2023 NSF AST Committee of Visitors (COV) Report

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Committee members

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van Belle, Gerard	Lowell Observatory
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Committee's Activities

July 11, 2023: online startup meeting, including the charge to the committee and conflicts of interest training. Presentations from James Neff and Debra Fischer.

Later in July 2023: small sub-groups of COV members met with James Neff and Program Officers. These meetings included Q&A about e-Jackets from members and other specific questions that came up as the COV prepared for its in-person meeting at NSF in August.

August 10 & 11, 2023: the COV convened at NSF HQ for the meeting that led to this report.

Executive Summary

According to its charge, the 2023 NSF Division of Astronomical Sciences (AST) Committee of Visitors (COV), evaluated, for FY19-22, the:

- the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions;
- the relationship amongst award recommendations, AST's balance and priorities for research, and both AST and NSF-wide programmatic and strategic goals; and
- the AST's response to the prior COV report of 2019.

Overall, the COV commends the AST staff for continuing to do an excellent job of allocating NSF funds over a trying four-year period that included not only a global pandemic, but also transitions through four division directors. The funded portfolio of research, especially given these challenges, is world-leading in astronomical research.

During its review, the COV paid careful attention to the "Core Questions" it was asked to address, and this report presents explicit answers to all these questions. In addition, the COV prioritized five issues where we suggest that changes in NSF AST strategy could benefit the astronomy community, the STEM ecosystem in general, and the nation. These **five top issues,** expanded upon in the following section, are:

1. Clarifying the meaning of **"Broader Impacts"** for both proposers and reviewers, with a broad range of examples.
2. **Strategizing** directly with PIs about how **co-funding** with other **NSF divisions and directorates** (including the new TIP) and/or with **other agencies and foundations** might help them fund their research.
3. Making more sophisticated use of **automated literature analysis tools** to identify the most **relevant reviewers** while also reducing unnecessary **conflicts of interest.**
4. Making use of **astronomy's lead in data sharing** and **open-source code development** in (commercial) technology development (potentially via TIP).
5. Emphasizing and restructuring **communication** with the public.

Additional important issues identified in response to "core questions" and the COV's evaluation of AST's response to the 2019 report include the following.

- In response to a recommendation from the 2019 COV report, pre-meeting briefings for AST panels now highlight **broader interpretation of broader impact**. These briefings appear to be

a step in the right direction, but, as issue #1 above emphasizes, community and panel reviewers still appear to have difficulty interpreting and assessing "broader impacts."

- Since the **distribution of panels** is so crucial to the distribution of funding, the AAG should openly articulate how they establish the process for sorting proposals that lead to the selection of review panels.
- The **allocation of funds amongst AST's various endeavors,** which include grants and facilities, is a perennial issue. The COV applauds the recent implementation of a "firewall" around (portions of) the grants program, and also wonders if some additional programs that would **attach research funding to time allocation on NSF facilities** would also help maintain enough funding for the "science" made possible by new and existing NSF facilities. More drastic solutions might include separating construction, infrastructure, and maintenance (facility) funding from grant funding in Astronomy more formally, and future NSF-wide evaluations might want to consider that option.
- There are differences amongst program officers in how much **feedback** is given to proposers. Some care should be taken to harmonize feedback, especially around reporting ranks, or, more helpfully, "top-third, middle-third, bottom-third" style scores.
- In evaluating demographic information provided, the COV found that AST is making good progress in increasing **participation** by historically underrepresented groups and in assuring the success of early-career investigators.
- Mechanisms for funding **instrumentation** using funding from beyond AST are vital in astronomy, and the COV recommends looking at ways to increase and enhance the MRI and MSRI lines in the NSF budget.

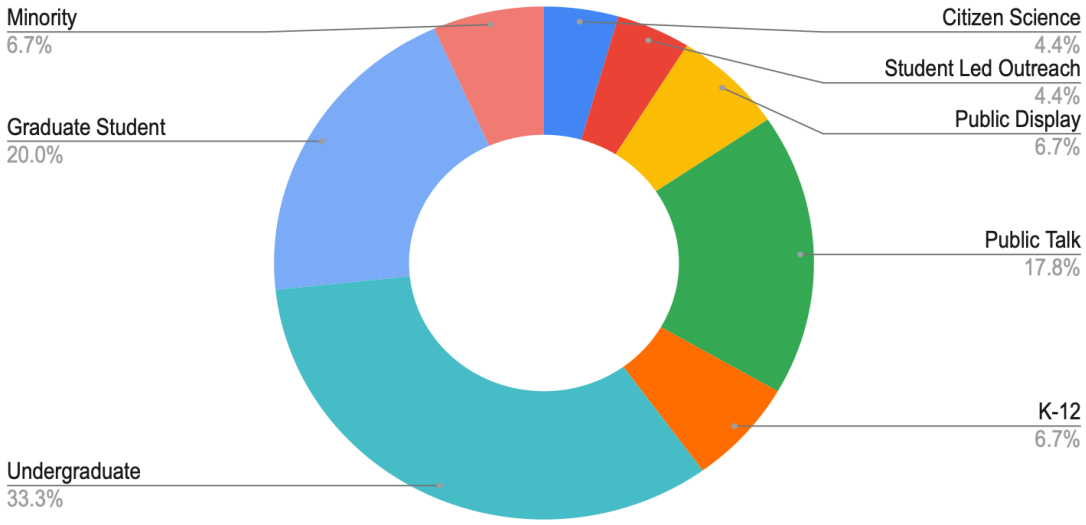
We additionally comment, only as it relates to our charge, in this report on AST's response to-date to the 2020 Decadal Survey on Astronomy and Astrophysics (Astro2020).

- As has been pointed out by many groups who have preceded the 2023 COV, expected AST budget allocations are far below what would be needed to implement even the top recommendations of Astro2020. The most expensive projects are, at present funding levels, unaffordable without starving out researchers. Theorists and data scientists whose work is seldom attached to a particular facility could be hardest hit, even if funds are attached to time allocation on new facilities.
- The cost of sustaining technological infrastructure **(data archives and software**) is a rising fraction of real costs in doing research but is hard to fund as "research" via direct costs in standard grants programs. Ways to expand the funding base for sustainable software should be sought, as this need is likely to continue to grow, as Astro2020 points out.

Details on Recommendations beyond the Core Questions

The details of these five recommendations presented above are as follows.

1. The section below on **Broader Impacts** (BI) discusses how we recommend NSF proceeds in addressing the persistent confusion over the meaning and evaluation of "Broader Impacts." Even though some proposers might mis-interpret examples of good BI as direct guidelines, the COV still feels that documentation of the broad range of successful BI efforts would be very helpful. The chart below summarizes the broad range of proposed BI efforts in a sample of recent AST awards, and the information on which it is based is presented in Appendix B. We note that confusion about Broader Impacts was also highlighted as an issue to be addressed in the 2019 COV report to AST.

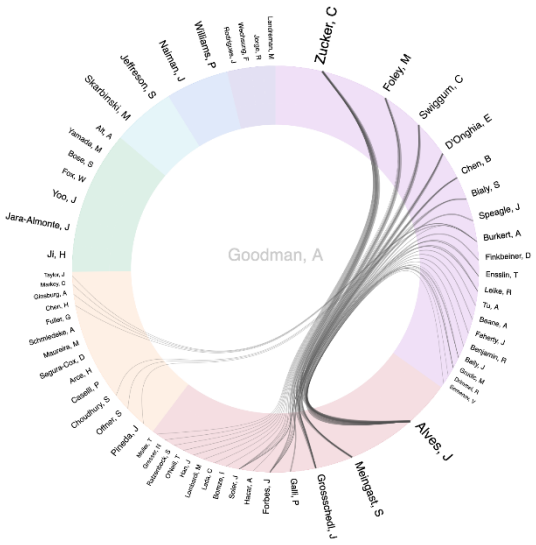


2. In principle, proposals to NSF can span **multiple divisions**, or even **multiple funding sources** (including other government agencies, private foundations, or commercial entities). Historically, PIs have not been savvy about how to approach NSF about these co-funding opportunities. Sometimes funders at NSF beyond AST are skeptical that AST's proposers can add value to their Division.

   We recommend that AST convene a special working group to assemble examples of where AST-funded research has had impact, both scientific and commercial, beyond astronomy. The examples in Appendix C, relevant to data science (see recommendation 4), extend beyond astronomy in their utility. The working group should tap into community expertise, especially via those who have had successful co-funded projects in the past, and then should seek ways to expand funding to the astronomy community via co-funding that would be mutually advantageous to all funders. Instituting this working group would also address the (possibly

impractical) suggestion made in the 2019 COV report of designating POs as liaisons to specific other agencies.

3. Proposal review is so central to NSF's mission that improving methods for **finding expert reviewers is of utmost importance.** Over the past ~decade, it has become extremely challenging for AST to assemble panels of highly-qualified yet unconflicted reviewers in fields where collaborations are large (e.g. Smith 2016). The first group of recommendations in the 2019 COV report (see its Appendix B) concerned reviewer selection and training, and the suggestions in this 2023 report address similar concerns to those raised in 2019.



Astronomy's "ADS" is the paragon of literature search, consolidation, integration, and access to which other fields of science aspire (Borgman and Wofford 2021; Borgman et al. 2016). As a result, **AST has a unique opportunity to lead at NSF** by making use of ADS tools to identify both qualified reviewers and conflicted reviewers. For example, amongst its many sophisticated features (Kurtz, Chyla, and The ADS Team 2020), ADS offers an "author network" graph that shows the strength of connections between authors. ADS and AST leadership are already in touch about how NSF can set standards for how "closely connected" authors must not be to avoid COI. Appendix A shows how extant ADS tools can be used to narrow down the list of conflicted reviewers, using networks like the one shown here for Alyssa Goodman's collaborators over the past decade. In addition to using ADS, we recommend that NSF still explicitly ask proposers to identify conflicts that might not show in co-authorship networks.

4. Just as astronomy is held up as an exemplary community when it comes to organizing its literature (see recommendation 3, re:ADS), **astronomy is also seen as leading in data sharing** and **open-source code development practices.** Appendix C gives a short list of examples where recent NSF-supported data science efforts by astronomy researchers have led to viable, profitable, technologies that impact the US economy. Proposers are asked for a "data management plan," but explicit support for the kinds of sophisticated data and data science infrastructure that have led to successful tech transfer (e.g. Appendix C) is scarce. Either by re-alignment of priorities within AST, or by collaboration with other Divisions or agencies (e.g. TIP, see recommendation 2), increased near-term investment in data and data science in support of astronomy should yield substantial gains in the long run.

5. Emphasizing and restructuring **communication** with the public would: 1) improve STEM awareness in the US; and 2) raise the value of AST's portfolio, which should ultimately also lead to higher funding levels.

Core questions

INTRODUCTION

The COV commends the AST staff for their excellent work. The program officers and leadership are doing a fantastic job at advancing our understanding of the Universe with NSF funding. The **recommendations above** reflect the particular areas where the COV believes AST's processes could be further improved. As per the COV's charge, though, the specific "core questions" posed to the committee by NSF policies are addressed below.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS

Are the review methods (for example, panel, ad hoc, site visits) appropriate?

Panels are the primary method of review in the AST program. When a proposal with a particularly esoteric topic comes up, *ad hoc* reviews are solicited. These are often overlooked at first by panelists, but usually added to the discussion. Site visits are only used as part of a selection effort for large facilities. The COV finds this range of methods appropriate.

Are both merit review criteria addressed in:

- ***individual reviews?***
- ***panel summaries?***
- ***Program Officer review analyses?***

The COV found that, overall, both intellectual merit (IM) and broader impacts (BI) are addressed in individual reviews, panel summaries, and Program Office review analyses.

There is considerable variation in the length and detail of **individual reviews** and **panel summaries**. Some reviews delineate only "strengths" and "weaknesses," while others explicitly "major" and "minor" strengths and weaknesses. Merit review criteria for BI tended to be much more cursorily addressed than IM.

It was concerning to hear that occasionally inaccurate, irrelevant, and especially unprofessional content was included in reviews prior to returning them to the PI. AST should investigate ways to ensure the accuracy of reviews, as well as that offensive language not be included. This could include more extensive editing of reviews by program officers or post-panel editing by reviewers. The COV was told that strikethroughs and redactions are sometimes used in these cases but the meaning of

these were not clearly communicated to PIs in a standard way. The COV recommends that AST standardize communication in such instances to improve clarity.

The COV formed a general consensus that there was a **large dispersion in how BI were assessed in the reviews.** While reviewers are not asked to weigh IM and BI in particular ways, it appears that many proposals are much more heavily weighted to the former than the latter. While the PAPPG notes specific elements of both IM and BI, detailed assessment of BI was often missing or inappropriate. For example, some proposal reviews criticized BI plans for lacking public outreach, but this is a very narrow reading of broader impacts.

The COV heard that review panels are briefed on what is included in BI. The COV would like to see a more active role of the program officer in redirecting when a panel summary uses a narrower interpretation. We understand that assessing the BI of a proposal is a thorny issue that transcends the AST division.

With help from current and former NSF staff, Appendix B was assembled after the COV visit (see "Recommendation 1," above) to provide an overview of BI from a recent sample of successful proposals. A more thorough analysis along these lines might inform future efforts in reviewing BI.

Program officer review analyses were by and large thorough, detailed, and thoughtful reflections of the panel discussion. A sentiment was expressed that releasing these to the PI would be potentially much more helpful than the individual reviews and panel summary. These analyses also contain the rationale for why a proposal may have remained unfunded despite strong backing from the panel.

Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals?

Almost all reviewers take the process very seriously, and most do their best to provide substantive comments. **Nevertheless, a mismatch in expertise between reviewer and PI is not uncommon,** and this may account for some discrepancies in ratings (see "Recommendation 3, above). Some reviewers simply do not like some topics, and some do not see the proposed BI efforts as meeting their definitions of the NSF criteria. While most reviewers strive to keep their personal opinions out of reviews, not everyone is successful. The panel summary, written after extensive discussion among the entire panel, should make (more) clear how the panel discussed and resolved any discrepancies between an individual review and the final summary.

Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)?

The panel summaries sometimes provide the rationale for the panel consensus. There are examples where the panel summaries seemed to be copy-pasted from individual reviews, with little additional information provided, or at worst a statement about agreeing with individual reviews. Comments on the data management plan, if available, were often perfunctory.

Does the documentation in the jacket provide the rationale for the award/decline decision?

For the vast majority of the jackets, the rationale for the award decision is provided. This rationale is **not** necessarily clearly articulated in the reviews or the panel summary. Instead, the ranked list available to Program Officers is helpful, so program officer review analyses included in jackets shared with the COV provide important additional information and context that explains the award/decline decision. It would be good if more of this information could be shared with PIs after the reviews (see below).

Does the documentation to the PI provide the rationale for the award/decline decision?

The documentation provided to the PI sometimes provides a clear rationale for the award/decline decision, but frequently falls short. Proposals with similar-sounding strengths and weaknesses are not funded while others are. In many cases, the ratings from the initial reviews (excellent, very good, etc.) will be strong (all excellent, or E,V,G), yet the proposal is not funded. This can be confusing to the proposer. It does not appear to be standard NSF policy to report to the proposer a sense of where the proposal ranked (e.g. what quartile it fell in), so proposers do not automatically get a sense for how well their proposal was received in relation to other proposals. While Program Officers will often reveal this information if contacted, and some will include it in follow-up emails to proposers, this is not a uniform practice. It is often the case that the clearest documentation of why a proposal was funded or not is in the review analysis (RA2), but this is not transmitted to the proposers.

As a result, the **COV recommends** that AST adopt as standard policy that the official decision letter sent to proposers contain at least some information on the **relative rank (e.g. quartile)** early in the text where it is more likely to be read. Information on the number of proposals funded in a panel, and its size, and financial constraints, or offers of such information if PIs want to contact Program Officers, would also help.

The **COV also recommends** that, absent some critical need such as triaging proposals, initial reviews not be required to include a rating (excellent, very good, etc.). If it is decided these ratings must be collected, it is recommended that these **initial ratings not be sent to PIs**, primarily because, prior to a panel's discussion, not all reviewers will have enough information regarding strengths and weaknesses

in order to offer an appropriate rating. Secondarily, studies of group decision making procedures show ranking/voting before committees discuss the relative merits of what is being considered (the proposal in this case) is often not optimal (Hochbaum and Levin 2006). Furthermore, studies of committee decision making processes find that people often look for and more heavily weight perspectives that support their initial vote (confirmation bias; e.g. Frey and Schulz-Hardt 2001) instead of equally considering all perspectives. So, as individual reviewer ratings often do not reflect the final panel decision, or even an individual reviewer's post-panel opinion, it can be confusing to send them to PIs without explanation of how a panel discussion might/might not have changed a reviewer's mind.

Additional comments on the quality and effectiveness of the program's use of merit review process.

Minimizing Return Without Reviews (RWR)

The merit review process can only work when proposals are actually reviewed, so AST should do as much as possible to ensure that proposals submitted qualify for review. While the vast majority of the proposals are reviewed, some are returned to the proposer without review. The primary reason for this RWR is a proposal's failure to discuss results from prior funding for the PI or any listed Co-PI. Many PIs think this prior funding requirement pertains only to work related to what is being proposed, but that is not correct. It can be very frustrating for proposers to have their proposal returned, so the most common RWR causes should be stated openly, perhaps on AST's website, if possible.

Hopefully as proposal submission moves fully to Research.gov, results from prior funding will move to a specified field in the system that can be automatically checked to make sure that the requirement is fulfilled. The COV recommends that AST work with NSF to ensure this **automatic checking can be implemented.** Also, having proposers submit extra-early was not deemed a viable solution to this issue.

Broader Impacts

Many astronomers proposing to NSF as well as many reviewers of NSF proposals apparently do not understand what constitutes acceptable BI. The COV understands, from discussions with AST staff, that by "Broader Impacts," NSF means impacts to society, broadly interpreted. The committee noted a tendency of AST reviewers to define BI simply as "outreach" with a goal of reaching particular communities that are currently under-represented in STEM, and thus penalizing in their reviews, other valid proposed BI efforts (see Appendix B). The COV found that the range of BI quality was larger than the range of IM quality as assessed in the reviews. Common criticisms of BI content pointed to deficiency in describing how the activities would be evaluated (only one of the five review elements for BI).

The COV came up with several ideas to assist proposers with the broader impacts portion of the proposal evaluation. **The COV recommends that the AST Division offer:**

- examples of successful proposals with strong broader impacts, noting that these are representative only and should not be used to narrow an interpretation of how to demonstrate broader societal impact (perhaps selected from examples in Appendix B).
- workshops, town halls, and panels with program officers and successful proposers with strong BIs
- a statement about how BI efforts could/might/should be evaluated
- guidance on how and when to work with one's institution should any IRB approval be needed

SELECTION OF REVIEWERS

Did the program make use of reviewers having appropriate expertise and/or qualifications?

Did the program recognize and resolve conflicts of interest when appropriate?

Additional comments on reviewer selection.

The selection of reviewers is a persistent COV topic. Responding to the 2019 COV advice, AST vowed to explore new ways to identify and recruit potential reviewers. The 2023 COV commends AST for:

- Removing the strict COI rule that barred anyone who proposed to AAG in a given year also reviewing for AAG in that year.
- Keeping an option (post pandemic) for hybrid-panels, which has the potential to improve the diversity of panels.
- Assembling diverse panels across a range of factors (e.g., gender, institution type, geographic location, career stage, etc.).
- Using *ad-hoc* reviews as appropriate, including from international reviewers.

In addition, the 2023 COV has the following recommendations concerning reviewer selection:

- As explained under "Top Recommendations" and in Appendix A, the use of (ADS) **author networks** should dramatically reduce conflicts of interest and thus improve panels' expertise and diversity.
- Starting around 2019, there appears to be a notable increase in panelists across multiple programs identifying as a **third gender option** ("unknown", "other", or blank; see Figure below). The COV suspects this rising unwillingness to report gender identity may be a reaction against NSF's old-fashioned gender-selection options. AST should consider lobbying NSF to update the methodology of its profile information collection to allow for a broader range of gender identities, while continuing to ensure discretion and security of collected personal information. Another

contributor to non-selection of binary gender options may also be concern that reporting as "white male" puts a proposal at a disadvantage.

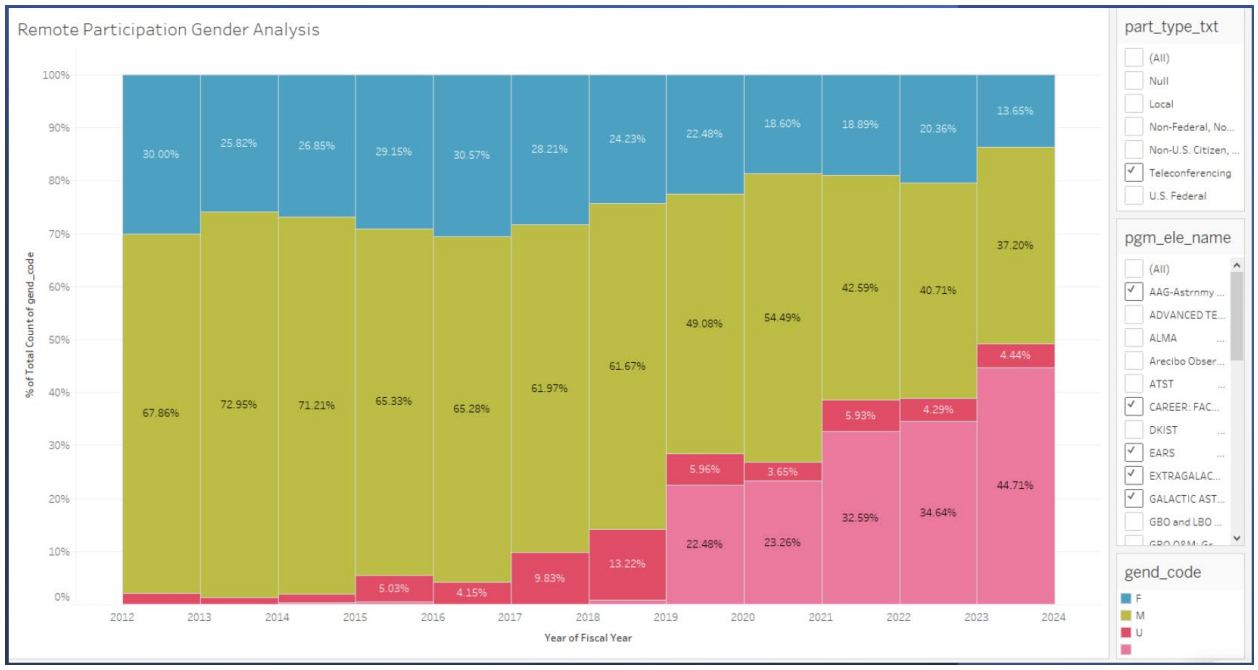


***FIGURE**: The trend over time of how remote panelists in major programs identified – male, female, unknown ("U"), or blank. This trend of a growing number of "U" or blank responses is also representative of in-person panelists, non-US citizen panelists, and federal employee panelists. **SOURCE**: Panelist Type Analysis, SharePoint, Matt Viau.*

MANAGEMENT OF THE PROGRAM UNDER REVIEW

Management of the Program

The AST faced major challenges in 2019-2022 including the global pandemic, **transitions through four division directors,** and flat or decreasing budgets. They have continued to successfully manage the complex portfolio and support their awardees who were experiencing disruption in their programs as well.

Previous COV reports noted the need for **increased PO staffing of AST;** this continues to be a relevant issue, based on the increase in panel reviews and total reviews across all programs compared to FY 2019. Important efforts to expand the participant pool for panels and other reviews also adds to the workload of PO staff, as do the necessary ongoing efforts to educate new participants on the expectations of their roles and the entire community on the subtleties of evaluating the BI criterion within grants.

In an organizational management context, successful long-term internal planning and implementation efforts are facilitated by coherent formal frameworks designed to provide rapid dissemination of information and encourage collaborative feedback. AST has a robust structure for implementing changes leading to continuous improvement. AST takes a team approach, using documented operational procedures, wikis, and group collaboration tools to impose a defined structure to approaching decisions while still providing flexibility to PO staff actions. The AST division has also implemented formal end of year retreats in which forward-looking issues germane to NSF as a whole and to the division specifically can be addressed.

Responsiveness of the program to emerging research and education opportunities

AST has been proactive in implementing new NSF-wide science and opportunities. One of the NSF's Ten Big Ideas, "**Windows on the Universe**: The Era of Multi-Messenger Astrophysics (WoU-MMA)," provided new funding starting in FY19. The WoU-MMA program has funded programs in CISE, ENG, & EDU, but most of its funding has gone to MPS and GEO. WoU-MMA supported research to advance the interoperability of studies using electromagnetic waves, high-energy particles including neutrinos and cosmic rays, and gravitational waves to realize integrated, multi-messenger astrophysical explorations of the universe. In AST the program has supported theory, observation, and computation studies, as well as infrastructure to enhance communication and interoperability within the MMA community. This program averaged an additional **$7 million/year for AAG**, which resulted in **an increase in success rates in supported programs**.

The AST Program Officers are working on establishing relationships with the staff at the new **Directorate for Technology, Innovation and Partnerships (TIP)**. This new Directorate is focused on advancing use-inspired and translational research in all fields of science and engineering, giving rise to new industries and engaging all Americans — regardless of background or location — in the pursuit of new, high-wage jobs in science, technology, engineering and math. The COV encourages the POs to continue these efforts, as is reflected in "Top Recommendations" 2 and 4, above.

The PAARE (Partnerships in Astronomy and Astrophysics Research and Education) program was restarted in 2021, which the COV was delighted to see. AST is also participating in MPS-LEAPS (Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences) and MPS-ASCEND (Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowships) programs. These programs were initiated during the pandemic.

> **PAARE** supports partnerships between institutions that provide pathways into research and broaden the participation of individuals from groups underrepresented in astronomy.

LEAPS supports the research of pre-tenure faculty in mathematical and physical sciences, with an emphasis on those at institutions that traditionally do not receive significant NSF funding, such as minority-serving, predominantly undergraduate or R2 institutions.

ASCEND supports postdoctoral fellows performing impactful research in MPS fields while broadening the participation of groups that are underrepresented in the mathematical and physical sciences.

Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Given overall budget pressures and increasing facilities costs, AST has done a remarkable job of making the hard choices to balance a portfolio that attempts to serve the community as widely as possible. AST recognizes the need to support not only established scientists, but also those at the early stages of their careers. However, proposal pressure from special programs for early-career applicants (NSF Astronomy and Astrophysics Postdoctoral Fellowships and CAREER awards) results in a funding rate that tends to remain lower than the overall grants rate. The AST is still working to balance the multiple **recommendations from the Astro2020 Decadal Survey, which cannot all be implemented without increased funding for the portfolio.**

Responsiveness of program to previous COV comments and recommendations.

The AST provided responses to the previous COV recommendations that are relevant to the more focused charge of this COV. AST's response to specific recommendations from the 2019 COV are shown **as indented bulleted lists** below. **Additional related suggestions** from the 2023 COV are **bolded**.

2019 # 1. AST should explore additional avenues to identify potential reviewers.

AST instituted multiple methods for identifying potential reviewers, including:

- web sign-up form
- more recruiting at meetings
- mass invitations to larger groups of potential panelists
- hybrid panel option for all panelists
- less restrictive NSF COI rules

2019 # 2. Strengthen the pre-meeting briefing

The slides have been improved in multiple respects:

- Broader Impacts

- implicit bias mitigation
- suggested review language

2019 # 4. AST should undertake a trade study to explore the potential impact of double-blind (anonymous) reviews (a.k.a. dual-anonymous peer review, DAPR)

- The AST FFRDC TACs have or are in the process of implementing dual anonymous reviews for telescope time. NOIRLab and ALMA have implemented it and NRAO will implement it in the future.
- For NSF individual investigator awards the DAPR model was studied across the board, and it would need to be implemented NSF-wide. The decision was made not to go forward with implementing dual-anonymous peer review.

Additionally: The 2023 COV suggests that a **public report explaining the decision not to implement DAPR at the NSF**, based on data, would be well-received by the community AST supports.

2019 # 7. We recommend that AST implement a more rigorous approach to Broader Impacts in all aspects of the review process.

- Internal training on review of Broader Impacts was implemented, along with improving the pre-panel briefing.
- Reviewers with expertise in Broader Impacts are recruited for the education and special programs panels.

2019 # 8. AST takes a leadership role toward developing a STEM workforce that reflects the rapidly changing demographics of the United States.

- AST and MPS established DEI working groups. These include assessment of broadening participation across the portfolio.
- Restarted the PAARE program and AST participates in LEAPS and ASCEND programs.

2019 # 11. Rapidly recruiting additional AST POs and replacements for key AST staff

- IPAs can now be hired before incumbents leave the NSF. The hiring process proceeds as rapidly as federal and NSF HR guidelines allow.

2019 # 12. Achieve a more representative Program Officer and Division leadership.

- New hiring has led to a more diverse program staff than in 2019.

2019 # 13: AST formally designate interagency liaisons for NASA and DOE.

- Liaisons have been formally designated to NASA Astrophysics, Planetary Science, and Heliophysics Divisions

- Formal collaborative structures already exist with DOE through the Rubin Observatory program.

Additionally: See "Top Recommendations" 2, above.

RESULTING PORTFOLIO OF AWARDS

Does the program portfolio have an appropriate balance of awards across disciplines sub-disciplines of the activity?

Program awards are driven by a balance of demand (number of submitted proposals per sub-discipline), merit-review, and program officer assessment of the most competitive proposals within and between panels and sub-disciplines. We recommend this approach continue, with one key nuance. Since the **distribution of panels** is so crucial to the distribution of funding, the AAG should articulate how they establish the process for sorting proposals that lead to the selection of review panels.

One area of imbalance is in **instrumentation**, in both Advanced Technologies and Instrumentation for the Astronomical Sciences (ATI) and Mid-Scale Innovation Program in Astronomical Sciences (MSIP), where there is insufficient program funding to meet levels recommended, e.g., by the Astro2020 Decadal survey. The program should consider opportunities to compete facility instrument development, e.g., Gemini (as recommended in last COV), as part of existing AST programs and also other NSF-wide opportunities. Setting expectations with the community, especially in light of significant funding shortfalls in comparison with the Decadal Survey recommendations in this area would be wise. A targeted facilities review, not the purview of the COV, by a group cognizant of the complexities of specific facilities and international partnerships, may be the best way to proceed.

Are awards appropriate in size and duration for the scope of the projects?

The median award size has remained fairly consistent at $117,000 per year. With inflation, this represents a decrease in real dollars going to fund each project. Most awarded grants were funded at or close to their requested budget. Exceptions to this were well documented and justified. The median project duration has held steady at 3 years (36 months), which seems to be appropriate for most PI funded projects. It would be useful, however, for AAG to provide guidance to PIs or review panels on how to best implement 3-year postdoctoral hires into 36-month projects given the lead time (6-12 months) typically required to recruit and hire.

Does the program portfolio include awards for projects that are innovative or potentially transformative?

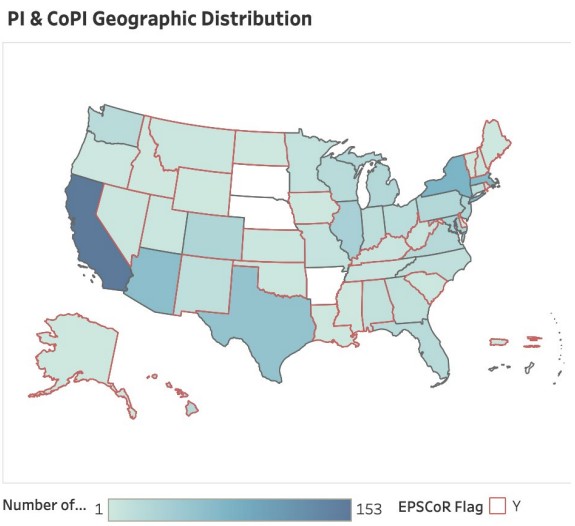
Yes. There were specific examples of awards for general research projects that satisfied these criteria, with panels specifically identifying them as "novel," "transformative," and/or "high-risk/high-reward" in their Intellectual Merit, and "unique" for Broader Impacts. There are additional specific, innovative instrumentation examples in NSF AST ATI proposals. Fewer examples of truly *transformative* efforts are readily apparent in instrumentation, but we note that: (a) determining what is transformational versus what is potentially transformative often takes time; (b) the limited scope of the instrumentation budget within NSF Astronomy is one limiting factor.

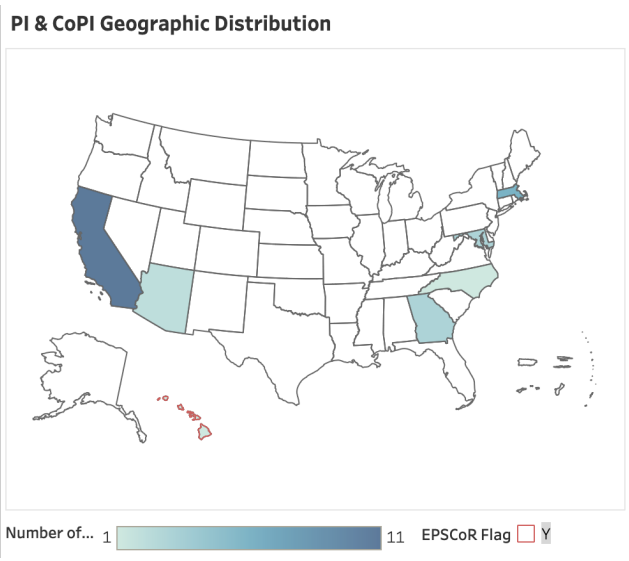
Does the program portfolio include inter- and multi-disciplinary projects?

There were inter- and multi-disciplinary projects in the portfolio, some representing net gains for AST, others representing net losses, in terms of effects on the AST budget. Most notable was Windows on the Universe (WoU-MMA), which added almost $30 million over the COV period. The largest share of funding leaving AST went to support programs in the PHY division (about $10 million in total), mostly the Physics Frontier Centers, Integrative Activities in Physics, and the AI Research Institute. These seem appropriate, as they all contain or support astrophysics components.

Does the program portfolio have an appropriate geographical distribution of Principal Investigators?

The geographical distribution of PIs and co-PIs appears representative of the expected concentration of proposing institutions across the nation (see Figure below from Tableau; **left**): CA had the largest number of PIs at 112 followed by NY and MA at 59 and 51, respectively; 14 and 13 PIs were in HI and NM, which are Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions (25 states, plus Puerto Rico, Guam and USVI), although 3 of the EPSCoR jurisdictions (SD, NE, AK) did not receive any awards. Larger program (e.g., MSIP; **right** Figure below from Tableau) awards tend to be concentrated in a very small number of states; this may be appropriate, but without additional metrics it is not possible to assess. In this case, given small number statistics, a larger time-window would be beneficial to review.



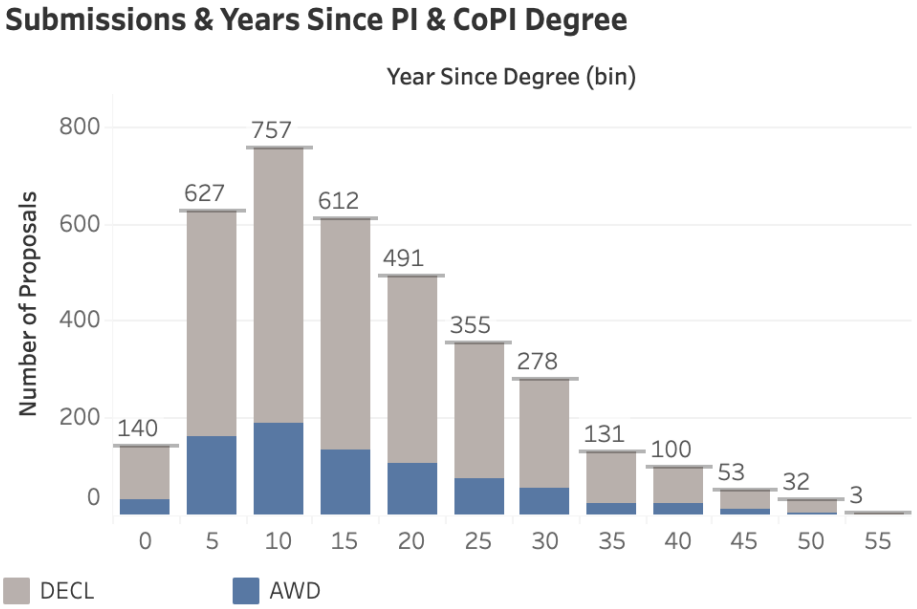


Does the program portfolio have an appropriate balance of awards to different types of institutions?

In some programs, e.g., AAG, 4-year institutions have equivalent or higher success rates than PhD granting institutions, but with many fewer applications. Several members of the COV teach or have taught at 4-year institutions and agree that the burden of heavy teaching loads and small or understaffed Offices of Sponsored Programs (OSPs) can make the prospect of submitting research proposals daunting. If the dearth of proposals from smaller institutions is due to the increased investigator burden of grant management at 4-year institutions, NSF could consider ways to aid in grant management for smaller schools - perhaps a consolidated Office of Sponsored Programs that could serve a consortium of schools. The NSF's new GRANTED program appears to be a step in the right direction. Similar consolidation may also be appropriate for data management. Determining if this conjecture of burden is correct would be the first course of action.

While applications do come from 4-year institutions, the numbers of applications are low overall. CAREER grants had a higher decline rate overall for 4-year institutions. Where smaller institutions seem to have a higher success rate than PhD and Masters program schools is in Special Programs in Astronomy. We recommend NSF consider ways to increase the number of applications from 4-year institutions, particularly public institutions.

Does the program portfolio have an appropriate balance of awards to new and early-career investigators?



The NSF has done a commendable job in assuring that new and early career investigators have success in grants at a rate similar to those at other stages in their career. Overall, investigators with 0-5 years since degree are awarded at a slightly lower rate (19%), than those with 10-15 years of experience (26%). The difference (see figure above) is smaller for AAG grants (21% awarded for 0-5 years since degree compared to 25% awarded with 10-15 years since degree). Success rates for CAREER grants are about half this rate (10% for investigators with 5-10 years since degree), but this is a highly competitive program, so this difference is expected.

Does the program portfolio include projects that integrate research and education?

For review of eJackets, funded proposals often had excellent Broader Impact (BI) plans that were detailed and specific and made the explicit integration of research and education. Other successful proposals had more discipline-specific BI plans, but even these plans were detailed and specific and went beyond a narrow community.

Does the program portfolio have appropriate participation of underrepresented groups?

The fractional participation of reviewers and awards of underrepresented groups is exactly matched; this is commendable, but insufficient. It is *highly* desirable to raise the overall level of 7% in both categories, and the NSF should continue exploring ways to do this. This must be a priority.

Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports.

The NSF AST Division has been relevant and responsive to the national priorities as expressed in the recent National Academy of Science, Engineering, and Medicine (NASEM)'s Astro2020 Decadal Survey ("Pathways to Discovery in Astronomy and Astrophysics for the 2020s"), within their means. The three science themes called out in this survey for focus and investments align well with the research activities supported by the division at all scales from individual investigator grants to mid-scale instrument/facility development to large projects. AST admirably has been satisfying its mission (stated at nsf.gov/mps/ast/about.jsp) in supporting forefront research, access to world-class research facilities, development of new instrumentation and facilities, and promoting understanding of astronomical sciences by a diverse population of scientists, policy makers, and the public.

Astro2020 recommended a range of expenditures for astronomy, from new large facilities at the MREFC level on down through midscale instrumentation (MSRI / MSIP / MRI / ATI), and grants (AAG, CAREER). Recommendations on workforce initiatives, transparency in budgets and proposal statistics, and efforts to ensure a sustainable future for astronomy additionally touch topics within AST's remit. The COV notes that it has been less than two years since the release of Astro2020, and only one budgetary cycle has occurred in which to implement recommendations. AST notes that many of the recommendations related to the state of the profession and workforce development are aligned with existing initiatives to support students, postdocs, and early-career faculty from under-represented groups. One recommendation from Astro2020 on re-establishing bridge programs was fortuitously (and likely coincidentally) resurrected by AST shortly after the release of the Astro2020 report. (NSF/AST's Partnerships in Astronomy & Astrophysics Research and Education [PAARE] program was specifically called out in Astro2020 as an exemplar bridge program, and a notice about its reinstatement occurred four days after the public release of Astro2020).

While there is insufficient time to have implemented the specific recommendations from Astro2020, the COV notes that a constant theme in the last several decadal surveys pertaining to AST has been increasing alarm about the falling success rates for individual investigator grants. Meeting overall constituent needs in the past has been limited by NSF AST's top-line budget, which has failed to keep pace with inflation, averaging only 1.35% growth year-on-year during 2019-2022. This has been further exacerbated by a significant decrease in support for the Individual Investigator Program, which has sunk by an average of 2.1% year-on-year during 2019-2022. The COV recognizes the need to balance building new facilities, maintaining existing facilities, renewing facilities of all ages and classes through clever new instrumentation, and providing grants that support researchers to produce the wide array of science that comes from ground-based telescopes.

AST is moving forward with activities related to the large ground-based facilities recommended by Astro2020. Note that both TMT and GMT completed Preliminary Design Reviews, an environmental review process has started for TMT, and a Blue-Ribbon panel to advise the MPS directorate about advancing these projects to the Final Design Phase is being planned. This partly addresses the decision rules underpinning Astro2020's priority recommendation for the US ELT program in the area of frontier ground-based observatories; additional information regarding management plans, governance structures and plans for public data access and archiving is still needed. Other large ground-based projects, CMB S-4 and ngVLA, are slowly advancing, commensurate with the equal priority given to these facilities for their expected scientific contributions, and availability of funds to support the differing stages of design and development. Partnership decisions are still in flux for these two projects. For the former, there has been a need to develop scenarios to address infrastructure issues at the South Pole. The ngVLA is presently entering NSF's MREFC Conceptual Design phase.

Additional comments on the quality of the projects or the balance of the portfolio.

Generally, the quality of the projects is outstanding. In fact, there were many high-quality proposals that went unfunded. There seems to be no shortage of great science awaiting NSF support, which is another clear call to increase funding.

OTHER TOPICS

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

1. There is a lack of funding for development of new astronomy instruments, which are growing in complexity and cost. This is a serious gap that AST/ATI and the NSF-wide MRI and MSRI programs were designed to address, but are not able to do so within increasing budgetary pressures from facilities. We recommend **additional investment in both ATI and MSIP**, more regular MSIP calls, as well as setting aside part of MSIP funding to explicitly ensure seed-funding to initiate and/or develop concepts into future MSIP or MSRI projects, especially those that are broadly responsive to decadal priorities or long-term goals of the division.
2. AST urgently needs to **engage more with TIP** and build a strong collaboration and pipeline with TIP that serves both AST, TIP and the wider astronomical community. Steps have already been taken in this direction - and we recommend that additional resources, effort and people are dedicated to this effort, as well as more direct communication with the community and PIs to guide them in navigating this funding landscape.
3. The **division is understaffed** for the level of effort and complexity in AST given the complexity of both facilities and grants programs. This has led to increasingly long turnaround times for grant proposals. This also impacts the ability for AST POs to be "out in the field/community".

More engagement with the community could be managed through more virtual meetings and workshops.

4. We recommend the division move towards the development of an effective 'firewall' to ensure that the individual grants program is protected from rising facility-costs so the grants program **does not shrink in real-year dollars, an**d is in fact able to increase as the astronomical community continues to grow. The principle should be to enable funding rates around 33% in AAG and 50% in ATI/MRI. These points connect to astro2020 recs in their Section 4.2.1.
5. The COV recommends that the division moves towards a more streamlined and efficient way for proposers to identify actual **conflicts of interest** (see "Top Recommendations" and Appendix A). With the rise of large collaborations, existing mechanisms are untenable for a robust review process with real expert reviewers.
6. A common if not ubiquitous occurrence is for a proposer to receive an **inquiry**, while the proposal is still pending, regarding **possible reductions in the budget**. This has the potential to be incorrectly perceived as a requirement to cut the requested funding in order for the proposal to be awarded. Most proposers currently think they must make some cuts to be seen as responsive and therefore willing to help AST. The intent of the program officers is to learn whether the project has received other resources since the NSF proposal was submitted or if there are other changes in circumstances that would affect the budget. Communication of this intent, and of expectations regarding this standard practice should be made much clearer to the proposers to avoid any ambiguity and fear.
7. We are concerned that **science** done with **NSF-funded facilities** (theory and data) is **not adequately supported**. At a minimum, we need to collect data to assess whether this is significantly hampering the science return from these facilities. Maximal plan would be to **provide facilities with money** to disburse for, e.g., archival research, facility-specific pipeline/algorithmic development, along the lines of how NASA missions support their work. A good example of an existing NSF facility-support tie-in is the NRAO "student observing support" program.
8. **Panel definition and proposal sorting.** NSF should explore, with the goal of reducing the workload on program managers, whether PIs should self-sort by checking boxes for programs (EXC, GAL, SAA, PLA). **Explore use of AI and other tools for clustering** proposals into panels.
9. Technology development initiatives and instruments that are funded by NSF at Federally Funded Research and Development Centers (**FFRDCs**) should be held to at least **similar levels of review, risk-assessment and oversight** as applied to technology and instrumentation awards in the **grants** programs, to minimize risk to the overall portfolio.

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.

1. The ATI and NSF-wide MRI (and in principle MSRI) instrumentation programs are key to realizing the science on non-FFRDC facilities, and a relatively inexpensive way for NSF to fund high-impact science. Technology and instrumentation investments at such facilities are significantly leveraged due to the existing partnerships, largely privately funded, that operate them. A current frustration in the community is the different standards that are applied to different facilities for the expected direct return for every NSF investment; for example, public access to archival data associated with one MRI-funded facility, or immediate open access telescope time at another facility. The **appropriate and acceptable exchanges should be standardized in a way that is transparent to proposers**.
2. Furthermore, there is discussion around whether the standards applied in AST for return on investment (beyond realizing the science enabled by the NSF technology or instrumentation award) should be consistent with those in other divisions, where grants to provide instrumentation in laboratories or facilities that are private to a single university or even a single research group are routinely awarded, without an expectation for public access to the lab.
3. Historically, the suite of private and public-private telescopes and collaborations in both optical/infrared and radio astronomy have been a key cornerstone of US astronomy, and the private-federal partnership model is one that we have to get right for ELTs.

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

1. NSF prides itself on partnerships with universities and industry to realize science and technology. The "mid-scale" investments in instrumentation are a highly effective way to do this. **The COV recommends looking at ways to increase and enhance the MRI and MSRI lines in the NSF budget.**
2. More **inter-agency collaborations** are desirable. A clearly defined pathway to such collaboration seems to be absent, relying instead heavily on individual relationships between (already very busy) program officers at the different agencies. These issues should be addressed NSF-wide with additional resources and people.
3. Agency-wide there is a critical issue with operational costs of increasingly complex facilities. While MREFC processes have been effective in development of new facilities, there needs to be urgent development of **mechanisms for operational funding of these future facilities.** It is no longer reasonable to expect individual Divisions to be able to cover costs. This situation is particularly dire in AST- where lack of agency-wide recognition and action on this issue is

preventing the Division from moving forward to Astro 2020 key Decadal Survey recommendation.

4. NSF policy has a requirement for data sharing "...at no more than incremental cost…". The volume and complexity of astronomical data, metadata, and processing will typically make this impractical or an unreasonable load on proposers. Data management is critical infrastructure that must be funded, but not at the cost of not completing the proposed science. This committee recommends that the Division engages with the MPS Directorate to ensure that we do not impose unfunded mandates on the community and this important effort is supported and adequately funded.

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

1. **Data management plans in proposals:** The utility and review of data management plans (DMPs) lacks clarity and robustness. The need for DMPs in proposals comes from the NSF-wide data sharing policy. Some AST-specific guidance is provided to PIs through a supplementary document. After reviewing a representative sample of proposals to the AAG program, it is apparent that the quality and review of DMPs is highly variable but most often not robust.
    a. Many panelists may **not be qualified to review** the technical aspects and best practices of DMPs. We recommend that the NSF include a more comprehensive review of data management, either through including **relevant expertise in panels or through another review process.**
    b. **PIs may not be aware of accepted best practices** for archiving and sharing data. NSF AST does provide *"Advice to Principal Investigators (PIs) on the Data Management Plan (DMP)"* as a PDF on its website with guidance from *"Ten Simple Rules for the Care & Feeding of Scientific Data,"* (Goodman et al. 2014). In addition, a constantly-updated list of specific exemplar data management solutions (e.g., NOIRLab astro data lab, Dataverse, Zenodo, and others), with guidance to PIs, should be available. While responding to the Astro2020 recommendations related to data management, the NSF should **explore the need for NSF-hosted or NSF-supported data repositories**, within astronomy or across divisions. The NSF should develop stronger collaborations with NASA and other agencies to minimize duplication of effort.
2. **Support for astronomical software:** Significant individual investigator funding goes, indirectly, into supporting the creation of astronomical software, for example, through funded student and postdoctoral time. In the existing programs, this effort is generally only funded to do the proposed science. This has the potential to lead to an extraordinary amount of duplicated effort in software and algorithmic development. Investigators may be willing to mitigate this by supporting work to generalize and release tools for the community or work to maintain

widely-used software for long-term use by the community, but existing programs will generally disfavor this type of work as not being "transformative." **The NSF has other initiatives that may be more willing to fund this type of infrastructure work (e.g., TIP, CSSI)** and lead to value-added gains on existing investigator-led projects. However, astronomical software work may be considered **too specialized, or too "practical,"** to receive general technology and innovation funding. Furthermore, existing funding schemes generally do not address the needs of longer term (~10 year), lower level, and continuous support that would be needed to sustain software efforts for the community. We recommend that the **NSF develop a working group to address software, and its sustainability,** within the context of its individual investigator programs as a part of its response to the Astro2020 recommendation to "…develop a plan to address how to design, build, deploy, and sustain pipelines for producing science-ready data across all general-purpose ground-based observatories."

3. **Co-funding:** Proposers applying for funding across multiple agencies should indicate to their program officers at each agency of their intent to prompt inter-agency communication for potential shared funding opportunities. TIP Funding of projects related to **Electromagnetic Spectrum Management (ESM)** could be a way to benefit from additional funding sources as well as respond to the importance of ESM for both protection and coordination as called out in the 2020 Decadal Survey. We note that the 2019 COV report recommended raising the profile of the ESM office, and that ESM is an issue of growing concern as more and more of the spectrum is used by non-astronomical human endeavors.

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

1. More time for deliberations, review, and discussion is needed for the COV to fully vet the program. Less than one month was set aside during this COV session.
2. The COV appreciated access to the plethora of information contained in the eJackets. However, it would be useful to extract some key metadata (research theme of the proposal, panel and subpanel name, current and pending grants, rank in subpanel, highly competitive/ competitive / not competitive) about the proposals into functional spreadsheets or plots for our use.
3. The Tableau resource to which the COV was given access was almost great, but its interactive and export features were largely turned off, making it just shy of being really useful. It also went down on a critical day in the COV meeting!

Appendix A: Using ADS tools to narrow the list of conflicted reviewers

The information in this appendix is based on an email sent by the head of NASA ADS (Alberto Accomazzi) in response to a July 2023 request for information sent by the COV Chair (Alyssa Godoman). AST's James Neff and others are also on the email thread.

The suggested procedure for identifying COIs using NASA ADS:

1. Ask each proposer to create or update an **ADS Private Library** that contains all their papers. (Example, 334 papers, for A. Goodman) The library can be easily started using the proposers ORCID, which they should have in any case. For Goodman example, that [ORCID, automated, approach] would give this result (275 papers) which is an incomplete list in comparison with the private library.
2. NSF can, and should, determine how far they would like (a proposer, or an automated system) to narrow down the list of papers by adding publication date constraints to limit the "conflict." For example, the request could be "the top 20 author-author associations on "papers within the past five years."
3. This narrowed query can give a visualization for example, this, or a CSV file.

Note that the current procedure AST proposers use on ADS to create a list of (all) Author Affiliations is similar, but does not use the author network to rank the "closeness" of collaborators.

AST may also have to request author curation of their own ADS Private Libraries to facilitate a fair COI review by POs. But, since a Private Library summarizing all a researcher's work is very useful (e.g. on a researcher's website, for institutional measurement of research output), a request for a curated link to a Private Library is unlikely to be considered burdensome busywork.

Appendix B: FY 2023 Broader Impact Efforts, deduced from Galactic Astronomy Abstracts

Based on public Award Abstracts that may be searched via https://www.nsf.gov/awardsearch/advancedSearch.jsp

PI	Citizen Science	Student Led Outreach	Public Display	Public Talk	K-12	Under-graduate	Graduate Student	Minority Focused
1		✓			✓	✓	✓	
2						✓	✓	
3		✓		✓		✓		
4	✓			✓		✓		
5						✓	✓	
6						✓	✓	
7						✓	✓	
8						✓	✓	✓
9				✓		✓	✓	✓
10					✓	✓		
11						✓	✓	
12						✓		✓
13			✓	✓	✓		✓	
14	✓			✓		✓		
15				✓		✓		
16			✓	✓		✓		
17			✓	✓				
TOTALS	2	2	3	8	3	15	9	3

A summary of the distribution in this table is shown in the doughnut chart in the body of this report.

APPENDIX C: TECH TRANSFER EXAMPLES

Wise.io

wise.io founded by UC Berkeley Astronomy Professor Josh Bloom, was a pioneering effort applying machine learning to large data sets. The company was acquired by GE in 2016, as described in this TechCrunch article (GE acquires Wise.io to deepen its machine learning stack), which includes the statement "GE expects that software will bring in $15 billion in revenue by 2020 "

glue and glue genes

glue solutions, inc. is a consultancy founded by Harvard Astronomy Professor Alyssa Goodman in 2019 to build upon the (NSF-supported) glue exploratory data visualization environment. The company's main product is currently "glue genes," a version of glue currently used in genomics, and being tailored for use in the coming spatial omics revolution. An article on The Jackson Laboratory's (JAX) website, "glue: Making sense of the universe in three dimensions," explains that "glue is now being applied to genomics at JAX through a suite of tools called "glue genes," making visualizations possible for the endless streams of bases (A T G C) and biological complexity to reveal patterns and insight otherwise hidden in the data."

Vaex

Vaex.io offers super-fast calculation capacity for very large tabular data, and it is now in use across several industries. It was founded by Maarten Breddels, trained as a PhD astronomer, who used pieces of the open-source glue library (see above) to build the software. Breddels is also an author of several packages in widespread use across the Jupyter community, including Solara and Reacton.

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