to ease the burden of running and/or advocating for them is recommended***.

An additional concern was that it was not clear how well the various smaller and/or specialized programs have been communicated to the community. However, it was also not clear to the COV as to how to make them better known.

6 Mid-Scale Innovations Programs (MSIP)

During this COV period, spurred in part by recommendations from the 2011 PR to help AST respond to the goals of the NWNH Decadal Survey, AST restructured some of its activities to support smaller ($4-100M), shorter-term (1-5 year) projects through MSIP. The intent is to support projects, facilities, and/or instruments that emphasize student training, particularly with instrumentation development. MSIP funding solicitations are currently planned to occur every other year. The University Radio Observatories (UROs), Telescope System Instrumentation Program (TSIP), and Renewing Small Telescopes for Astronomical Research (ReSTAR) programs have all been phased out and subsumed into MSIP, which is designed to support projects with specific relevance to the field of astronomy and with funding needs between Major Research Instrumentation (MRI) and Major Research Equipment and Facilities Construction (MREFC). This broad redefinition allows MSIP to support moderately large research projects, not just instrumentation projects, filling a perceived funding gap in the portfolio of the Division. The Advanced Technologies and Instrumentation (ATI) program (also managed through AST) additionally provides support for instrumentation and computational infrastructure in the optical, near-IR, sub-mm, and longer-wavelength radio regimes. While there seems to be some overlap in the goals of these two programs, It is clear that the MSIP and ATI opportunities jointly address many of the goals and benefits the previous mid-scale programs were intended to address, and should provide new project funding opportunities.

The first solicitation in alternating-year opportunities was in mid-2013, and the first awards under the program were issued just before this committee met. Despite a high over-subscription rate (commensurate with the corresponding AAG rate), the results of this first round appear to be encouraging. AST established a two-stage proposal process, utilizing a strict prioritization protocol. The three fully-funded projects clearly emphasized student training and were aligned with the 2011 PR recommendations. In addition, seed funding was provided for three additional projects. As this is early in the MSIP implementation phase, we encourage NSF to experiment with the process in order to ensure appropriate balance in the future MSIP portfolio.

Recommendation 6: We recommend that solicitations for MSIP proposals alternate between solicitation cycles, either by proposal category or by requested funding level.

Some COV members expressed concerns that NSF operations funding for smaller radio facilities such as the Combined Array for Research in Millimeter-wave Astronomy (CARMA) and the Caltech Submillimeter Observatory *(*CSO) is being phased out and that these mostly open-access facilities are finding it necessary to obtain funding from other sources to maintain operations. This is not unlike the situation for small optical observatories years ago, which triggered similar concerns as to the potential loss of student training and community access. The COV highlights this as a potential future problem, particularly in the context of the 2014 Astronomy and Astrophysics Advisory Committee (AAAC)-recommended *Principles of Access*[8]: US astronomers

[8] http://www.nsf.gov/mps/ast/aaac/aaac_2014_principles_for_access.pdf

would like NSF involvement to ensure more reciprocity from international partners for access to their facilities, while we continue to maintain global access to ours.

There is also some concern about the funds available for MSIP. The funding for the previous mid-scale opportunities totaled $20-30M per year, while the cost to AST for FY14-15 was less than $15M per year. The cost-sharing opportunity with OMA and PHY allowed MSIP to reach total spending of $37M over the FY14-15 two-year funding cycle, just slightly higher than the one-year peak of the AST mid-scale portfolio in 2010 (due to the American Reinvestment and Recovery Act of 2009). Yet, this remains well below the NWNH-recommended $40M per year expenditure for the mid-scale innovations program, its second-ranked priority in large ground-based projects. It remains unclear to what extent the program can support any upper-limit proposals in the $20M to $40M range. ***The Division should continue to investigate means of filling this funding gap.***

Due to the expansive and collaborative nature of many of the proposed projects in the eJackets, it was very difficult to find qualified panelists without conflicts of interest. At 12 months, the review process for full proposals is longer than the annual AAG process. A new solicitation for MSIP every 24 months should therefore work well.

7 Facilities Management

The NSB has mandated that NSF contracts with Federally Funded Research and Development Centers (FFRDCs) that operate NSF facilities be recompeted. The COV is very concerned with the impact that the current recompetition policy has on AST and the research community. Typically, a Cooperative Agreement (CA) with an FFRDC to operate an astronomy facility runs 5 to 10 years. With five such facilities wholly within AST and one shared with GEO (the Arecibo Observatory), together with ~60% of the AST budget going to these facilities, AST facility oversight represents a very large fraction of the Division's workload. When a facility is recompeted, this workload is substantially increased over the typical two-year recompetition period. In the best case of 10-year CAs, 20% of the PO's time may be spent on recompetition. But that may actually be the smallest impact; during recompetition the contractor must also expend enormous effort, which falls particularly on the facility director and her/his staff. The real concern here is the substantial distraction of the director and staff from the key task of running the facility for the benefit of the science community. In addition, the uncertainty associated with a recompetition can impact staff morale and productivity and may even lead to unwanted departures of key individuals. The increased workload for AST POs and the negative impact on the facility operations are costs that must be weighed against the benefit of all recompetitions. Recompetition as a policy will have mostly negative impacts if there is no real concern over the performance of current management. Clearly, however, where there is a real concern, recompetition may have a positive effect. While the COV recognizes the power of competition, it strongly recommends that before any recompetition is mandated, a cost-benefit analysis be performed that justifies the cost in time and effort to carry out the recompetition. The COV recognizes this is not the prerogative of MPS but strongly urges MPS management to take this case to NSF top management.

> **Recommendation 7: We strongly recommend that the circumstances and period of any future recompetitions be strongly guided by a comprehensive cost-benefit analysis with delivered science being the main criterion**

7.1 Arecibo Observatory

The AST Division continues to provide oversight of the Arecibo Observatory through a joint Cooperative Agreement with SRI international, Universities Space Research Association (USRA), and Universidad Metropolitana (UMET), which is co-funded by the Atmospheric and Geospace Sciences (AGS) Division. In FY14 the annual NSF contribution to Arecibo was nearly $8M, with $4.5M from AST. In response to the AST Portfolio Review recommendation, AST continues to reevaluate its participation in Arecibo in the context of community priorities and budget forecasts. AST's contribution to this observatory—and that from the NSF as a whole—has gradually decreased over the years. However, there have been growing contributions from other stakeholders. From within the NSF, the AGS Division has taken an increasingly large stake in the annual contributions since 2010, and AST are now equal contributors through the end of the current Cooperative Agreement in FY16. Further, NASA has become a major contributor in recent fiscal years through increasing contributions to planetary radar projects, and now has a stake nearly equal to each of the AST and AGS Division's shares. The Arecibo Observatory continues to provide unique radio facilities to the community, and it continues to make high-impact discoveries, particularly in solar-system and atmospheric sciences. ***In response to the 2011 PR recommendation, AST continues to reevaluate its participation in Arecibo in the context of community priorities and budget forecasts.***

7.2 Gemini Observatory

NSF serves as the Executive Agency for the international Gemini partnership of countries (United States, Argentina, Australia, Brazil, and Chile: the "Gemini Partners"). It oversees the Association of Universities for Research in Astronomy (AURA), which manages the Gemini Observatory. Gemini operates two twin eight-meter telescopes: Gemini South (on Cerro Pachón, Chile) and Gemini North (Mauna Kea, Hawaii, United States). These two telescopes are the largest optical and infrared facilities available to the astronomers of the partner countries.

Since FY 2011, Gemini has been challenged by changes to its membership and in management personnel. In 2011, Fred Chaffee began service as Interim Director, following the resignation of Founding Director Matt Mountain. In 2012 Markus Kissler-Pattig began service as the new permanent Gemini Director.

A major financial challenge to the Observatory occurred at the end of 2012, when the United Kingdom (UK) withdrew as a 25% partner. The partnership was further modified with the plans of Australia to transition to a limited-term partnership. New partners have since been added: the South Korea Astronomy and Space Science Institute and the University of Hawaii.

The withdrawal of the UK meant that Gemini's budget was substantially diminished. Consequently, the number of employees had to be reduced from approximately 200 in 2012 to fewer than 160 expected by the end of 2017. In 2012, the observatory planned to spend less than the entire amount provided by the Gemini Partners in order to help smooth the effect of the loss of the UK as a partner. The Gemini leadership instituted a Transition Program, which included streamlining its science operations, and finding cost savings in facilities.

Despite the budget cuts, there have been several improvements in instrumentation, such as the Gemini Multi-Conjugate Adaptive Optics system, and the re-commissioning in 2013 of Florida's Multi-Object Infrared Grism Observing Spectrograph-2 (after a catastrophic failure in 2012).

As the Executive Agency for Gemini, NSF has held competitions to select organizations to run the facility. In January 2011, NSF received from AURA its renewal proposal. AST ran a panel to review the proposal two months later, and put together a package including the review analysis for the National Science Board (NSB) over the summer of 2011. NSF went before the NSB twice (in December 2011 and February 2012) to obtain approval of AURA's renewal, and finally (18 months after the renewal proposal was received) the renewal contract went into place in July 2012 for only 42 months (ending in December 2015).

Shortly after the renewal contract went into place, NSF issued a "Dear Colleague" letter for a re-competition of the management of Gemini. With a one-year delay announced, AST organized a proposal solicitation (after six months of preparation and clearance); held site visits to both Gemini North and Gemini South; assembled a review panel; and received letters of intent. AST now expects to receive proposals in February 2015, to hold a review of the proposals, and to put together a package to present to the NSB by 2016, with a new contract to start in January 2017. Because of the one-year gap between the end of the current contract and the beginning of the new one after the re-competition, *yet another* proposal and review will have to be performed for the extension of AURA's contract.

Clearly, this extensive and continual contractual work takes up a lot of the time of AST's staff and program managers, who are also simultaneously overseeing two other major facility recompetitions (as described above). ***It would help to alleviate the pressure on the time and energy of the AST staff if the various recompetitions were not held simultaneously.***

7.3 National Optical Astronomy Observatory (NOAO)

The core mission of NOAO is "to facilitate access for all qualified professional researchers to state-of-the-art observational capabilities and data bases in O/IR astronomy, and to enable the U.S. research community to pursue a broad range of modern astrophysical challenges from small bodies within the Solar System, to the most distant galaxies in the early Universe, to indirect observations of dark energy and dark matter" (NSF Solicitation 13-582). In meeting this charge, NOAO operates several facilities: A headquarters and development laboratories in Tucson on the University of Arizona campus; the Kitt Peak National Observatory outside of Tucson; a headquarters in La Serena, Chile, housing the southern central administration and labs; and observatories on Cerro Tololo and Cerro Pachón, both near La Serena. As an FFRDC, NOAO is currently managed by the Association of Universities for Research in Astronomy (AURA) and funded through Cooperative Agreements to AURA. The current Cooperative Agreement expires at the end of 2015 and a recompetition is currently underway.

For FY16, the NOAO base budget has been reduced from $25.5M (in FY15) to $17.5M; there is little question that NOAO has entered a period of historic and unprecedented challenges to its mission and capabilities. Following the recommendations of the 2011 PR, AST has been working on plans to divest several telescopes and to transition Kitt Peak operations to infrastructure support for tenants.

The COV wishes to commend the AST staff on their stewardship throughout this process, and in particular, on their involvement of the community through the establishment of the 2011 PR and invitations for public input. Perhaps even more critical, AST has begun to move forward with the implementation of the 2011 PR recommendations (*e.g.*, the NOAO Transformation plan, as considered by the NOAO Program Review Committee), again working closely with NOAO,

AURA, and members of the community. The COV further notes the impressive amount of work behind efforts by NSF and NOAO to develop strong partnerships that will lead to the continued operation of the Blanco, Mayall, and WIYN 3.5-m telescopes (which were all recommended for divestment by the 2011 PR). The WIYN telescope will now be partly funded by NASA to do exoplanet research through the EXPLORE program. The Mayall 4-m telescope on Kitt Peak will now be the home of the DOE-funded Dark Energy Spectroscopic Instrument (DESI). And several other facilities are being offered to stakeholders for potential partnerships. These creative approaches to stretching the AST budget are a great credit to Division management and should help to ease the pain caused by the unprecedented loss of facility access due to flat budgets stretching into the foreseeable future. ***Overall the COV supports this approach, but the AST Division should apply a cost-benefit assessment where the cost of staff effort both within AST and the facilities are considered.***

While we cannot help but be disappointed in the reduction in community access to medium aperture O/IR telescopes, particularly in the northern hemisphere, the COV is excited about and agrees with the direction for NOAO in 2016 and beyond. It is clear that both AST and NOAO recognize the importance of the Observatory's potential role in training next generation how to do science in the new era of big data.

7.4 National Radio Astronomy Observatory (NRAO)

Headquartered in Charlottesville, Virginia, the National Radio Astronomy Observatory (NRAO) operates world-class facilities at several sites: Green Bank, West Virginia, is home to the world's largest, fully steerable dish with an unblocked aperture, the 300-foot-diameter Richard C. Byrd Green Bank Telescope (GBT). Green Bank is located within the National Radio Quiet Zone, an area kept free from electronic interference that extends east as far as Charlottesville. The Very Large Array (VLA) is located on the Plains of San Augustin, near Socorro, New Mexico. The Array Operations Center (AOC), co-located with the VLA, houses the Correlator and other resources for analyzing data from both the VLA and the Very Long Baseline Array (VLBA)—a suite of ten antennas distributed on transcontinental baselines stretching from St. Croix in the Virgin Islands to Hawaii—which provides the capability for about 10 micro-arc second resolution at centimeter wavelengths. In addition, NRAO serves as Executive Agency for the international Atacama Large Millimeter Array (ALMA) facility located in the high Atacama Desert in northern Chile. All of the NRAO facilities are on the leading edge of the world's ground-based radio astronomy facilities. At $77.4 million in FY 2014, the NRAO base operations budget comprises about one-third of the entire budget for AST. About $34.2M of this constitutes support for ALMA operations (discussed in Section 7.5 below).

The Expanded VLA, an 11-year project to upgrade the electronic infrastructure of the VLA, was completed on time and on budget in FY 2013. These enhancements have increased the VLA's observing capabilities by an order of magnitude or more.[9] *The COV commends AST and NRAO for this accomplishment.*

One of the major divisions at NRAO's Charlottesville headquarters is the Central Development Laboratory (CDL), which has been instrumental in developing new technology for use throughout the radio spectrum. ***A significant concern that has emerged over the past few decades—and which this COV shares—is the increasing reliance of the CDL on work for others***, such as

[9] https://science.nrao.edu/facilities/vla/docs/manuals/oss2013b/intro/project

universities and industry. The additional work is essential in order to maintain the in-house expertise and capabilities needed to keep NRAO at the forefront of research in radio astronomy, but the concern is to ensure that the outside work does not overwhelm the laboratory's ability to meet the needs of NRAO itself.

Another concern is that there has been considerable churn in the POs assigned to oversee NRAO during FY2011—FY2013. As demands on AST's program staff changed, Vern Pankonin was first replaced by Phil Puxley, then by a combination of Puxley and Dana Lehr, and currently by Dana Lehr alone. While AST has experienced pressures during the period covered by this report that made these changes unavoidable, and while each of these POs has performed in exemplary fashion**, *the COV is concerned that lack of continuity in the position of the NRAO Program Officer does not serve NRAO or the U.S. astronomical community well.***

AST is currently charting a new course for NRAO as a result of two different sets of recommendations: The 2011 PR urged divestment of both the GBT and the VLBA; and the National Science Board (NSB) mandated that the NRAO management contract be recompeted, and that AST separate ALMA from NRAO in planning the NRAO recompetition. In FY 2013, AST decided against separating NRAO and ALMA but did decide to divest the GBT and VLBA and thus separate them from the NRAO management recompetition. Proposal review for the NRAO recompetition is currently underway, with the goal of making a new award for the ten-year period FY 2017—FY2026.

There is currently some hope that organizations in the state of West Virginia may be interested in stepping in to help sustain the GBT. And in FY 2014, the Naval Research Laboratory (NRL) is considering ionospheric research that piggybacks on directions in which the VLBA points. Whether or not this will develop into a longer-term relationship between NRL and the VLBA remains to be seen. *AST's efforts to develop partnerships to take over the GBT and VLBA are continuing, and the COV strongly endorses these efforts.*

Another issue has emerged with the divestment of the GBT and the end of support for the University Radio Observatories in 2014 in order to undertake the Mid-Scale Innovations Program (MSIP). Effectively, NRAO is shifting to centimeter-wavelength facilities, and the U.S. astronomical community is losing access to millimeter-wavelength facilities. In contrast, the European nations retain substantial mm-wavelength access—for example, *via* the Institut de Radioastronomie Millimétrique (IRAM) facility on the Plateau de Bure—which will be very important to enable competitive access to ALMA and to one of the leading frontiers of radio astronomy today. AST and NRAO urgently need to develop policies and procedures to enable U.S, astronomers to gain access to mm-wavelength facilities under the international "Open Skies" protocol. For example, perhaps access to IRAM could be made a condition to allow European astronomers to obtain access to the VLA.[10] ***The COV urges AST and NRAO to consider seriously a means to address this concern.***

7.5 Atacama Large Millimeter/submillimeter Array (ALMA)

ALMA is the largest radio observatory ever constructed, and it represents the single largest facility in AST's portfolio over the review period covered by this COV. It is an international partnership between North America, Europe, and Asia. ALMA construction was completed in 2014, with the

[10] See "2014 Astronomy and Astrophysics Advisory Committee Recommendations on Principles for Access to Large Federally Funded Astrophysics Projects and Facilities."

North American partners having delivered 25 out of 25 antennae, as well as all the promised receivers and digital back ends, the correlator, and various pieces of site infrastructure (roads, power systems, *etc*.). The remaining deliverables are mostly minor items such as handling parts and utility vehicles, and are expected to be on-site by early- to mid-2015. *In a significant success for AST, construction is forecast to be complete with roughly $350K remaining in the budget.*

ALMA's early science operations began with Cycle 0 in 2011, and are ongoing. Observations are currently in Cycle 2, with a call for Cycle 3 proposals anticipated for April 2015. Even in its early science state, ALMA has begun to return remarkable results in areas such as high-redshift galaxies and protoplanetary disks. The number of published results based on ALMA is steadily increasing, and the rate of production promises to accelerate as ALMA operations transition from early science to regular operations.

ALMA operations costs will place a continuing strain on the AST budget, but on balance the science payoff appears to be worth it. AST appears to have a viable plan in place to balance these costs against other parts of its portfolio. ALMA construction has been a significant success story for AST, and the COV is hopeful that ALMA science operations will be equally successful.

7.6 National Solar Observatory (NSO)

The NSO is in currently in a profound transition with a focus on building and commissioning the DKIST in Hawaii and in making a major move from its facilities near Tucson, Arizona, and Sacramento Peak, New Mexico, to a new home on the University of Colorado campus in Boulder. AST management of NSO for DKIST is also in transition, as retiring DKIST PO Craig Foltz hands off to new PO David Boboltz. *The COV commends AST, AURA, and NSO on implementation of the NSO Transition Plan. In particular, the relocation of NSO to Boulder will strengthen the user community for DKIST and take advantage of efforts at the University of Colorado, HAO, and NOAA.*

During the past 18 months, AURA and NSO also had to work through a proposal process to establish a new Cooperative Agreement (CA) as the current one expired Dec 31, 2014. This proposal constituted a substantial re-baselining of NSO for the DKIST era as well as a response to the 2011 PR to divest the McMath-Pierce solar telescope at Kitt Peak and the Dunn telescope at Sacramento Peak. Both telescopes will be ramped down by the end of 2017 when the DKIST is expected to ramp up. The COV is concerned, however, that a gap of two years without a ground-based solar facility may negatively impact the solar community. *We commend NSF's efforts to find new partnerships for these telescopes,* and ***encourage NSF to explore opportunities that could lead to continued community access to these facilities up to the start of DKIST operations.***

The COV feels that AST oversight of these activities over the past few years has exemplified the highest standards, culminating in the approval of a new CA with AURA that started 1 Jan 2015 and runs through 2024. A recompetition process is envisioned to begin after this, per current NSB policy. It is likely that DKIST will have been operating for only a few years before this next planned recompetition. As we addressed at the beginning of this section, this NSB mandate for frequent recompetitions has substantial potential to harm the scientific output from the affected facilities.

8 Major Research Equipment and Facility Construction (MREFC) Projects

AST is currently managing two MREFC projects: the Daniel K. Inouye Solar Telescope (DKIST) and the Large Synoptic Survey Telescope (LSST). The sections below summarize the presentations heard by the COV about these large new facilities, and the findings of the COV.

8.1 Daniel K. Inouye Solar Telescope (DKIST)

Under construction now, DKIST is an exciting new facility that will enable huge strides in solar physics. A four-meter, off-axis reflecting telescope, DKIST will have the spatial, temporal, and spectral resolution and the dynamic range necessary to measure basic magnetic structures at the surface of the Sun and into the outer solar atmosphere. Its collecting area, spatial resolution, wavelength performance, and instrumentation are all designed to address the basic questions: What is the nature of solar magnetism? How does magnetism affect the Sun? And how can we model and predict the changing solar outputs that affect the Earth? DKIST will observe solar plasma processes and magnetic fields with unprecedented resolution in space and time, probing solar magnetic fields to scales of about 25-30 kilometers. It will provide the information needed to understand the generation, structure, and dynamics of the surface magnetic fields, which in turn govern the solar wind, solar flares, and short-term solar variability. Sited on Haleakala in Hawaii, it will replace NSO facilities at Sacramento Peak and Kitt Peak. Recommended by NWNH and prioritized as the top solar facility by the 2011 PR, DKIST will be the flagship ground-based solar facility for decades to come. The NSF decision to operate DKIST in the AST division is a testament to the vast experience in facilities operations within the division. The NSO will construct and manage DKIST through AURA.

Legal and administrative challenges in obtaining the building permit for DKIST resulted in a 30-month delay on groundbreaking. This led to a complete re-baselining of schedule and cost of DKIST construction, which NSF began in 2012. After a thoughtful and thorough analysis, including community input, NSF submitted a request for re-baselining to the NSB, which approved the revised baseline in 2013. The project cost is now $344 million, an increase of about $46 million over the original request. Currently, DKIST is expected to overrun by about 16% in cost and to finish construction 16 months late, compared to the original baseline. *The COV commends NSF and AST on this re-baselining effort, which will result in an operational facility with minimal cost increase and schedule delays*.

The Final Design Review (FDR) for the telescope enclosure was held in January 2012; it has since been constructed in Bilbao, Spain, and is currently on-island in Hawaii. All the other major components of the telescope assembly, mirror cells, and control system have passed their respective FDRs as well. First light instrumentation will include a Visible Broadband Imager (VBI), a Visible Tunable Filter (VTF), a Visible SpectroPolarimeter (ViSP), a Diffraction-Limited Near-Infrared Spectro-polarimeter (DL-NIRSP), and a Cryogenic Near-Infrared SpectroPolarimeter (Cryo-NIRSP). Critical Design Reviews (CDRs) have already been held for three of these instruments, and CDRs for the two remaining will be held before summer 2015.

The advent of DKIST is already beginning to transform the solar community: the project is participating in Town Hall meetings and is hosting workshops, an approach similar to that used to prepare the community for the advent of ALMA.

8.2 Large Synoptic Survey Telescope (LSST)

The Large Synoptic Survey Telescope (LSST) is a large-aperture (8.4 m) wide-field (3.5˚ diameter) optical survey telescope. The LSST will conduct observations from Chile, where it will photograph the entire available sky every few nights. It will employ the largest digital camera ever constructed (3,200-megapixels), which will take 15s exposures every 20s in six broad wavelength bands. The major science goals are: Achieving an order of magnitude improvement in dark energy and dark matter measurements; investigating the structure and formation of our Galaxy through detailed mapping; developing an unpreceded inventory of Solar System objects, including those that may collide with the earth; and opening the transient sky through time-domain observations. The project timeline is: engineering first light in 2019, science first light in 2021, and full operations for a ten-year survey commencing in October 2022. The total cost of the NSF funded portion is capped by the NSB at $473 million.

Excluding down time (due to maintenance and weather), the camera is expected to create approximately 200,000 images (6 million gigabytes) per year. While the telescope and the camera are technically challenging, it is possible that managing and mining this incredibly large volume of data will be the major technical challenge of the entire project. Initial computer requirements are estimated at 100 teraflops of computing power and 15 petabytes of storage, increasing as the project collects ever more data. Mastering this data flow and making it readily accessible to the public will represent a major advance of big data science. The LSST can have a significant educational impact if it achieves its goal of providing ready access to its data to secondary school educators. The aspirational goal to make this data so easily available that even citizen scientists can make astronomical discoveries promises to be transformative.

NWNH ranked the LSST as the highest-priority ground-based astronomical project. NSF funding was authorized as of 1 August 2014, and getting the LSST project to this point took an enormous effort from AST. We reviewed the manner in which AST handled the MREFC process, including obtaining NSB approval, and on plans to oversee the construction, including joint DOE and NSF management oversight.

The COV heard a presentation by PO Nigel Sharp about the many steps that AST went through to bring the LSST project into the initial stages of the MREFC process. Fifty individual steps were taken, starting in January 2011, just five months after the publication of NWNH. The last step, release of FY 15 NSF funding, was taken in December 2014, the same month the COV met. *What the AST staff achieved in such a short time frame is extremely impressive, and this very-qualified team should be commended highly for its excellent work.*

The COV has some concerns about potential problems associated with the joint DOE and NSF funding and management, due to the differing cultures and budget appropriations processes in the two agencies. For example, in April 2013 the LSST Camera Major Item of Equipment (MIE) fabrication start was not approved in the DOE FY13 appropriation. This caused a year-long delay in funding, which then necessitated replanning the entire project. Although the stated cause of this delay was the FY13 Continuing Resolution, ***the COV recommends that every effort be made to optimize the remainder of project construction***. *The COV commends DOE and NSF for creating a Joint Oversight Group (JOG) between AST and DOE's Office of High Energy Physics (HEP), for drafting a coordinated timeline for construction, for meshing the agencies' review processes and most importantly for initiating weekly JOG meetings.* These steps go a long way toward addressing our concerns.

The Association of Universities for Research in Astronomy (AURA) is now the legal entity responsible for the LSST construction project. AURA has created the LSST Project Office (LSSTPO), which is an AURA-managed center for the construction phase of the LSST project. The LSSTPO provides the project management, budget control, and systems engineering necessary to design, construct, integrate, and commission the LSST system. AURA is an experienced managing organization for NSF facilities and will have full financial responsibility and accountability under the planned Cooperative Agreement for the LSST.

Although the LSST project is a joint endeavor of NSF and DOE, NSF is the lead agency carrying the overall responsibility for the project. With this in mind, AST has assigned a full-time permanent PO with the responsibility for NSF oversight of the LSST Project. A second permanent PO in the Division, having significant MREFC experience (with ALMA) is assigned as backup and was present throughout the Final Design Review (FDR); the AST Division Director also attends the JOG meetings and was present throughout the Preliminary Design Review and the FDR. The lead PO (Nigel Sharp) is in frequent contact with the project and with program management at DOE outside of the weekly JOG meetings. The PO attends LSST team meetings and sessions of the AURA Management Council for the LSST when feasible, and talks with members of the science working groups as needed. The PO is assisted as necessary by other NSF staff members, including representatives of the Large Facilities Office, the Division of Acquisitions and Cooperative Support, and the Directorate for Education and Human Resources. All participated in the Preliminary Design Review and the Final Design Review.

The COV believes that NSF has put in place an excellent management team and management structure for the LSST project. We therefore do not have any specific recommendations for improvements in regards to these crucial issues. *Rather, the COV emphasizes that the NSF managerial work performed so far on this project has simply been superb*.

9 Electromagnetic Spectrum Management (ESM)

The Division of Astronomical Sciences is home to a little-known but extremely important program: the office of Electromagnetic Spectrum Management (ESM). Currently managed by Mangala Sharma and Sandra Cruz-Pol, this office serves the entire NSF, reviews and comments on very large numbers of applications for access to portions of the radio spectrum, and represents the interests of the United States at quadrennial World Radio Congresses. Among numerous other activities, ESM works to ensure that the National Radio Quiet Zone—where the Green Bank site of the National Radio Astronomy Observatory is located—is protected from encroachment by unwanted sources of radio noise, such as cell phones and other wireless communication devices. Because there is extremely strong and growing demand for access to the radio spectrum, the function of ESM is critically important for AST and for NSF as a whole.

Currently, AST spends about $100 million per year to support facilities for research in radio astronomy and for research grants in this area. To convey a sense of the value of the radio spectrum that is monitored and protected for science by ESM, Dr. Sharma advised the COV that the value of the 21-centimeter radio band alone for use by wireless devices is about $14 billion! NSF's Division of Polar Programs also has huge needs for access to the radio spectrum, but these are dealt with by the Department of Defense (DoD) rather than by ESM.

While demand for access to the radio spectrum from wireless devices has been increasing over the past decade, a relatively new threat to radio astronomy is posed by the advent of "nano-satellites" (also known as "CubeSats"). Groups of these small satellites can be ejected from rockets or launched into space from the International Space Station. NSF's Geosciences Directorate has a CubeSat program to study space weather, which has already launched six experiments, with five more in the pipeline. In addition to the NSF program, both NASA and the DoD maintain very large nanosat programs, typically launching 30 or more CubeSats per launch. Commercial launches of CubeSats are also rapidly increasing.

The threat from CubeSats is caused by the necessity to link the satellite *via* radio communication with a ground station. If the downlink happens to occur while the CubeSat is traversing the beam of a radio antenna, the interference has the potential to render the observation useless unless stringent control is maintained onboard the satellite. Although each satellite has to be licensed—and this procedure provides ESM with the opportunity to review the license application and require modifications to the system if necessary—the increasing popularity of nanosats will require a corresponding increase in effort by the ESM Program Officers.

Further complicating the job of ESM, "access to wireless services for all Americans" is a current Presidential priority. The Foundation-wide program entitled Enhancing Access to the Radio Spectrum (EARS) is managed by ESM to provide grants in support of efforts to promote this directive, while still protecting the use of the radio spectrum for science.

The COV applauds the efforts of the ESM Program Officers (PO/ESM) to maintain access to critical portions of the radio spectrum for scientific research.

At the same time, we note with concern that there has been recent turnover in the staff assigned to this critical function**.** The position of PO/ESM requires highly specialized knowledge of the radio spectrum and of the national and international regulatory process. The position also requires a security clearance because of the interface with DoD programs. These qualifications are not easy to find. *AST appears to have done a good job in replacing the long-time PO/ESM, Dr. Tomas Gergely, with capable new people in the persons of Drs. Sharma and Cruz-Pol, and* ***we urge the Foundation to continue to provide the resources necessary to meet the needs of the critically important ESM program****.*

10 Other Issues

In this section, we provide comments on a few additional issues that arose during the 2014 COV meeting: US competitiveness in ground-based Optical/Infrared astronomy, operation of large new projects, building a solar community within NSF AST, US competitiveness in computational astrophysics and concerns of junior investigators.

10.1 US Competitiveness in Ground-based Optical/Infrared (OIR) Astronomy

At the present time, NSF AST operates many different ground-based OIR telescope facilities including NOAO (with headquarters in Tucson, and telescopes on Kitt Peak and in Chile). In addition, NOAO runs the US Gemini office, providing support to US users of data from the two 8-m Gemini telescopes (one in each hemisphere). The Gemini Observatories are run by an international partnership, with NSF as the Executive Agency. NSF AST is also overseeing the

construction and eventual operation of the Large Synoptic Survey Telescope (LSST) and has provided a planning award to the Thirty Meter Telescope consortium.

In the future, OIR Astronomy in the US will be very different. The divestment of northern hemisphere facilities on Kitt Peak, and the transition of NOAO to a data-providing organization will change the way ground-based astronomy is done forevermore. Although students at many universities will still be able to get hands-on experience with small and medium-sized telescopes, the trend towards "big data" and the types of pipeline analysis needed to keep up with the flood of data from LSST will fundamentally change ground-based OIR astronomy and astronomers. The skills needed to conduct astronomical observations will shift as well, from an emphasis on understanding peculiarities of individualized instruments, to statistical and analytical competencies to handle large data sets. Ground-based astronomy will come to resemble space-based astronomy: the observer writes a proposal, and bits are delivered, along with access to data analysis tools. The nights spent by individual astronomers on lonely mountain tops are disappearing, to be replaced by huge volumes of data to be analyzed by large teams of collaborators.

While these trends may lessen the romantic appeal of astronomy to some, the incredible power of the 8-m Gemini telescopes (and accompanying instrumentation), coupled with the unprecedented wide field of view of LSST and its torrent of data, will be able to keep US astronomers at the forefront of OIR astronomy for many years to come. However, to take advantage of these high-throughput new observatories, it will be extremely important to ensure that funding to these ground-based "guest observers" is sufficient to optimize the science return, and to train the next generation of astronomers. In the more distant future, planning for 30- or 100-m telescopes to be used by US astronomers will continue, and in an improved funding climate, at least one of these facilities will need to be built in order for the US to maintain its competitiveness.

More detailed recommendations will be issued by a future NRC committee to be established to review the impacts of LSST on the national OIR program.

10.2 Operation of Large New Projects

Large new telescopes (~$100M) are funded through a non-AST line-item budgeting category known as Major Research Equipment and Facility Construction (MREFC). Items eligible for MREFC funding are planned as part of an NSF-wide strategy. However, once the facility is built, AST funding must be used to operate it. These ongoing costs can be considerable. For example, LSST is currently under construction through the MREFC process (augmented with additional funding through private and other-agency partnerships), and its operations costs are expected to be considerable. AST will need to continue to examine its portfolio when LSST becomes operational in order to accommodate operations costs within the ~60% of its budget that is assigned to facilities.

Another issue is the influence of the Large Facilities Manual (LFM) on MREFC projects. The LFM defines Project Life Cycle Stages from initial development to facility termination, and also specifies roles and responsibilities for NSF staff throughout the multi-step process. The LFM is a complicated document, which changes more quickly than projects can be completed***. In order to limit the impacts of rapid changes (with ensuing cost escalation) on projects under construction, we recommend that the LFM process in place at project start be grandfathered-in for the life cycle of the project.*** Alternatively, POs should have the ability to decline to change the project in

response to newly mandated requirements that were not in place when the project was begun. This is similar to changes in college catalogs – student requirements stem from the catalog year in which they entered, unless they prefer to change their plans to meet newly imposed requirements. Flexibility in these situations can save considerable expense, and help to keep major construction projects on budget and on schedule. (The LSST program managed to start in 2014, only one year late, despite various road blocks mandated by LFM requirements for audits, cost estimation processes, and complicated management reviews. This is an instructive example for future project management.)

We also recommend that individuals with management experience in the construction of large science facilities be permanently resident within NSF's Large Facility Office. These individuals can then be given temporary work assignments in different divisions that are engaged in building major new facilities, so that Division POs can concentrate on optimizing the scientific output of the facilities, rather than becoming experts on the details of construction budgets, schedules, cost estimation methodologies, Requests for Proposals (RFPs), and reviews.

10.3 Building a Solar Community

When completed, the Daniel K. Inouye Solar Telescope (DKIST) will serve not only the space weather research community, but also the solar physics community pursuing the fundamental goal of understanding solar magnetism, with connections to stellar magnetic activity studies as well. Currently, solar proposals to the NSF are split between space weather proposals, which go to AGS, and a relatively small number of solar physics proposals, which go to AST. Within the US, there is a large solar physics community which is primarily space mission oriented, with a home in the NASA Heliophysics division. Given the executive priority to increase involvement in Space Weather, the COV encourages AST to continue working on cross-agency opportunities that prepare the U.S. solar community to fully utilize the capabilities of DKIST.

> **Recommendation 8: We recommend that AST continue to work with AGS, NASA's Heliophysics Division, and the solar research scientists to build a cohesive community that will become the future users for DKIST.**

The large solar physics community involved in space missions needs opportunities to understand and prepare for the DKIST era, not only for planning coordinated ground- and space-based observations, but also as potential new DKIST users. Given that a great deal of solar physics research is conducted by scientists on soft money, outside of universities, NSF needs to consider grant funding for mid-career and senior scientists beyond the traditional "summer salary."

Workshops and other training opportunities are also needed to develop junior researchers and to broaden participation by mid-career and senior researchers in this area. ALMA user development programs might serve as a template. Exploring synergies in instrument development between the solar and stellar communities might be fruitful.

10.4 US Competitiveness in Computational Astrophysics

While the advent of "big data" observing is changing the nature of ground-based OIR astronomy, the advent of large-scale computation as a tool has brought about a similar change in the nature of theoretical astrophysics. Few modern theorists perform their work exclusively with pencil and paper, and even those whose computational needs can be met by workstation-level computers are becoming less common. Since few individual universities or similar organizations can maintain

their own supercomputers, this change has led to an increasing dependence of US-based theoretical research on the availability of national computational facilities. For the astrophysics community, such facilities are provided primarily by the NSF, NASA, and (in some sub-fields of astrophysics) the DOE. The competitiveness of US-based computational astrophysics depends crucially on the adequacy of the computational resources provided by these agencies.

NSF's computational resources are currently provided primarily through the Extreme Science and Engineering Discovery Environment (XSEDE) partnership, overseen by the NSF Division of Advanced CyberInfrastructure (ACI), within the Directorate for Computer and Information Science and Engineering. While a review of this division is not within the COV's purview, the increasing dependence of US astronomy on NSF-provided computational resources makes it impossible to assess the performance of AST and its relationship to the larger US astronomy community, without considering the issue at least tangentially.

At present, there are two significant issues for the US computational astrophysics community in relation to the NSF. One is that the current proposal process creates a significant administrative burden both on the NSF and on PIs. At present, requests for computer time require full 10-page proposals in the standard NSF format, covering both the science goals and the computational methods, and these must be submitted on an annual basis. This means that a standard, 3-year AAG award for a computational project that requires NSF computing resources would require, over the lifetime of the proposal, *four* full-size NSF proposals. Preparing these proposals creates a significant burden on PIs, and reviewing them creates a significant burden on NSF personnel and on community members who are called to serve on review panels. In comparison, the proposal process for NASA and DOE computational resources is much less cumbersome, generally requiring that the applicant complete at most a few pages of information on their code and their science goals. These reviews focus on the computational aspects of the work (*e.g.*, code performance and scalability). Such a streamlined process is possible because the primary screening of proposals takes place at the stage of funding: if a NASA or DOE award is funded, the effective presumption is that computational resources to go along with it should also be awarded, without the need for an additional review that is as rigorous as the initial one for funding.

It is far from clear that the extra review stage within the current NSF process actually improves science outcomes. Due to the need for computational expertise and the broad range of topics covered by XSEDE review panels, the reviewers are almost certainly *less* equipped to review the scientific content of the proposals than an AST panel. Thus the extra layer of science review at the computational resource allocation stage adds little when the project in question has already been approved by AST.

A second issue is simply the availability of computing cycles on NSF facilities. The last few years have seen very large oversubscription rates on NSF XSEDE resources, typically by factors of three or more. The response to this oversubscription has typically been not to award most of the resources requested to roughly 1/3 of the projects, but instead to award to a significant fraction of the projects a reduced share of the amount requested. This approach seems sub-optimal, in that the amount awarded is often so small as to make it essentially impossible to complete the project in a meaningful way. The analogous situation for observational astronomy would be if telescope allocation committees responded to a factor of 3 oversubscription not by awarding 1/3 of the proposals, but by awarding all proposals 1/3 of the nights requested. The result would probably be significantly less science output.

As a result of these two issues, the current system of allocating computational resources at the NSF creates a significant problem for the US astrophysics community, and damages the competitiveness of US computational astrophysics. Since this issue crosses NSF division lines, the COV recommends that AST approach this issue by opening a dialogue with ACI to address these issues. The first goal of this interaction should be to develop a streamlined allocation process that will reduce administrative burden for both PIs and NSF program officers. Such a revised procedure might be modeled on the procedures used by NASA or DOE, where the review is smaller in scope and is focused specifically on computational issues, at least in cases where the resource request is in support of an already-awarded science proposal from another NSF division. Regardless, the goal should be to reduce the proposal burden on both PIs and NSF program officers. A secondary goal should be to consider whether NSF allocation policies ought to be altered to award a larger fraction of the time requested to higher ranked proposals, while reducing awards to lower-ranked ones. Such an approach seems preferable to the current one in the short term as a means of dealing with computational over-subscriptions. Over the longer-term, AST should communicate with ACI that the US astronomical community has a clear need for more computing power than current NSF facilities provide.

Recommendation 9: The COV recommends that AST personnel continue to try to improve the interface with XSEDE with the goal of reducing the proposal burden. One way to do this would be to allow simultaneous proposals for funding and computer time.

10.5 Professional Development Opportunities for Junior Research Astronomers

To address the balance of the portfolio, we also need to address the relative value of junior fellowships and other programs for junior investigators. Some in our community advocate "birth control" (fewer postdocs and graduate students); however, the unemployment rate for astronomers is relatively low, once we look outside the traditional academic career. One relevant example is the NIH program for universities to develop broader training programs for graduate and postdoctoral training[11]. The purpose of this NIH program is "to seek out, identify and support bold and innovative approaches designed to broaden graduate and postdoctoral training, such that training programs reflect the range of career options that Ph.D. graduate students and postdoctorals (regardless of funding source) pursue and that are required for a robust biomedical, behavioral, social and clinical research enterprise. Collaborations with non-academic partners are encouraged to ensure that experts from a broad spectrum of research-intensive and research-related careers contribute to coursework, rotations, internships or other forms of exposure. This program will establish a new paradigm for graduate and postdoctoral training; awardee institutions will work together to define needs and share best practices."

If funding allows, we recommend that AST consider offering this type of solicitation.

[11] http://grants.nih.gov/grants/guide/rfa-files/RFA-RM-13-019.html

10.6 Use of Reviews in Young Faculty Dossiers

Junior faculty members are especially vulnerable to declining funding rates because federal research awards are one key criterion in evaluating research quality for tenure and promotion. In response to the historically low award rate in AST, many young faculty are being asked to include information from unsuccessful proposals in their tenure and promotion dossiers, such as the panel review summary and/or relative ranking within the panel. Reviewers and Program Officers should be cognizant of the fact that Panel Summaries may have a wider audience that includes tenure and promotion committees and include as much information as possible about the strengths and weaknesses of a proposal, especially in those cases that would have been funded during less dire times.

CORE QUESTIONS and REPORT TEMPLATE
for
FY11-FY14 MPS/AST COMMITTEE OF VISITOR (COV) REVIEW

Guidance to NSF Staff: This document includes the set of Core Questions and the COV Report Template for use by NSF staff when preparing and conducting COVs. Specific guidance for NSF staff describing the COV review process is described in the "COV Reviews" section of NSF's Administrative Policies and Procedures which can be obtained at https://inside.nsf.gov/aboutnsf/hownsfworks/rolesresponsibilities/Pages/Committee-of-Visitors.aspx [12]

NSF relies on the judgment of external experts to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. Committee of Visitor (COV) reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and (2) managerial matters pertaining to proposal decisions.

The program(s) under review may include several sub-activities as well as NSF-wide activities. The directorate or division may instruct the COV to provide answers addressing a cluster or group of programs – a portfolio of activities integrated as a whole – or to provide answers specific to the sub-activities of the program, with the latter requiring more time in 9.1 but providing more detailed information.

The Division or Directorate may choose to add questions relevant to the activities under review. NSF staff should work with the COV members in advance of the meeting to provide them with the report template, organized background materials, and to identify questions/goals that apply to the program(s) under review.

Suggested sources of information for COVs to consider are provided for each item. As indicated, a resource for NSF staff preparing data for COVs is the Enterprise Information System (EIS) – Web COV module, which can be accessed by NSF staff only at http://budg-eis-01/eisportal/default.aspx. In addition, NSF staff preparing for the COV should consider other sources of information, as appropriate for the programs under review.

In section IV (addressing portfolio balance), the program should provide the COV with a statement of the program's portfolio goals and ask specific questions about the program under review. Some suggestions regarding portfolio dimensions are given on the template.

Guidance to the COV: The COV report should provide a balanced assessment of NSF's performance in the integrity and efficiency of the ***processes*** related to proposal review. Discussions leading to answers of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. ***COV reports should not contain confidential material or specific information about declined proposals.*** The reports generated by COVs are made available to the public.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions. For past COV reports, please see http://www.nsf.gov/od/oia/activities/cov/.

[12] The COV Reviews section has three parts: (1) Policy, (2) Procedures, and (3) Roles & Responsibilities

FY 2015 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: 17 – 19 December 2014
Program/Cluster/Section: All Division programs and activities
Division: AST (Division of Astronomical Sciences)
Directorate: MPS (Math & Physical Sciences)
Number of actions reviewed: **Awards: 81** **Declinations: 144** **Other: 22 (3 INVT, 3 NINVT, 2 WTH, 14 RTNR)**
Total number of actions within Program/Cluster/Division during period under review: **Awards: 731** **Declinations: 2954** **Other: 226**
Manner in which reviewed actions were selected: **AST staff categorized all the jackets from each individual investigator program area during the review period into subsamples based on the type of proposal action. This ensures a "representative" sample of actions was selected. Within each subsample, a random selection of jackets was made. The number of jackets selected from each subsample was chosen primarily to demonstrate the range of possible outcomes in that category, so it is only roughly proportional to the number of actions in that category.**

COV Membership

	Name	Affiliation
COV Chair or Co-Chairs:	**Lawrence Ramsey**	**The Pennsylvania State University**
COV Members:	**Katelyn Allers** **Nancy Brickhouse** **Mike Briley** **Robert Brown** **Lynn Cominsky** **Kelle Cruz** **Kelly Holley-Bockelmann** **Mark Krumholz** **Charles McGruder** **Windsor Morgan** **Tim Paglione** **Lou Strolger** **Hugh Van Horn** **William Zajc**	**Bucknell University** **Harvard-Smithsonian Ctr. for Astrophys.** **Appalachian State University** **Cornell University (retired)** **Sonoma State University (Vice Chair)** **City Univ. of NY, Hunter College** **Vanderbilt University** **University of California at Santa Cruz** **Western Kentucky University** **Dickinson College** **City Univ. of NY, York College** **Space Telescope Science Institute** **University of Rochester (retired)** **Columbia University**

INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program(s) under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

I. Questions about the quality and effectiveness of the program's use of merit review process. Please answer the following questions about the effectiveness of the merit review process and provide comments or concerns in the space below the question**.**

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	**YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE**
1. Are the review methods (for example, panel, ad hoc, site visits) appropriate? Comments: **Data Source: EIS/Type of Review Module**	YES
2. Are both merit review criteria addressed a) In individual reviews? b) In panel summaries? c) In Program Officer review analyses? Comments: **Data Source: Jackets**	**YES**

3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? Comments: **Data Source: Jackets**	**YES**
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Comments: **Data Source: Jackets**	**YES**
5. Does the documentation in the jacket provide the rationale for the award/decline decision? [Note: Documentation in the jacket usually includes a context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), program officer review analysis, and staff diary notes.] Comments: **Data Source: Jackets**	**YES**

6. Does the documentation to the PI provide the rationale for the award/decline decision? [Note: Documentation to PI usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written in the PO Comments field or emailed with a copy in the jacket, or telephoned with a diary note in the jacket) of the basis for a declination.] Comments: **Data Source: Jackets**	**YES**
7. Additional comments on the quality and effectiveness of the program's use of merit review process:	

II. Questions concerning the selection of reviewers. Please answer the following questions about the selection of reviewers and provide comments or concerns in the space below the question**.**

SELECTION OF REVIEWERS	**YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE**
1. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: **Data Source: Jackets**	YES
2. Did the program recognize and resolve conflicts of interest when appropriate? Comments: **Data Source: Jackets**	YES
Additional comments on reviewer selection:	

III. Questions concerning the management of the program under review. Please comment on the following:

MANAGEMENT OF THE PROGRAM UNDER REVIEW
1. Management of the program. Comments:
2. Responsiveness of the program to emerging research and education opportunities. Comments:
3. Program planning and prioritization process (internal and external) that guided the development of the portfolio. Comments:
4. Responsiveness of program to previous COV comments and recommendations. Comments:

IV. Questions about Portfolio. Please answer the following about the portfolio of awards made by the program under review.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
1. Does the program portfolio have an appropriate balance of awards across disciplines and sub-disciplines of the activity? Comments: **Data Source: EIS/Committee of Visitors Module. From the Report View drop-down, select the Funding Rate module to see counts of proposals and awards for programs. The Proposal Count by Type Report View will also provide a summary of proposals by program.**	**APPROPRIATE**
2. Are awards appropriate in size and duration for the scope of the projects? Comments: **Data Source: EIS/Committee of Visitors Module. From the Report View drop-down, select Average Award Size and Duration.**	**APPROPRIATE**
3. Does the program portfolio include awards for projects that are innovative or potentially transformative? Comments: **Data Source: Jackets**	**APPROPRIATE**

4. Does the program portfolio include inter- and multi-disciplinary projects? Comments: **Data Source: If co-funding is a desired proxy for measuring inter- and multi-disciplinary projects, the Co-Funding from Contributing Orgs and Co-Funding Contributed to Recipient Orgs reports can be obtained using the EIS/Committee of Visitors Module. They are available as selections on the Report View drop-down.**	**APPROPRIATE**
5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators? Comments: **Data Source: EIS/Committee of Visitors Module. Select Proposals by State from the Report View drop-down.**	**APPROPRIATE**
6. Does the program portfolio have an appropriate balance of awards to different types of institutions? Comments : **Data Source: EIS/Committee of Visitors Module. Select Proposals by Institution Type from the Report View drop-down. Also, the Obligations by Institution Type will provide information on the funding to institutions by type.**	**APPROPRIATE**
7. Does the program portfolio have an appropriate balance of awards to new investigators? NOTE: A new investigator is an investigator who has not been a PI on a previously funded NSF grant. Comments: **Data Source: EIS/Committee of Visitors Module. Select Funding Rate from the Report View drop-down. After this report is run, use**	**APPROPRIATE**

the Category Filter button to select New PI for the PI Status filter or New Involvement (PIs & coPIs) = Yes.	
8. Does the program portfolio include projects that integrate research and education? Comments: **Data Source: Jackets**	**APPROPRIATE**
9. Does the program portfolio have appropriate participation of underrepresented groups[13]? Comments: **Data Source: EIS/Committee of Visitors Module. Select Funding Rate from the Report View drop-down. After this report is run, use the Category Filter button to select Women Involvement = Yes or Minority Involvement = Yes to apply the appropriate filters.**	**APPROPRIATE**
10. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports. Comments: **Data Source: Jackets**	**APPROPRIATE**
11. Additional comments on the quality of the projects or the balance of the portfolio:	

[13] NSF does not have the legal authority to require principal investigators or reviewers to provide demographic data. Since provision of such data is voluntary, the demographic data available are incomplete. This may make it difficult to answer this question for small programs. However, experience suggests that even with the limited data available, COVs are able to provide a meaningful response to this question for most programs.

OTHER TOPICS

1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

See sections on staffing (4.1), planning for facility de-commissioning (4.2) and facility re-competition (7)

4. Please provide comments on any other issues the COV feels are relevant.

5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

SIGNATURE BLOCK:

For the COV for the NSF/MPS Division of Astronomical Sciences
Lawrence W. Ramsey,
Chair