NSF CISE Committee of Visitors Report

for the Divisions of

Computing and Communication Foundations (CCF)

Computer and Network Systems (CNS)

Information and Intelligent Systems (IIS)

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September 29, 2023

Executive Summary

A Committee of Visitors (COV) was assembled in July 2023 and charged to review the quality and effectiveness of the merit review process, the selection of reviewers, the management of the programs under review, and the resulting portfolio of awards for three divisions in the directorate for Computer and Information Science and Engineering (CISE), namely Computing and Communications Foundations (CCF), Computer and Network Systems (CNS), and Information and Intelligent Systems (IIS), for the four-year period from fiscal year (FY) 2019 through FY 2022.

The COV found the processes followed by CISE and its portfolio of awards to be of exceptional quality in all three divisions reviewed. CISE continues to manage the review process with impressive quality and integrity, and continues to maintain a balanced portfolio of awards that addresses national priorities, despite a shortage of staffing and limited software tools. CISE is to be commended on its efforts to innovate in its processes, and to thoughtfully address the recommendations of past COVs. CISE is managed by an outstanding team.

The above-mentioned successes notwithstanding, they have been realized in a manner that cannot be sustained. There is a significant risk that CISE will soon become unable to continue to fulfill NSF's mission. The problem is exacerbated by a number of recent trends, including the increasing importance of foundational computing research to emerging industries for economic and national security and to the development of research infrastructure, the rising challenges to US leadership in research and technology, the surging demand for computer science education, and the explosive growth of computer and information science and engineering departments in universities and colleges nationwide.

To continue to support NSF's mission --- and, specifically, to (a) match the increasing importance of foundational computing research for tackling societal grand challenges, and (b) train the next generation of the nation's computing workforce that will drive economic growth --- the COV recommends increasing funding for CISE.

The COV makes eleven additional recommendations to achieve a number of strategic and operational goals. These goals include effectively supporting the growing CISE-funded community, expanding access to computing-related opportunities, frequently aligning programs with national needs, developing effective partnerships with industry, increasing the visibility of CISE-funded research and education, streamlining proposal processing, and facilitating the sharing of best practices across CISE.

This report details the findings and recommendations of the COV.

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1. Context of COV

This Committee of Visitors (COV) review comes at an exciting time in computing research. The community that the directorate for Computer and Information Science and Engineering (CISE) funds (i.e., the CISE-funded community, or "the community" for short) is making foundational contributions to longstanding and emerging research areas. The community is actively exploring the opportunities and identifying the risks posed by recent developments in generative artificial intelligence (AI) and large language models (LLMs). Quantum computing, quantum networking, and post-quantum cryptography are making great strides. The community has a renewed focus on sustainability and a continued focus on cybersecurity, privacy, and the next generation of wireless networking technologies. Interdisciplinary research is thriving, including in areas such as smart health, smart agriculture, and smart cities and communities. The foundational contributions made by the community have both immediate and lasting impacts on our daily lives, and will continue to drive the innovations and industries of the future.

The four-year review period for this COV was marked by the COVID-19 pandemic. The pandemic upturned life everywhere on the planet. Yet, life and work continued, from music lessons to on-line classes, yoga sessions to working-from-home. This was the case because of the technologies, tools, and systems directly enabled by foundational research supported by NSF CISE over the past decades. As we enter the always-connected digital world of societal, economic, and healthcare systems, the importance of foundational research supported by CISE cannot be overstated. More and more computing technologies are adapted, integrated and/or translated to accelerate scientific discovery, solve hard engineering problems, and catalyze emerging industries, and it is critical to support the foundational research pipeline that has driven these advances, and will continue to drive future innovations.

The US tech job market continues to grow, with a significant fraction of the projected fastest growing occupations for 2022-32 being in computing, information, and related fields (see https://www.bls.gov/ooh/fastest-growing.htm). Computer and information technology companies have been tremendous creators of broad economic wealth. Computing innovations are becoming enablers to a large number of disciplines in almost all domains of human knowledge, and are core to solving societal grand challenges.

As a direct result of this increasing importance of computing, the number of students majoring in computer science has skyrocketed nationwide (see https://cra.org/resources/taulbee-survey/). Additionally, the number of non-majors taking computer science classes at universities across the country has surged. For example, in mid-level computer science courses, the number of majors increased by 152% and the number of non-majors by 251% (see https://cra.org/data/generation-cs/impact-nonmajors-enrollments/).

To cope with this rising demand from students, the number of faculty members in most computer science and computer engineering departments in the country is growing rapidly. The number of

assistant professors among the faculty is also growing as a result (see https://cra.org/crn/2023/01/analysis-of-current-and-future-computer-science-needs-via-advertised-faculty-searches-for-2023/). CISE is the major source of federal support for these faculty members.

The COV also comes at a time of rapidly rising costs of conducting research. These costs include the costs of hardware, infrastructure, talent, and expertise. Graduate student research assistantship stipends and benefits are being substantially raised (see https://www.forbes.com/sites/michaeltnietzel/2022/12/16/as-grad-student-unionizing-effort-grows-universities-raise-stipends-benefits/), and Facilities & Administrative (F&A) rates of Modified Total Direct Costs (MTDC) are increasing at universities nationwide.

Last but not least, the COV also comes at a time when US leadership in research and technology is being challenged. As noted by the National Science Board (see https://www.nsf.gov/pubs/2020/nsb20222/nsb20222.pdf), "the data in Science and Engineering Indicators show that the U.S. is at an inflection point as science & engineering (S&E) is increasingly global, demand for STEM talent rises, and knowledge- and technology-intensive industries grow." The same report also notes that "the U.S. no longer leads by default."

2. Cross-Cutting Findings and Recommendations

In light of these recent challenges and opportunities, the COV reviewed a sample of proposal actions, several strategic planning documents and management plans, a data book with extensive statistics, and a set of panel survey responses, for the divisions of Computing and Communication Foundations (CCF), Computer and Network Systems (CNS), and Information and Intelligent Systems (IIS) over the four-year review period. The COV concluded that:

- CISE continues to manage the review process with impressive quality and integrity, and maintain a balanced portfolio of awards that addresses national priorities, despite a shortage of staffing and limited software tools.
- CISE processes are supported by an exceptional and dedicated team.
- CISE is to be commended on continuing to update and refine its processes, e.g., eliminating fixed submission deadlines for programs.
- CISE has made a considerable effort to address the recommendations of past COVs, e.g., by developing innovative programs for broadening participation, by adjusting the CAREER and CRII programs for early career faculty members, and by developing effective data analysis tools.
- The above-mentioned successes notwithstanding, the current state of affairs is not sustainable. There is a significant risk that, without sufficient staffing and budget support, CISE will soon become unable to continue to fulfill NSF's mission. This is critical

due to CISE's leadership in emerging technologies, national security, and research infrastructure.

The COV makes twelve recommendations to address this important concern, and to achieve a number of strategic and operational goals. The twelve recommendations are grouped into four categories, described in the following four subsections.

2.1 Continuing to Fulfill NSF's Mission

NSF's mission is "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes" (see https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf). As noted in its strategic plan, NSF is "leading the world in discovery and innovation, STEM talent development and delivery of benefits from research."

This mission aligns with national priorities, as translated into NSF's budget priorities (see https://new.nsf.gov/about/budget/fy2024). CISE contributes fundamentally towards these priorities, including: (1) Emerging Industries for Economic and National Security, where CISE contributions include AI, advanced wireless, microelectronics & semiconductors, quantum information, and cybersecurity; (2) Creating Opportunities Everywhere, where CISE contributions include K-12 education, research experience for undergraduates (REUs), returning (graduate) students (CSGrad4US), EPSCoR, research experience for teachers (RETs), Broadening Participation in Computing, CISE Education and Workforce, and CISE MSI Research Expansion; (3) Resilient Planet, where CISE contributions include Design for Environmental Sustainability in Computing (DESC); and (4) Research Infrastructure, where CISE has made foundational contributions to every aspect of modern research infrastructure, from hardware to data analytics, and likewise where CISE investments catalyze the construction and use of advanced cyberinfrastructure, wireless testbeds, data repositories, and more.

The above-mentioned successes notwithstanding, CISE is at a serious risk of being unable to continue to fulfill NSF's mission, as a result of the challenges discussed in section 1. Therefore, the COV makes the following recommendation.

Recommendation 1: To continue to support NSF's mission --- and, specifically, to (a) match the increasing importance of foundational computing research for tackling societal grand challenges, and (b) train the next generation of the nation's computing workforce that will drive economic growth --- the COV recommends increasing funding for CISE.

In addition to the challenges in matching the growing importance of CISE-funded research and education, there are key challenges in attracting and retaining talent in NSF's CISE directorate to serve the growing community. Therefore, the COV makes the following recommendation.

Recommendation 2: To effectively serve the growing community, the COV recommends that NSF CISE expand the mechanisms for attracting, retaining, and supporting CISE personnel.

There is a critical need to develop innovative career-friendly and family-friendly incentives for CISE program director and administrative staff recruitment, retention, and support.

CISE employs both permanent and temporary program directors, who are known as rotators. Rotators face a number of challenges with respect to their career, finances, and family when they serve at NSF. A number of ideas are worth exploring to address these challenges. First, working fully – or at least mostly -- remotely may be a more attractive option for rotators, since they can continue residing in their hometowns, without incurring the cost of maintaining two residences. Second, rotator appointment mechanisms other than the currently applied Intergovernmental Personnel Act (IPA) mechanism can be explored. Third, reimbursing expenses instead of paying per diem rates may be better for rotators in certain cases. Fourth, since restarting their careers after their term ends is a key hurdle for rotators, a seed grant upon their return would be extremely valuable.

Additionally, CISE can consider recruiting a larger number of "expert" part-time program officers, or creating a type of position that is between a rotator and an expert. Prospective program directors can visit with a program director for a day to learn about the job.

The COV also recommends that CISE strive to recruit program directors who span more than one division or directorate to handle interdisciplinary programs and proposals, as well as program directors with industry experience who can be instrumental in establishing industrial partnerships that attract significant funding.

Finally, the COV recommends that workload metrics for program directors and administrative staff be carefully tracked, in order to avoid excessive load on any individual. Adequate compensation for administrative staff is extremely important, and their pay grades need careful consideration. Opportunities for upward mobility and career growth for administrative staff are also critical to the continued success of CISE.

2.2 Access and Inclusion

Some talent pools are being excluded from computing research and education opportunities due to their lack of access to resources. Resources for supporting on-ramp access programs are falling short of demand. The current demand for computing-related educational activities vastly exceeds academic programs offered by computing departments. For every major in their own academic programs, institutions have 10x more students from other majors in their courses, creating a need for a new class of instructional staff and educational products. Therefore, the COV makes the following recommendation.

Recommendation 3: To bridge the widening gap in access to computing resources and education, the COV recommends that CISE expand the on-ramp for access to computing-related opportunities.

As an example, CISE can invest more in community resources and initiatives that advance, develop, and deploy computational and data infrastructure, as well as new educational opportunities for enhancing access for diverse talent. Additionally, the emerging talent pool of teaching faculty and of faculty from Minority-Serving Institutions (MSIs) or Hispanic-Serving Institutions (HSIs) can be further engaged through programs tailored to their needs.

The COV also makes the following recommendation.

Recommendation 4: To grow a more inclusive community, the COV recommends that CISE institute processes that analyze portfolios to identify and further engage underserved communities.

Several methods can be employed to further engage underserved communities once they have been identified. First, opportunities to engage with program directors can be created to reach out to those communities who may not be submitting proposals, or who may have been discouraged by repeated proposal declines. Second, funded faculty members at non-R1 institutions can serve as ambassadors and mentors to other faculty members at non-R1 institutions who are launching new research programs. Third, regional conferences can be held for community building and for sharing research and educational artifacts and experiences. Fourth, administrators at non-R1 institutions can be trained on how to support their faculty in initiating research programs. Finally, best practices on engaging underserved communities can be shared across CISE.

2.3 Programs and Portfolio

The COV found that the portfolios of the three CISE divisions under review are well-balanced and address critical national priorities. However, a number of measures can be taken to further enhance CISE program management and portfolio balance, and the COV makes the following three recommendations.

Recommendation 5: To frequently align programs with national needs, the COV recommends that CISE refine the processes for creating, prioritizing, and sunsetting programs.

The COV recommends that the processes for creating, prioritizing, and sunsetting programs be refined to be more data-driven and be more agile.

First, increasing agility in the process of creating new programs that address urgent national needs is extremely important. However, the process also needs to be driven by a cost/benefit analysis.

Second, prioritizing programs and redistributing budgets can be periodically driven by data. For example, the COV noted that funding needs to be increased for early-career programs such as the CAREER and CRII programs in research areas of high growth.

Third, the process of sunsetting a program can be made more consistent across CISE. This can be accomplished by further formalizing and normalizing the process and using data-driven measures that support sunsetting discussions. Sunsetting programs through such formal processes guards against the proliferation of programs and the high workload of managing these programs.

The community is currently engaged in the process of program management through vehicles such as community workshops and Principal Investigator (PI) meetings. However, the COV felt that there are missed opportunities when review panels convene. Review panels can be valuable resources for engaging the community and gathering feedback on the evolving research landscape and its alignment with CISE programs. Program directors and division directors already ask for feedback during panels, but the COV deemed that a more formal process, such as adding specific questions to post-panel surveys, can ensure that feedback from panelists is accurately captured.

Recommendation 6: To develop effective partnerships with industry, the COV recommends that CISE periodically perform a cost/benefit analysis of each partnership, and share best practices on managing partnerships across CISE.

Industrial contributions to research programs, such as the Resilient & Intelligent NextG Systems (RINGS) program, can supplement CISE funding. However, each new or continuing partnership needs to be carefully assessed to ensure its cost effectiveness and mutual benefit. "CRA-industry" (see cra.org/industry/) and industry consortia can be leveraged to aid in creating joint programs and attracting significant industry funding. Documents that allow NSF to educate partners on how to build a relationship with CISE can be developed and shared across CISE. Similarly, standardized procedures for partnering can be used across CISE whenever appropriate. The partnerships need not be limited to co-funding or to cloud computing credits; other types of in-kind contributions such as access to data, labs, testbeds, and experts, can be explored.

Recommendation 7: To increase the visibility of CISE-funded research and education, the COV recommends that CISE extend and enhance methods of communicating project outcomes and impact.

Effectively communicating project outcomes was deemed critical by the COV. Communication specialists, e.g., science communication fellows, can aid investigators in communicating outcomes in ways that resonate with their target audiences. Many CISE awardees are eager to provide “nuggets” that can be used to highlight the impact of their CISE-funded grants and to amplify their work. The awardees can submit these highlights throughout the project duration, as well as for a few years afterwards, since measurable impact often takes time. A project with high impact after a number of years can be honored with a “test-of-time” highlight. The COV also

recommends that updates to project-funded publications and public outcome reports be allowed past the end of the award duration in order to continue tracking project results.

Finally, it is important to clearly articulate why CISE-funded research cannot be supported by industry in the long term, and to communicate important advances that have been made through CISE-funded projects. Several examples, such as software verification research advances, show how CISE-funded research moved the needle when industrial research did not.

2.4 The Review Process

The COV was extremely impressed with the CISE merit review process, with several COV members noting that it is "the gold standard." However, a number of measures can be taken to further refine the process. The COV makes the following five recommendations.

Recommendation 8: To streamline proposal processing, the COV recommends that CISE work with foundation IT staff to establish infrastructure stability and update pathways for CISE-developed tools.

Foundation-supported, integrated tools can significantly reduce the burden on administrative staff and program directors. A focus group comprising a cross-section of program directors and administrative staff can discuss and prioritize tools. For example, tools for checking compliance, tools for checking and handling conflicts of interest, tools for matching proposals with reviewers, and tools for automatically sending requests to serve on panels and sending review assignments to panelists, can have a profound effect on the efficiency of the review process. The process for requesting that a tool is enrolled for NSF-support can also be formalized. The e-jacket system can be modernized.

Maintaining a pool of potential reviewers and tracking their information is a key challenge. This has traditionally been done individually by each program director, or by groups of program directors. However, many members of the community are involved in multiple division programs and multiple directorate programs. Therefore, a centralized repository of reviewer pools and their expertise would be extremely valuable. Frequently populating the repository with members of the community, such as new faculty members and researchers in industry, is extremely important, so that they are not excluded from the review process. Leveraging ties to ACM, IEEE, CRA, and other organizations to identify untapped pools of reviewers is also important for inclusion. Finally, using a single ID for tracking PIs, senior personnel, reviewers, students, and collaborators can be extremely valuable for enabling integrated search capabilities. This can bring numerous benefits such as recognizing senior personnel on award web pages, and reducing the likelihood that conflicts of interest are missed.

Recommendation 9: To increase the quality of proposal reviews, the COV recommends that CISE communicate expectations at the time of reviewer invitation or review assignment.

The COV expressed concerns that briefings on the day of a panel may be too late to make a substantial difference in review quality, since reviewers would have already completed their proposal reviews by that point. It is important to clearly communicate, at the time of reviewer invitation or at the time of review assignment, instructions on how to evaluate a proposal ethically, thoroughly, and without bias. The intent of the question on PI qualifications, which is part of the merit review criteria, needs to be clarified to the reviewers. The COV felt that the answer needs to primarily consider the resources to which the PI has access in order to conduct the research. This would reduce implicit and explicit bias, e.g., bias against new investigators, or against investigators from underrepresented institutions. The evaluation of the broader impact criterion and its integration with the intellectual merit criterion also remains a challenge for many reviewers. The reviewers can be provided with sample reviews, which can be especially helpful to inexperienced reviewers.

Consistent methods to convey feedback to PIs can also enhance the review process. For example, program directors can all be encouraged to utilize the "Program officer comment" field that is conveyed back to the PI to explicitly state that the PI can contact the program director for more information, and to convey other feedback deemed important.

Another idea worth exploring is the introduction of some "memory" in the review process. The idea is that a description of changes from a previous submission can be included with the proposal, so as to give more background on the history of the proposal, if not to the reviewers, then to the program directors. This may be helpful in evaluating certain classes of proposals, e.g., proposals to large programs and/or to programs for early career PIs like CRII or CAREER.

Recommendation 10: To facilitate community interactions, the COV recommends that CISE consider both modalities, virtual and in-person, for proposal review panels.

Virtual proposal review panels have a number of advantages, including increasing inclusion, and reducing the time commitment for panelists. The COV noted, however, that the limited personal interaction during virtual panels disproportionately affects panelists who are new or prospective investigators, or faculty members at underrepresented institutions, who can potentially find mentors or form collaborations during in-person panels. Conducting a fraction of the review panels in-person or in hybrid mode can be valuable for community building.

Recommendation 11: To streamline the review of proposals submitted to programs with rolling deadlines, the COV recommends that CISE evaluate the impact of rolling deadlines and make any necessary adjustments.

The COV noted that rolling deadlines have been effective in increasing the quality and timeliness of submitted proposals and reducing the number of proposal submissions. However, refinements

to the submission rules and review process for programs with rolling deadlines may be required to avoid inconsistencies and facilitate convening review panels. The COV recommends that CISE study the trends in the number of submissions, program director workload, reviewer pools, and the limit on number of proposals a PI can submit at any given time, before and after rolling deadlines were introduced, and make any necessary adjustments.

Recommendation 12: To facilitate coordination across CISE, the COV recommends that CISE expand the processes and invest in systems for sharing best practices among program directors.

Program directors informally share best practices, e.g., for selecting reviewers to serve on a review panel, for processing EAGER and RAPID proposals, and for handling award supplement requests. More formal processes and systems for sharing best practices and for coordination across CISE would both reduce the burden on program directors and ensure consistency of the processes that are followed.

With respect to award supplement requests, the COV recommends that CISE continue to educate the community on the use of supplements for accelerating artifact creation and sharing, technology transfer, and civic outreach activities. The production of artifacts, such as software and datasets, is vital for the reproducibility of research results and for supporting educational activities. Technology transfer and civic outreach activities are also extremely important for broadening the impact of CISE-funded projects. CISE can continue to educate the community on the process of requesting supplements to their awards to support such activities. Partnerships with the Technology, Innovation, and Partnerships (TIP) directorate and the Office of Advanced Cyberinfrastructure (OAC) can provide further opportunities for support.

3. COV Process and Suggestions for Future COVs

The timeline for the COV process is summarized in Appendix A and the agenda for the hybrid meeting on September 20th to 22nd is included in Appendix B. During the period of time starting on July 13th, 2023 when the COV was charged until the hybrid meeting was held at NSF starting on September 20th, 2023, each co-chair managed the work by COV members in their sub-committee. The COV members used material shared on a website that included a COV databook with statistics and links, a sample of proposal actions (157 for CCF, 190 for CNS and 225 for IIS), several strategic planning documents and management plans, and a set of panel survey responses.

The COV members found the databook easy to navigate and use to analyze trends (compared to the annual reports used by previous COVs). The COV members also found the video conference calls of each division sub-committee with division leadership before the hybrid meeting extremely helpful. The COV chair and co-chairs also found their calls with CISE and division leadership valuable.

A few changes can further improve the process, including (1) communicating expectations in more detail, e.g., level of effort required and conflict of interest window during which proposals may not be submitted, when inviting COV members to serve; (2) revising the division report templates to replace tables with lists, and to increase clarity; and (3) utilizing a more effective method for communication among the COV members, e.g., Slack channel.

During the hybrid COV meeting on September 20th and 21st, the COV members noted that the interaction with CISE leadership, division leadership, program directors, and administrative staff was informative. The interaction with COV members in sub-committees of other divisions was helpful, and the breakout sessions with program directors provided valuable insight.

4. Acknowledgments of COV Members and NSF Staff

In closing, we wish to acknowledge the efforts of all COV members over the past ten weeks. Special thanks to Kavita Bala, Samee Khan, Anita Raja, Deborah Shands, Rebecca Wright, and Ben Zorn for their excellent summaries of the breakout sessions. We know that we speak on behalf of the entire community in saying "thank you" to all COV members for their thoughtful input.

We are also grateful for the immense work by CISE leadership, program directors, and staff in preparation for and throughout the COV review process. Their dedication and service to the community is inspiring and much appreciated. The CISE data and systems teams (Carl Anderson, Kristen Oberright, Julian Navarre) deserve special thanks for promptly providing us with additional data whenever we requested it, and for their patience in answering our many questions. We extend our sincere thanks to all CISE program directors and staff members who participated in the hybrid COV meeting. In particular, we would like to recognize the Division Directors, Deputy Division Directors, and Operations Managers for CCF (Dilma Da Silva, Irina Dolinskaya, Velma Swales), for CNS (Ellen Zegura, Behrooz Shirazi, Tracey Zeigler), and for IIS (Michael Littman, Wendy Nilsen, Siara Wolley) who participated in several virtual conference calls before the hybrid meeting, and patiently answered our questions. Last but not least, we are truly indebted to Margaret Martonosi, Assistant Director of CISE, to Joydip (JD) Kundu, Deputy Assistant Director, to Nina Amla, Senior Science Advisor, and to Chantini Reid, Directorate Operations Officer, for supporting the work of the COV, and for all they do for the community.

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Appendix A: Timeline of the COV Process

- November 2022: Commitment of the overall COV chair
- January-April 2023: Commitment of the COV co-chairs and members to serve on the sub-committees for CCF, CNS, and IIS
- May 11, 2023: Introductory video conference call between the COV chair and co-chairs, and members of CISE leadership responsible for managing the COV process
- July 13, 2023: Conference call between the COV and CISE leadership to formally kickoff the COV, discuss the COV charge, conflict of interest guidelines, and provide an overview of CISE and the three divisions under review
- July 14 to August 4, 2023: Website and e-jacket system made available to COV members through a number of training sessions
- August 7 to September 13, 2023: Periodic calls of COV chair and co-chairs with division leadership and members of CISE leadership responsible for managing the COV process
- August 8 to September 19, 2023: Review of e-jackets, documents, and information in the databook by the three COV sub-committees, organized by COV co-chairs and coordinated through periodic calls of each sub-committee with division leadership and the COV chair
- August 23, 2023: Additional data requests sent to division leadership and the data team
- September 8, 2023: Additional data made available and announced to entire COV
- September 12, 2023: Agenda for the hybrid meeting finalized in consultation with CISE leadership, and shared with entire COV
- September 13, 2023: Suggested breakout group assignments and scribe assignments shared with entire COV
- September 20 and 21, 2023: Hybrid meeting of entire COV at NSF, during which sub-committee reports and cross-cutting findings and recommendations were discussed
- September 22, 2023: In-person meeting of the COV chair and co-chairs to discuss cross-cutting findings and recommendations
- September 29, 2023: COV report submitted to CISE by the COV chair

Appendix B: COV Meeting Agenda

Note: All COV-wide sessions are held in Room W2210/2220

Wednesday (09/20)

08:30am-09:00am: Refreshments
09:00am-09:30am: CISE AD welcome and reminder of COV charge
09:30am-10:00am: COV chair welcome and COV member introductions
10:00am-10:45am: Sub-committees convene to discuss status and formulate the questions to ask division leadership

- Room W2250: CCF sub-committee
- Room W2240: CNS sub-committee
- Room W2190: IIS sub-committee

10:45am-11:00am: Coffee Break
11:00am-12:30pm: Each sub-committee meets with division leadership (division director, deputy division director, and operations manager)

12:30pm-1:30pm: Lunch (W2210/2220)

01:30pm-3:00pm: Breakouts on select issues, part 1 (with CISE Program Officers and CISE Staff)

- Room W2190: Tools for proposal review and program management
- Room W2250: Research culture (e.g., reproducibility, tech transfer, interdisciplinary research)
- Room W2240: Creating and sunsetting programs

03:00pm-03:15pm: Coffee Break

03:15pm-04:45pm: Breakouts on select issues, part 2 (with CISE Program Officers and CISE Staff)

- Room W2190: Program director recruitment and workload
- Room W2240: Supporting and interacting with the research community
- Room W2250: Partnerships with industry and other national and international foundations and agencies

4:45pm-5:45pm: COV sub-committee discussions to develop report-outs to full COV

6:00pm COV members only Dinner

Galae Thai, Alexandria, VA 22314

Thursday (09/21)

08:30am-9:00am: Refreshments; Room W2210/2220

9:00am-10:00am Report out of discussions in breakout sessions by breakout scribes to full COV

10:00am-10:45am: COV meets with CISE AD

10:45am-11:00am: Coffee Break

11:00am-12:30pm: Sub-committees reconvene separately to finalize division templates in light of discussion of breakout topics and meetings with division leadership

- CCF sub-committee in Room W2250
- CNS sub-committee in Room W2240
- IIS sub-committee in Room W2190

12:30pm-12:45pm: Pick up lunch and reconvene in W2210/2220

12:45pm-01:45pm: Working lunch: COV sub-committee chairs report out of key findings and recommendations in division templates to full COV

01:45pm-02:45pm: Full COV discussion of cross-cutting themes

02:45pm-04:00pm: COV chair and co-chairs prepare cross-cutting findings and recommendations in Room W2180

02:45pm-4:00pm: Sub-committees reconvene separately to finalize division templates

- CCF sub-committee in Room W2250
- CNS sub-committee in Room W2240
- IIS sub-committee in Room W2190

04:00pm-05:00pm: COV chair and co-chairs present cross-cutting findings and recommendations to CISE management

05:00pm Most COV members depart

Friday (09/22)

08:30am-1:00pm: COV chair and co-chairs finalize recommendations in Room W2190

Appendix C: Subset of Acronyms Used in this Document

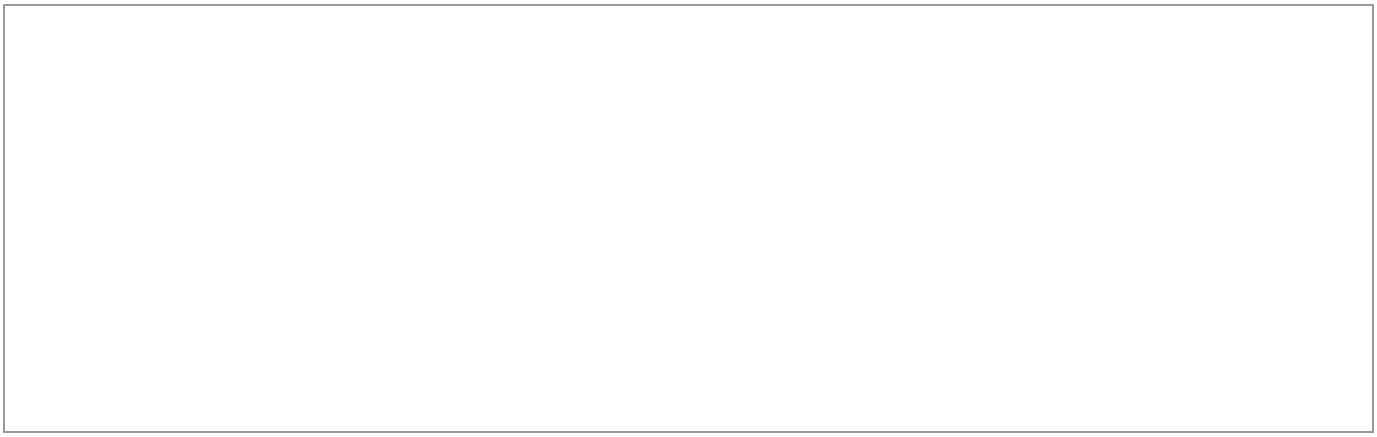
Acronym	Meaning
CCF	Computing and Communication Foundations
CNS	Computer and Network Systems
CRA	Computing Research Association
CRII	CISE Research Initiation Initiative
CISE	Computer and Information Science and Engineering
COV	Committee of Visitors
EPSCoR	Established Program to Stimulate Competitive Research
HSI	Hispanic-Serving Institution
IIS	Information and Intelligent Systems
IPA	Intergovernmental Personnel Act
MSI	Minority-Serving Institution
NSF	National Science Foundation
PI	Principal Investigator
R1	Institutions of higher education described by the Carnegie Classification as a Doctoral Universities with Very High Research Activity
RINGS	Resilient & Intelligent NextG Systems
REU	Research Experience for Undergraduates
STEM	Science, Technology, Engineering, and Mathematics

Report for the Division of Computing and Communication Foundations (CCF)

2023 NSF COMMITTEES OF VISITORS (COVs)

Table 1 - Summary Information

Summary Information
Date of COV: September 20-22, 2023
Program/Cluster/Section: **Algorithmic Foundations (AF)** **Comm & Information Foundations (CIF)** CRII CISE Research Initiation DASS-Dsgng Accntble SW Systms Expeditions in Computing **FET-Fndtns of Emerging Tech (FET)** FMitF: Formal Methods in the F FRR-Foundationl Rsrch Robotics HDR-Harnessing the Data Revolu PIPP-Pandemic Prevention PpoSS-PP of Scalable Systems SemiSynBio – Semicon Synth Bio **Software & Hardware Foundation (SHF)**
Division: Computing and Communication Foundations (CCF)
Directorate: Computer and Information Science and Engineering (CISE)
Number of actions reviewed: 157 **Awards:** 81 **Declinations:** 73 **Other:** 3
Total number of actions within Program/Cluster/Division during period under review: 5,644 **Awards:** 1,718 **Declinations:** 3,901 **Other:** 25
Manner in which reviewed actions were selected: The NSF recommends **5**% of the total portfolio be available to COV members for review. Sampling data consists of competitively reviewed proposals (awards and declines) as well as proposals that were returned without review. A random sampling of all FY 2019-2022 proposals reviewed or returned without review in the division was achieved using Excel macros designed to randomly sample within an excel list based on the proposal program coding and proposal status. Due to the large volume of proposals received in the CCF division, approximately 2.7% of the portfolio has been made available to the COV. If any additional proposals are requested by the COV they will be provided. CISE has randomly generated a sample of 157 out of 5,644 proposals, which is an aggregate of 2.7% across all fiscal years under review. COV members have been assigned to review proposals based on their areas of expertise and the complexity of proposals and programs in each area, while avoiding any declared conflicts of interest.



COV Membership

Table 2 - COV Membership

Role	Name	Affiliation
COV Chair or Co-Chairs:	Sonia Fahmy (COV Chair) Rajesh K. Gupta (CCF Chair)	Purdue University University of California-San Diego
COV Members:	Ben Zorn Cindy Rubio Gonzalez Dorian Arnold Jelena Kovačević Lori Pollock Michael Spear Rebecca Wright Shan Lu	Microsoft Research University of California-Davis Emory University New York University University of Delaware Lehigh University Barnard College University of Chicago

OVERVIEW OF CCF PROGRAMS, REVIEW PROCESS AND OUTCOMES

The CCF Division accounts for 4 out of the 10 core programs offered by CISE that are at the foundation of technologies driving algorithms, architectures, software, and hardware systems driving computing and information systems and their applications. In addition, CCF offers about two dozen interdisciplinary or multi-disciplinary programs representing a significant breadth of its programs ranging from formal methods, robotics, and data revolution to pandemic response. Nearly all these programs enjoy healthy submission rates and significant co-funding arrangements across the foundation. Beyond the number of suggestions made in this report to improve transparency and inclusion, the committee found that the division follows a satisfactory review process with healthy outcomes for most of its programs that support a large community of researchers, from algorithms and communications to microelectronics hardware and software design. Against this context of a well-run division, in this report, we first outline the current state of proposal submissions and review processes, an executive summary of main recommendations, followed by answers to specific questions raised by the COV review process.

This COV review period is marked by the COVID-19 pandemic leading to (a) a rise of virtual meetings and (b) changes in the volume of submissions and variability across the years. After a temporary decline in submissions due to COVID-19 in 2021 and 2022, the submissions have resumed an upward growth trajectory. The divisional research budget has flatlined to $198M over the last two years, a period that has seen tremendous new opportunities in existing and new areas, from learning algorithms, and quantum computing to accelerated computing architectures, while facing significant increases in the costs of supporting graduate student researchers and post-doctoral scholars as a result of the collective bargaining processes.

The CCF COV committee was assisted by the COV Data Book and eJacket information in preparing its responses. Guided by the report prompts, the committee has made several dozen observations and suggestions. Among the highlights of our findings are budgetary challenges seen by the PIs amid substantial increases in costs, and churn in well-reviewed but unfunded proposals in the absence of established mechanisms to resubmit with responses. The committee makes several suggestions in the spirit of incremental and continual improvement to a generally well-running proposal submission and review processes. Among the highlights of our suggestions are pre-panel reviewer training and other measures to reduce implicit and explicit bias sources from external reviewers and enhance participation of industry practitioners in the merit review process, measures to reduce and better manage program directors' workload, and systematic means to enable PIs to respond to reviewers concerns in case of otherwise well-received or borderline proposals. Given the expanding scope and impact of programs supported by CCF, and CISE in general, a concerted effort is necessary to attract and retain talent to run and manage programs through better contracting mechanisms for rotators and improved supporting tools to manage various processes.

In the following, we present our responses to the prompts in the COV review template. Important observations and suggestions are indicated with an asterisk (*) next to them.

I. **Questions about the quality and effectiveness of the program's use of merit review process.**

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
1. Are the review methods (for example, panel, *ad hoc*, site visits) appropriate? The committee members uniformly agreed that the methods deployed were appropriate. Some committee members appreciated the prompt response to EAGER and RAPID proposals by the program directors and a focus on BPC plans by an independent group that made this part of the review process consistent across CCF. The committee made several observations and suggestions listed here. **Observations:** a. CCF deploys a panel-based review process by constituting a panel of typically 10-12 external experts who divide a set of 20-30 proposals such that each proposal is reviewed on average by 4 reviews. The panel meets in a 2-day meeting to discuss and make recommendations under the active guidance of the program director(s). The Program Directors (PDs) can seek ad hoc reviews as needed, but these are not common for most programs, other than calls for specialized programs or center-scale projects. b. For center-scale proposals, the CCF deploys a multi-step review process starting with a panel for pre-proposals, followed by a panel for invited proposals and a "reverse site visit" by an externally constituted review team. Typically, 35-40 reviewers are involved in evaluating such proposals before a decision is recommended to NSF. c. For programs such as EAGER that target exploratory grants, the PDs deploy internal reviews. Some auxiliary programs such as REU and requests for Conference Travel support, are generally reviewed and decided by the PD(s) directly. The committee noted that EAGER grants may not come with much or any feedback to the PIs beyond the award/decline decision. d. Broadening Participation Plans (BPC) in many cases were reviewed independently and prior to the panel meeting by a separate BPC team at NSF. e. This period under review was dominated by the circumstances caused by the COVID-19 pandemic that mandated all meetings to be virtual starting March 2020, a guidance that continues. This virtualization trend was along the lines of previous COV recommendations to increase virtual meetings. Indeed, a CCF goal of 15% virtual meetings set in 2013 was exceeded by actual 18% meetings in 2014, a sudden shift to 100% virtual panels in the frightening context of COVID-19 has called into question the effectiveness of such virtual meetings for the long term. f. In our spot checks of the reviews through the eJackets, we noted that a few proposals were reviewed by more than one panel, apparently to ensure a fit with the technical expertise of the panelists. We also noted occasional ad hoc reviews, especially in the case of Expeditions proposals. In a few cases, we noted a response to "Panel Concerns" filed by the PI before a favorable funding decision was entered by the PD. **Suggestions:** Improving the Review Methods 1. The committee was unable to analyze proposal outcomes against reviewer and PI characteristic data. We recommend the collection of such information for the future that informs NSF of potential biases. 2. The NSF should increase the amount of asynchronous discussion among reviewers before the panel meeting. This would enable *ad hoc* and expert reviewers to be more integrated into the discussion and could streamline the panel meeting by addressing ambiguities and identifying points of disagreement in advance. *Ad hoc* reviewers should also participate in the panel meeting when discussing their reviewed proposal.	YES* [*Pandemic]

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
2. Are both merit review criteria addressed **a) In individual reviews? b) In panel summaries? c) In Program Officer review analyses?** **Observations:** The merit review criteria are part of all solicitations and must be addressed by the PIs in all proposals. Consequently, these elements are addressed in virtually all proposals in some depth. When it comes to the review process, once again the structure of the review and review form ensure that individual reviews examine the proposal's responsiveness to the two merit review criteria. However, the committee members noted variation in the emphasis placed on the two review criteria—specifically the broader impacts sections sometimes received less description, review and even weightage in the decision-making process. The committee members noted that program-specific criteria were sometimes not addressed, or addressed inadequately by the individual reviewers. We noted quite a disparity among the panelists and PDs about what is the minimum requirement for a CAREER proposal's education plan. Similarly, PPoSS review criteria were often neglected. **Suggestions:** 3. We suggest better structuring the review form, or at least the more detailed template given to reviewers so that some separate boxes or headings and the solicitation-specific review criteria, as well as which questions are required or optional. 4. NSF may consider assigning weights to different components of the review criteria (on a panel-by-panel basis) to ensure proposals and reviews address these adequately. 5. (*) To attract more experienced reviewers, CCF may consider inviting reviewers from a broader community of industry participation. While we noted individuals from the industry on panels related to architecture, software proposals could benefit from greater industry participation where the proposed research has a significant practical impact.	YES
3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? **Observations:** A majority of committee members found that the reviews were substantive. They also noted the balance that the reviewers must strike between giving substantive and useful comments against succinctness. The reviewers are encouraged to be succinct and put in only the essentials of their arguments. A large variability in the length and quality of reviews is noted. In rare cases, we found that the reviews are extremely short, hastily written or the descriptions do not match the merit grade assigned. The committee has made suggestions about how we can further reduce or eliminate such reviews including the need for experienced reviewers as well as reviewers from industry in specific areas. The committee also noted that the requirements for PPoSS were so extensive that the reviews became perfunctory when addressing all the criteria specified pointing to measures NSF can take in its solicitations. Against these requirements, it appeared that some reviews were conforming to the style rather than substance by offering narrowly defined "hyperspecific" technical or even stylistic concerns to justify a subjectively negative opinion. Upon closer examination, these concerns did not feel significant enough to warrant a negative assessment. In general, there is a sociological dynamic that favors the "most detailed" review when there is a disagreement among	Yes with deficiencies noted in specific solicitations.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
reviewers which may or may not be most calibrative of the quality of the proposal. **Suggestions:** 6. The committee noted high-impact reviews when the panelists concluded their review with a statement that justified their rating. But such a statement is not always present in the reviews. We recommend requiring such a summary statement in all reviews. 7. Occasionally, reviews contain unsubstantiated and subjective statements, e.g., "ambitious project", "not novel", or "without substantiation." This could be addressed by having the scribes during the panel meeting suggest review changes, or more asynchronous conversation among reviewers prior to the panel meeting. It would also be beneficial for the PDs to provide more guidance ahead of time.	
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Despite a few outlier cases of (a) no summary; and (b) rather thin summaries in the case of proposals that were *not* discussed, generally the committee members found the summaries to be well-written, in fact, in some cases more detailed than the reviews. The committee members especially appreciated the "suggestions for improvement" that seems to have been instituted in recent years. **Suggestions**: 8. We suggest continued use of "suggestions for improvements" in summaries. 9. We also caution that the reviewers should be instructed so that they do not make suggestions for other solicitations that the PI can apply for instead. Not only is it inappropriate for the reviewer role, but the reviewers may also well lack the expertise to make such recommendations.	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.] **Observations:** A majority of committee members found the combination of panel summary and program officer's review analysis to be sufficient in understanding the rationale for the decision. This was useful in cases where the award decision wasn't completely obvious from reviews, and yet the proposal was awarded. There are some important observations that emerge from our sampled review of eJackets: • Explanations tend to be terse or absent for decline decisions. It is understandable given that award decisions are much fewer than the decline decisions, and funded projects become a matter of public record. Yet some members would like to see more information provided for declines. For proposals that are not discussed (because of uniformly low reviewer rankings) this may be hard to provide more information beyond the reviews. However, in such cases an indication of "not discussed in the panel" would be a useful calibrative feedback to the PIs. • In a few proposals, the eJacket includes the PI's response to "Panel Concerns" filed just before the award decision was made. It seems that such documentation was	Yes

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
included in case of mixed reviews by the panel as a justification for the award decision being made. There was, however, no process-related information available as to when such a response is solicited or filed. • Since only a fraction of proposals in the Competitive category are funded, the HC/C<1,2,3>/LC classification needs a closer look at the message it sends to the PIs. Unfunded Competitive proposals were perhaps the least explainable since they seem to boil down to whether the program manager wanted to advocate for the proposal or not and the availability of funds. Either way, it adds an opaqueness to the process that can be reduced. It also adds to a proposal (re)writing and reviewer burden in the system since many of the proposals are likely to be returned as resubmissions without substantive changes in the content. **Suggestions:** 10. (*) In view of the observation above regarding the disposition of competitive but unfunded proposals, as well as the current use of "Panel Concerns" documents in a few proposals, a case can be made for the value of introducing some form of rebuttal and proposal revision mechanism into NSF review process as discussed in the next section.	
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.] **Observations:** In the absence of "review analysis", the context statement to the PIs serves the important role of conveying the totality of the picture related to the award/decline decision to the PIs. However, context statements, though detailed, often came across as a statistical explanation of the competitiveness of the solicitation, and were not useful to the PIs in understanding the specific decision taken especially in the case of "borderline" everything-is-good-but-not-great reviews. The Committee also noted that sometimes factors like "overlap with existing funding" seem to affect the outcome but were not included in any review or summary by the panel. The committee discussed issues surrounding the resubmission of rejected proposals and the chances of getting totally different feedback (from a different panel). While NSF has been rightfully focused on the review burden imposed by the growth in submissions and sought to limit this burden by imposing annual PI limits, it also needs to be cognizant of the burden on the community that the current regime of positively-reviewed-but-declined proposals imposes. In the absence of any memory in the review process, and lack of continuity across panels, the collective burden is high and increasing: is a proposal under review a possible resubmission? How are the prior reviews incorporated, if these are considered at all (based on informal recollections of the Program Directors)? These questions should be answerable during the review process. To do so, we strongly encourage NSF to rethink the panel and *ad hoc* review process that enables formal response and resubmissions. **Suggestions:** 11. Care must be taken in communicating a decline result in the case of proposals that are rated Competitive or higher by the panel and otherwise received positively by the reviewers. The committee recognizes limitations on what feedback reviewers and PD	Yes

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
can provide "to improve" a proposal; perhaps it is not even an obligation for NSF to do so. However, rather than pointing to weaknesses it could use scoring criteria (as NIH does) and/or point to funding limitations in not funding the proposal. 12. When a proposal is ranked at least Low Competitive, but not funded, the NSF should consider providing an opportunity for the PIs to resubmit with an optional single-copy document that a PI can provide to describe changes relative to the previous (declined) version of the proposal. 13. (*) It will be useful for the PIs to consistently be told they can talk with the PD after being declined and be able to receive a redacted version of the Review Analysis that helps PIs understand NSF's take on their proposal that includes panel information but forms a complete view.	
7. Additional comments on the quality and effectiveness of the program's use of merit review process: The CCF COV team was impressed by the level of detail maintained by NSF in its records of how a proposal was handled from the review process to its disposition. This was helpful to COV process. While NSF processes tend to reduce the variation in the quality of reviews across panels, the variations do exist and more could be done, and some of our suggestions are designed to reduce such variation. The sample of eJackets examined by the CCF teams covered a wide range of programs and both successful and unsuccessful projects. The following lists observations made by the committee members on individual eJackets. These are listed in no particular order of significance and without any claims regarding their generality across CCF or CISE: **Observations:** The committee wondered about the lifecycle of proposals that are generally received positively by the reviewers but not funded. Anecdotally, we believe that these proposals return to NSF program solicitations without significant modifications that add to the continuing review burden without the benefit (to NSF) of the feedback already given. An analysis of such data on award/decline rate for proposals rated as "Competitive" or "Highly Competitive" proposals would be useful in formulating a long-term strategy for streamlining the NSF solicitation and review processes. • Related to the previous observation, it was also not clear from the eJackets when the PDs asked the PI for a "Response to Panel Concerns" and what were the criteria applied for such a solicitation and what fraction of submissions benefited from such a rebuttal process. Yet, the existence of such a practice strengthens the argument for maintaining a prior history for a proposal and enabling the resubmission process. • Even though the evaluation of project outcomes was out of scope for the COV study, some committee members wondered if NSF has processes in place to review outcomes, and whether those are ever mapped to the initial merit assessment. This feedback loop would be an important means to ensure the relevance and effectiveness of NSF review processes. • Occasionally, the (lack of) depth of a review appeared to suggest insufficient reviewer expertise on the topic. There should be some explicit mechanisms in place to guarantee that aggregate reviewer expertise and confidence is sufficiently high. Similarly, we anecdotally observed that reviewers from the industry often, unsurprisingly, have a different set of broad focuses and perspectives on what is meritorious and what isn't. • In our spot checks, the team found the small and medium grant proposal reviews to be quite detailed and thorough with each merit review criteria addressed well. There were also Suggestions for Improvement in some cases. The Expeditions proposal reviews as well as feedback to the PIs were shorter than expected. • We also observed the possibility of explicit bias when evaluating PI qualification. PI qualification needs to (and is) formally defined based on educational training etc. A qualified	NA

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	Y, N, No Data, NA
PI should be able to write a proposal that makes clear their qualifications without relying on name, institutional reputation, or "track record". What is under review is the quality of the work being proposed under two NSF criteria and the PI's ability to carry out the proposed research within the resources and infrastructure available. That evaluation is explicitly done under Facilities and Resource descriptions and can be a more prominent part of the review. **Suggestions:** 14. (*) The committee had many discussions about implicit bias and concluded that the guidance given at the start of the panel was "too late". Ideally, training on bias should happen *before* panelists read proposals and at the start of the panel meeting. 15. (*) The committee also discussed explicit bias. The most significant example is the "qualifications of the PI" criteria. We suggest that the PI qualifications criteria be refined to be focused specifically on the resource sufficiency for the nature of the work proposed. 16. Panelists would benefit from more guidance about who is the audience for their reviews. Is it the PD? The PI? The panel? Some simple guidance might help to improve review quality. Likewise, PIs would benefit from more guidance about who is the audience for annual reports.	

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? Based on our study of the eJackets and Data Book, we find that the NSF has done a commendable job of finding reviewers with appropriate expertise. The following provides a succinct list of our observations followed by suggestions for the future. **Observations:** • NSF spends considerable effort to gather the necessary expertise for conducting its programmatic initiatives and review processes. Tools to automate this process are needed. • Virtual panels have made it easier to bring experts into panels due to their convenience without the need for travel. This also makes it possible to bring in experts as *panelists*, not just as *ad hoc reviewers* at short notice. • While journal review processes have had mixed experiences, we believe it may be beneficial to devise a way of tracking the quality of reviews that helps the PDs in assembling effective panels. • The use of targeted *ad hoc* reviews done by a separate dedicated team for BPC plans is useful in ensuring the quality and consistency of evaluation of these plans. Along the same lines, it is useful to integrate industry experts into the review panels. • Despite a sharp drop in the total number of proposals during the height of the COVID-19 pandemic, the number of reviewers has remained flatlined at around 1K drawn from 220-250 institutions across 45-48 states representing a broad participation to expertise in the review processes. • There is an even distribution of reviewers across universities and organizations: the highest percentage of reviewers from any Institution was 1-1.5% of the total reviewer pool in any given year. • Geographically, CA, NY, and TX continue to dominate the reviewer pools with roughly 10%, 7%, and 6% of the reviewers, respectively. Demographic distribution of reviewers across the 4 years shows no particular pattern and has remained steady, with approximately 16-22% of the reviewers identifying as women. **Suggestions:** 17. Continue to use virtual panels, whenever appropriate, to broaden participation in panels. 18. (*) We suggest considering more industry reviewers on proposals with a significant practical impact component. This will invite input from individuals familiar with the logistics of creating, deploying, and supporting products and would add important perspectives and advice in the feedback to the PIs. 19. It might be worth considering having *ad hoc* BPC reviews for CAREER proposals.	YES

SELECTION OF REVIEWERS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
2. Did the program recognize and resolve conflicts of interest when appropriate? NSF uses multiple methods to identify COI starting with a self-declared COA document from the PI and then using an automated search tool to identify potential COI relationships including searching the proposal for any COI not mentioned in COA declarations. The reviewers are provided with this information, and any late discovery of COI is incorporated by withholding the release of concerned reviews or its use in the decision-making. Besides technical declarations of COI, NSF PDs also pay attention to the appearance of COI that may not fit any defined categories. The committee members unanimously felt that this process worked well, and NSF programs were able to recognize and resolve conflicts of interest in a timely manner. **Suggestion**: 20. There was some inconsistency in how the handling of COIs was reflected in the documents that we examined and in the communication to the PIs. Specifically, COI is sometimes addressed in the review analysis, sometimes in the context statement, and sometimes not at all. We recommend this information be always communicated to PIs in a standard manner. The context statement for some of the sample proposals had a very thorough explanation of the handling of COI that could be a good template for use elsewhere.	YES
3. Additional comments on reviewer selection. Individual committee members provided the following observations and suggestions that are not verified for general applicability across CCF programs. These may, however, provide additional insights and follow-up work to consider the suggestions embedded here. **Observations and Suggestions:** 21. Based on our discussions in the breakout sessions with the program directors, we recommend (1) that measures be taken to measure and understand PD workload related to identifying and recruiting reviewers and (2) introducing useful tool automation to help PDs in their task (exploring existing matchmaking tools used in conferences and possible AI-based tools). 22. It appeared to some on the committee that a small pool of reviewers is often invited to the panels. This problem is exacerbated due to COI rules that make some institutions ineligible to serve on the panels due to their size and frequent participation in NSF programs. While monetary incentives are hard or impossible in a field with significant financial opportunities for the experts, it is possible that intangible benefits associated with NSF service could be articulated better, time investment limited (e.g., through remote/virtual participation) while keeping financial incentives unchanged for such participation. 23. (*) The data book should include information that allows an assessment of the size and demographics of reviewer pools, including how often individuals serve as reviewers.	NA

III. Questions concerning the management of the program under review

TABLE 5: MANAGEMENT OF THE PROGRAM UNDER REVIEW

1. Management of the program.

Observations:

Between the last CISE CoV review in 2019 and the current one, CISE has continued to evolve and improve its management and operations. CISE management is based on extraordinarily dedicated staff who continuously evaluate and improve various processes, resulting in effective management of the programs. The collaboration and interconnection of CISE's three divisions seem to be a model of great teamwork, with program directors being at the front lines and aware of and implementing the larger strategy.

NSF has generally strived to put as many resources as possible into its programs rather than administrative services; the program directors and their staff continue to innovate so they can do "more with less" thus continuously raising the bar on the amount of work considered normal. The CoV, both in its prework and at the in-person meeting, has been impressed by everyone's dedication to the CISE mission; the CoV commends such a team spirit and hard work. It has also raised issues about managing workloads. We hope that CISE management will expand capacity rather than limit its programs in response to its workload changes.

During the review period, the volume of proposals has dropped because of the COVID-19 pandemic. At the same time, the number of cross-collaborative initiatives has increased significantly, while the resources for staff have remained flat. Over time, this can seriously affect the quality of the proposal review process, turnover of the NSF staff, and by extension, quality of the US research enterprise in this area. The workload in terms of the number of proposals is only one indicative measure; harder to assess is the complexity of numerous cross-cutting programs and initiatives that require considerable time commitment from the CISE staff.

In the session with NSF staff on workload, all PDs expressed strongly how grateful they were for the opportunity to serve the nation. We identified several issues with respect to the unsustainable workload. One is the difficulty in hiring new IPAs, leading to vacancies, and increasing the workload on the existing personnel. This difficulty in hiring new IPAs is due to several reasons: (1) inability to afford the role financially, (2) inability to reconcile family obligations with the role, and (3) inability to restart their research program upon termination of role due to stringent rules. Examples of the above and other obstacles include rules about getting per diem only if having a full lease even though present only a percentage of time, confusion about remote policies, and change to a 'no-deadlines' submission process means that there are no more predictable breaks for IPAs and staff. All these issues mean that it is harder to get people from the West Coast, research active, and younger researchers. The PD job is increasingly viable for those closer to retirement and financially more stable, making it a less diverse population.

Recommendations: We suggest a focus group of CISE PD and administrative staff to identify the metrics for workload and employment issues that prevent hiring new talent and retaining/burning out current talent. To do so, we recommend the following actions:

24. (*) Introduce one or more contracting/funding vehicles to enable rotators from non-government institutions with the following characteristics: (a) Option for fully remote work; (b) Guaranteed seed funding (e.g., a small research grant) upon termination of the PD term to help resume research; and (c) Alignment with the academic calendar at the universities.

25. Investigate financial issues that pose hardship for current and potential rotators — e.g., substituting per diem by reimbursement, allowing for fully remote rotators, leasing a building for apartments for rotators.

26. If there is a new solicitation, CISE must provide sufficient time before the end of the FY for necessary actions to be taken (finding reviewers, organizing panels, issuing awards, etc.).

27. Investigate issues with low salaries for administrative staff that keep open positions unfilled.

A recommendation from the previous CoV review was to improve program evaluation and reduce the burden by reconsidering the need for CISE divisional annual reports and focusing instead on regular data collection and longer-term trend analysis. In May 2020, the response from CISE stated that CISE participated in developing an agency-wide COV

dashboard to present data in a standardized way. The current CoV has been the beneficiary of that dashboard, and we hope that it has reduced the reporting burden on CISE personnel. That dashboard now presents each question on the COV report template separately and links to appropriate data that can be queried by fiscal year or as a trend across multiple fiscal years. CISE stated it would re-examine the need, content and format of its annual reports going forward. In the update in July 2022, CISE expanded on the dashboards, thereby eliminating the need to generate annual reports.

Another recommendation pertaining to management and productivity from the previous CoV was with respect to award selection and oversight. The previous CoV recommended pursuing efforts to develop tools that are integrated with existing business processes as one of the ways to reduce and streamline administrative burden. In May 2020, the response from CISE stated that improving tools as well as management of the proposal portfolio was a priority for the directorate. A plan was announced to hire the Data and Analytics Officer, who would support the directorate in planning, decision- making, and identifying new tools needed (and potentially developing new tools). CISE also planned to review its engagement with the wider NSF IT mechanisms. CISE was part of Renewing NSF, an agency-wide modernization effort. In the update in July 2022, CISE stated that it has significantly matured its data and analytics capacity. "The directorate recruited several staff to build analysis and automation tools and see that these tools are adopted across the directorate.

The data and analytics team includes a data and analytics officer, a senior program analyst, a data analyst, a student trainee (data scientist), and two contractors. Complementing this team is a data and analytics working group comprising program officers and administrative staff from across CISE." The data and analytics team invested in new tools such as Lingo4G, Dimensions, and others that mine text, cluster, improve business processes, conduct analyses, etc.

While CISE has significantly upgraded its data and analytics capabilities, it has not been able to provide tools to help PDs and administrative staff to manage proposals, panels, and reviewers. Because many CISE programs no longer have deadlines, these programs have many more, albeit smaller panels, with a smaller number of proposals, but potentially from very disparate or emerging areas. This creates a significant workload, especially in identifying reviewers, which is mostly a manual process (a PD commented that the yield on reviewer invitations is about 20%). *Therefore, creating a common reviewer database would significantly remove the workload.* To identify potential Conflicts of Interest (CoIs), PDs and administrative staff members must manually process PDF files submitted with proposals that contain the names of personnel associated with the projects, export into spreadsheets, and clean the spreadsheet data. Enabling more automated processes to detect CoIs will require support from foundation-supported tools, such as the new PI and reviewer identifier and profile tools under development by the Innovation Management Group (IMG).

Recommendation (*): Work with a focus group of CISE PD and administrative staff to identify and prioritize their most critical needs for tools, then collaborate with NSF IT infrastructure staff to identify important systems touchpoints and develop processes to request needed interfaces. Specific actions consist of the following:

28. To reduce the likelihood of undetected Conflicts of Interest (CoIs) with reviewers, CISE should work with NSF to design tools that help to identify CoIs, for example, by (1) linking the identities of reviewers and submitters, and (2) gathering structured data that captures names of personnel associated with a proposal.
29. To reduce Program Director's workload and enable broader participation in review panels, CISE should work with NSF to design a publicly accessible repository to capture the contact information and expertise domains of willing reviewers.
30. To support CISE-developed tools for program management, CISE should work with NSF to establish API stability guarantees and update pathways for foundation-managed infrastructure systems.
31. To reduce panel management workload, CISE should develop automated tools for interacting with reviewers (e.g., creating review assignments and generating standard emails).

2. Responsiveness of the program to emerging research and education opportunities.

CCF programs consist of four core programs and four times as many interdisciplinary programs. CISE issues solicitations for funding opportunities and DCLs for drawing attention to new developments including priorities on existing programs (e.g., COVID-19 RAPIDS). During this period, CISE issued 13 solicitations in CCF and 22 cross-cutting or joint programs. Of these, the maximum number of joint programs were cross-cutting across CNS and IIS. CCF saw 3 dedicated DCLs and was part of 21 cross-cutting or joint DCLs.

CCF uses a variety of mechanisms for rapidly responding to research opportunities. In particular, we noted that:

- EAGER and RAPID proposals were a way to quickly fund research, without going through the panel process
- "Dear colleague" letters provide another means for focusing proposals on particular areas.
- Many proposals to CORE programs were responsive to emerging research.
- New programs covered important and emerging topics. These include "hot" areas like quantum computing and AI, but also topics that have seen much recent innovation while remaining "off the radar", such as formal methods, parallel computing, and nanotechnology.
- Refinements to programs (such as transitioning from SPX to PPoSS) indicate that CCF is evolving and adapting to respond to changes in the field.
- There is an acute focus on cross-disciplinary research, both between CCF/CNS/IIS and between CISE and other directorates.
- Funding partnerships with industry (such as Intel) are another effective vehicle for funding high-priority emerging research opportunities.

From this, we conclude that in general, CCF is doing an excellent job being responsive to emerging research opportunities. A case can be made, however, for corresponding expansion in core program areas for CCF.

Regarding responsiveness to educational opportunities, it would be beneficial to have more clarity about the charge of the NSF. We observed many examples of programs and mechanisms for increasing education around cutting-edge research. We also observed mechanisms for broadening participation. Examples include:

- Supporting graduate student education
- REU sites and REU supplements
- Requiring BPC plans, and using ad-hoc reviewers to ensure those plans are sound
- Programs like CAREER, which explicitly evaluate the integration of teaching and research

On the other hand, we heard many comments about how the material taught in universities is "25 years old". It is remarkable that technologies like ChatGPT, which build upon advances by the CISE community, took the CS education community by surprise in 2022-2023. This is despite many proposals having broader impacts related to innovative educational techniques and introducing new material into courses. This points to the need for improved dissemination of educational innovations, and it is an area in need of improvement.

Suggestions:

32. Eager proposals were funded at a rate of 100%, and RAPID proposals at rates between 66% and 100% during the last three years. CCF should take care to ensure that these panel-less mechanisms do not introduce bias. For example, it was not clear what criteria or situation led to a PI being encouraged to submit an EAGER proposal. Are these criteria or situations equally available to researchers from underrepresented groups, underrepresented institutions, and underrepresented geographic locations?
33. In conversations with PDs, it seemed that Dear Colleague Letters and unfunded mandates are a double-edged sword. They seem to have an oversized impact on workload. CISE should study whether DCLs and unfunded mandates create too much work.
34. (*) With regard to education, the NSF should lead efforts to connect teaching faculty at non-research-intensive institutions with the teaching innovations that are coming out of funded research. Note that such connections could also serve as an additional vehicle for increasing the domestic pipeline into graduate school.

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

Over the observation period, CCF represents a steady program within the CISE portfolio. The funding rate, however, has fluctuated due to a decline in proposal submission rate. Some analysis may be prudent to assess the cause for the shifts in the number of proposals submitted. At the program level, funding for CCF core programs, and the other programs that were running for all four years of the observation period remained relatively steady. Of the newly introduced balance of programs, only one, Predictive Intelligence for Pandemic Prevention, received new funding greater than 3% (or ~$6M) of the overall CCF budget; three other programs received new funding of around $1.5M. All these new programs were cross-cutting across several directorates.

TABLE 5: MANAGEMENT OF THE PROGRAM UNDER REVIEW

Formal documentation described only broad factors, e.g., national and agency priorities, budgetary considerations, etc. that influence portfolio development. Similarly, informal conversations with program officers revealed qualitative factors like "vibrancy of area", technology transfer, and outcomes from PI meetings and NSF workshops as evaluative mechanisms that influence the continuance or sunset of existing programs and the initiation of new ones. While these include the right factors, the specific application of these factors may not be sufficiently methodical.

Suggestion:

35. Considering that the level nature of CCF funding means that the continuance of existing programs directly limits the ability to support the exploration of new ones, we recommend more intentional and measurable program evaluation practices to inform how CCF's portfolio evolves.

4. Responsiveness of program to previous COV comments and recommendations.

It is good to see that the previous COV's comments and recommendations have all been taken seriously, with changes already in place in response to most of the comments and recommendations. For example, it is good to see that there have been budget increases, and program sunsets; it is great that there have been more support for CAREER award applicants, such as offering individual meetings with program directors at CAREER workshop; initiatives have been taken to improve diversity, such as Computing in Undergraduate Education program and CISE-MSI; it is also great to see that new data-analysis tools have been developed to help program directors and that data and analytics officers have been hired. These are all very positive changes in response to previous COV comments and recommendations.

Of course, we also noticed that some issues pointed out by the previous COV that remain in need of attention:

- (*) Although the overall budget has increased, the increase rate (2-5% per year) unfortunately is behind inflation rate. The graduate student unionization in the last couple of years has made the financial situations even more difficult for academic research. We hope that CCF and other divisions of CISE will continue the discussion about how to increase the budget, and how to better support PIs to face this increased financial pressure.
- We hope NSF will continue its effort in improving diversity in award institutes, PIs, and computer science participants, as there is still a long way to go.
- (*) We encourage CISE to re-evaluate and potentially refine the no-deadline policy. Although the no-deadline policy seems to have brought benefit of increased proposal quality and less peak workload for NSF program officers, it also seems to have its downside, including creating challenges in forming panels with appropriate expertise. A re-visit to fully understand the pros and cons of the no-deadline policy and consider how to refine this process would be helpful.
- Finally, one of the previous COV's main recommendations is about potentially changing the IPA policy and improving the recruitment of rotators. Unfortunately, the challenges then seem to remain today. The lack of clarity about working remotely vs. in-person and the legacy policy challenges seem to have put pressure on existing program officers and have made program officer recruiting difficult. We hope some support can come to support existing program officers and help recruit new program officers (both rotators and permanent program officers).

IV. Questions about Portfolio.

Table 3 - Resulting Portfolio of Awards

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? Overall, the spending balance seems appropriate across disciplines across the years of this COV period. One measure of portfolio balance is also the co-funding of activities. CCF outgoing co-funding remained steady over the review period.	APPROPRIATE
2. Are awards appropriate in size and duration for the scope of the projects? The awards have followed the trend of past years and represent effective allocations for exploratory research. Only 3-7% of the awards were funded at levels lower than 70% of the funds asked. In nearly all awarded proposals, the funded duration was identical to the asked. Outside of 100%-funded REU supplements, nearly all supplemental requests for funding were honored. This is healthy and not surprising due to the engagement of the program directors with the ongoing projects. During this period CISE raised the funding level of CCF Small programs from $500K to $600K. This is a welcome development but falls short of the over 40% increase in graduate student costs that many universities are seeing. **Suggestions:** 40. CISE should consider increasing the award amount for the Medium proposals, in light of inflation and increasing graduate student costs.	APPROPRIATE
3. Does the program portfolio include awards for projects that are innovative or potentially transformative? Due to the subjective nature of the question, the best assessment we can make is based on our review of individual jackets. Based on the sampling of eJackets in our group, there were several funded proposals that were potentially transformative and addressed important societal needs both current (such as COVID) and in the future (such as the potential for quantum computing). We note that the innovation claimed and the impact are part of the review criteria thus ensuring that proposals do explicitly respond to this prompt. It is also in the panel reviews as well as additional questions in some programs. As a result, the individual reviews directly reflect on the answer to this question and all the competitive and highly competitive proposals meet this bar.	APPROPRIATE

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
4. Does the program portfolio include inter- and multi-disciplinary projects? Many of the most pressing global challenges and national priorities require multidisciplinary collaboration including advances in computing. Additionally, advances in computer and information science and engineering require collaboration with other disciplines. Accordingly, CCF participates in several programs intended to be interdisciplinary or multidisciplinary, including TRIPODS, Foundational Research in Robotics, and Designing Accountable Software Systems. These are supported by robust co-funding rates. Co-funding comes from a variety of directorates including ENG, BIO, MPS, SBE, O/D, TIP, and EDU, as well as from all the other CISE divisions. We note an interesting trend in co-funding data: 2019 saw about half of $6M co-funding across NSF directed at ENG across 25 proposals (with the majority in Energy Efficient Computing and CPS programs). In the remaining three years, this co-funding has shifted to MPS programs, accounting for half of the cumulative $32M in co-funding obligations during this period. Within CISE, CNS remains a strong and consistent co-funding partner, accounting for $115M of a total $134M in co-funding obligations by CCF.	APPROPRIATE
5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators? During the period under review, CCF received proposals from every state in the union. Overall, the number of awarded PIs across all states is roughly proportional to the number of submitting PIs. However, it was observed that submitting PIs from EPSCoR states tend to have a slightly lower acceptance rate than submitting PIs from non-EPSCoR states. Note that the gap was more significant in 2020, presumably because of the pandemic. A positive trend in closing the gap is observed in 2021 and 2022. Among all the awarded institutes, 18.5-20.3% were from EPSCoR states reflecting a healthy participation rate. **Suggestions**: 41. We note that the data provided was not sufficient to determine whether the geographical distribution of PIs who *submitted* proposals is appropiate to the size of their state and/or number of institutions in that state. This is an important aspect that should also be considered in the future. 42. It is also recommended to continue efforts to interact with submitting PIs from EPSCoR to further close the gap in the success rate in relation to non-EPSCoR submitters.	APPROPRIATE
6. Does the program portfolio have an appropriate balance of awards to different types of institutions? There was a good balance overall. Among all the awarded institutes, around 13.4-16.5% are minority serving institutes in the past 4 years. There was also an appropriate balance among 4-year colleges, Masters degree-granting institutions, and PhD-granting institutions in the past 4 years. We note that that the number of awarded non-Minority-Serving Institutes has steadily increased over the last 4 years (116 in 2019, 118 in 2020, 129 in 2021, 136 in 2022), and yet the number of awarded Minority-Serving Institutes has not increased (23, 20, 23, and 21).	APPROPRIATE

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
7. Does the program portfolio have an appropriate balance of awards to new and early-career investigators? NOTE: A new investigator is an individual who has not served as the PI or Co-PI on any award from NSF (except for doctoral dissertation awards, graduate or post-doctoral fellowships, research planning grants, or conferences, symposia and workshop grants.) An early-career investigator is defined as someone within ten years of receiving his or her last degree at the time of the award. The distribution of new and early-career PIs awarded tends to follow the distribution of PIs submitting proposals. However, it is observed that prior PIs get funded at a higher rate than new and early-career PIs. It was also noted that there is a trend in submitters delaying submission to the new and early-career programs CRII and CAREER. In the COV period, the average experience in years to time of CRII award was 3.5 years, but average experience jumped from 3 years to 3.9 years from 2021 to 2022. Similarly, for CAREER the average in the analysis period is 6.8 years, with 7 years in 2022. This may be defeating the purpose that new and early-career programs are meant to help PIs establish themselves as relatively new faculty members. **Suggestions**: 43. It is recommended to look closer into the average experience of new and early-career investigators to determine the causes for the growing average experience at the time of the award. 44. It is also recommended to analyze whether the higher funding rate of prior PIs over new PIs is due to proper merit or systemic biases.	APPROPRIATE
8. Does the program portfolio include projects that integrate research and education? All the proposals have education plans in them. From eJackets, we could see that the education plans were carefully read and reviewed by the panelists, although occasionally the criteria for the education plan are not as clear as the criteria for the research part of the proposal. There is also a lack of guidance regarding how to disseminate education-related artifacts. It is particularly encouraging to see a steady increase in the number of undergraduate students involved in NSF-awarded research in the past 4 years. This is crucial for the pipeline building and the future of Computer Science.	Yes

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
9. Does the program portfolio have appropriate participation of underrepresented groups[1]? There continues to be under-representation in both submissions and awards for women PIs and PIs from under-represented, minoritized groups when compared to the U.S. population and even when compared to the population in the professoriate. Specifically, women comprise 50% of the U.S. population, 24.3% of faculty, and only about 18% of the CCF proposal submitters. These same statistics are roughly 32%, 5%, and 4% for Hispanics and Blacks/African Americans combined. Of additional noteworthiness, acceptance rates for PIs from underrepresented groups generally track with those not from these groups, except for Blacks/African Americans who observe a lower acceptance rate than the general population – though the numbers are so small that the difference may be statistically insignificant. The NSF has several programs that target broadening participation in computing. These programs target an increase number of students and professionals. However, the only ones that directly target the increase of PIs from under-represented groups target PIs at HBCUs and MSIs. **Suggestions:** 45. Consider programs or funding buckets (like EPSCoR) that can help to broaden the participation of NSF PIs from underrepresented groups even if they are not at minority-serving institutions. 46. Consider creating NSF-sponsored, NSF-led, professional development workshops or programs for aspiring PIs from under-represented groups, oriented around visits to NSF to meet with and learn from program officers and directors. This may prove additionally valuable given the shift away from in-person panels, which afforded a natural opportunity for the same. 47. NSF should also continue to sponsor and promote activities that broaden participation among the computing faculty. PIs from non-R1 institutions, particularly non-R1 MSIs or HBCUs, may not be afforded the time due to higher teaching loads or resources, e.g., research administration staff. Potentially, funding support for teaching releases or to support pre-award proposal administration may help faculty from smaller institutions better compete for NSF grants.	No

[1] 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.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
10. Is the program relevant to national priorities, agency mission, relevant fields, and other constituent needs? Include citations of relevant external reports. Overall, the program is highly relevant to national priorities, agency mission, etc. There is a level of maturity in the strategic documents provided to the COV that deserves praise: the NSF has done an excellent job of articulating a broad vision for scientific progress. During the period under review, the COVID-19 pandemic may have slowed progress, but we did not observe any mismatches between the priorities at different levels. It is also commendable how the NSF has used new and revised program solicitations to respond to shifts in the research community to keep the funded research aligned with its strategy. We anticipate a challenge as the federal government completes its transition out of "pandemic mode". On the one hand, it seems clear that full-time remote work for certain NSF employees is an essential tool for remaining relevant and effective. On the other, we see ways in which the pandemic might have led to some inter-agency initiatives stalling. Some positive observations include: • The transformative role of AI was appropriately considered. There was significant attention to AI (NAIRR report, 2023), and the report was broad and wide-ranging, including testbeds, accessibility, and ethics. • The National AI R&D Strategic Plan provides excellent depth when discussing AI research. • Cybersecurity received significant attention, which is appropriate, given its importance. • The NSF strategic plan aligns well with national priorities. • The enhancement of CloudLab is a key means of supporting "Equitable Data Infrastructure". • Presentations during the site visit demonstrate that issues related to energy efficiency are increasing in importance. There is a recognition that CISE researchers need to be more energy efficient while pursuing their advanced computational research. • Though not directly related to the documents, CISE did an outstanding job of keeping the national research infrastructure running during the COVID-19 pandemic and quickly supporting COVID-related computing research. This included working flexibly with PIs, creating more RAPID awards, and enabling virtual REU sites. **Suggestions:** 48. The strategic partnerships IWG (2021 CoSTEM Progress Report) seems to have primarily gathered data and identified new partners from whom data was needed, but "boots on the ground" implementation was limited by COVID. It will be important to re-invigorate these partnerships. 49. (*) During the pandemic, internships were virtual, or canceled. Some institutional knowledge about running internships was likely lost, and will need to be rediscovered. 50. (*) Domestic enrollment in PhD programs is too low. There are some initial steps to turn this around, but more cross-cutting efforts are needed.	Yes

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
11. Additional comments on the quality of the projects or the balance of the portfolio: We note that there is no evidence, either qualitative or quantitative, to suggest that the amount of funding provided to CISE is sufficient. CISE is understaffed, and staff turnover is high due to the workload. CISE struggles to attract PDs, in part because serving as a PD is financially unwise. On the research front, the amount of research funding has not grown commensurately with inflation or with increases in enrollment. CISE has been innovative in continuing its mission despite insufficient funding (e.g., through industry funding partnerships, and inter-agency programs), but many members of this COV are concerned that the situation is unsustainable and rapidly approaching a "breaking point". Increasing CISE funding must be an urgent priority, both within the NSF budget, and when advocating for increases in the NSF's budget. Failure to do so will impede the agency's ability to create new programs to meet national research needs.	Not applicable

OTHER TOPICS

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

   Among the program areas, demographic under-representation continues to be a work in progress.

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.

   No comments.

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

   We have identified several agency-wide issues in this report. Highlight among these budgetary and staff support for handling CISE workloads, process improvements that enable, at least in limited cases, NSF to respond with comments on submitted proposal and enable their resubmission after making necessary changes suggested by the review process.

4. Please provide comments on any other issues the COV feels are relevant**,** bearing in mind that COV reviews do not include assessment or evaluation of the outcomes or long-term impacts of program investments.

   No comments.

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

In the COV sample, the ratio of accepted to declined proposals was roughly 50/50. It is unclear if this is the right ratio, given that the overall NSF acceptance ratio is much less than 50% -- arguably the committee does not have a proportional vantage point for declined NSF proposals.

The Committee of Visitors is part of a Federal Advisory Committee. The function of Federal Advisory Committees is advisory only. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the Advisory Committee, and do not necessarily reflect the views of the National Science Foundation.

Report for the Division of Computer and Network Systems (CNS)

CORE QUESTIONS and REPORT TEMPLATE
for
2023 NSF COMMITTEE OF VISITOR (COV) REVIEWS

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 starting in July 2023. Specific guidance for NSF staff describing the COV review process is described in the COV Policy (2023 Update) and COV Procedures (2023 Update), available on InsideNSF.

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 NSF. COV reviews provide NSF with external expert judgments on (1) assessments of the quality and integrity of the merit review process and program operations and (2) program-level technical and managerial matters pertaining to proposal decisions.

The program(s) under review may include several sub-activities as well as NSF-wide activities. The organizational unit convening the COV ("the organizing unit") 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 but providing more detailed information.

The organizing unit may add questions relevant to the activities under review. Copies of the report template and the charge to the COV should be provided to OIA prior to forwarding to the COV. To provide COV members adequate time to read and consider the COV materials, including proposal jackets, COV members should be given access to the materials in the eJacket COV module a minimum of four to six weeks before the scheduled meeting of the COV members. Before providing access to jackets, (1) the Conflict of Interest and Confidentiality briefing for COV members must be conducted and (2) the organizing unit has received signed COI and Confidentiality Statements (NSF Form 1230P) from each COV member. The briefing for COV members is also an appropriate time to summarize the scope of the program(s) under review and answer questions from COV members about the template and process.

Suggested sources of information for COVs to consider are provided for each item. As indicated, resources for NSF staff preparing data for COVs include the COV Dashboard in Enterprise Reporting and Enterprise Information System (EIS) –Web COV module. Section 7 of the COV Procedures document on InsideNSF describes other sources of information that may be appropriate for a COV.

For programs using 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. These suggestions will not be appropriate for all programs.

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. COV reviews do not include assessment or evaluation of the outcomes or long-term impacts of program investments. Discussions leading to answers to the Core Questions will require study of confidential material such as declined proposals and reviewer comments. ***COV reports must 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 https://www.nsf.gov/od/oia/activities/cov/covs.jsp.

2023 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

The information below should be completed by program staff.

Table 1 - Summary Information

Summary Information
Date of COV: Sept. 20-22, 2023

Program/Cluster/Section:
 	
Clusters
• Computer Systems Research (CSR)
• Networking Technology and Systems (NeTS)
• Secure and Trustworthy Cyberspace (SaTC)
• Cyber-Physical Systems (CPS)
• Education and Workforce Development (EWF)
• Research Infrastructure (RI)
 	
Core programs
• Computer Systems Research (CSR)
• Networking Technology and Systems (NeTS)
• CISE Core Program Large
 	
Cross-cutting programs
• Secure &Trustworthy Cyberspace (SaTC)
  ○ Information Integrity DCL
  ○ Open Source Software Security DCL
• Cyber-Physical Systems (CPS)
• Smart and Connected Communities (S&CC)
• Civic Innovation Challenge (CIVIC)
• Foundational Robotics Research (FRR)
• Safe Learning Enabled Systems
• Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science (SCH)
• Future of Work at the Human-Technology Frontier: Core Research (FW-HTF)
• Future Manufacturing
• Accelerating Research through International Network-to-Network Collaborations (AccelNet)
• Predictive Intelligence for Pandemic Prevention Phase II (PIPP Phase II Centers Program)
• Designing Materials to Revolutionize and Engineer our Future (DMREF)
• Design for Environmental Sustainability in Computing (DESC)
• Resilient & Intelligent NextG Systems (RINGS)
• Spectrum Workforce Development
• Design for Environmental Sustainability in Computing (DESC)
• Platforms for Advanced Wireless Research (PAWR)
• Computer Science for All (CSforAll: Research and RPPs)
• Broadening Participation in Computing (BPC)
• Improving Undergraduate STEM Education: Computing in Undergraduate Education (IUSE: CUE)
• Computer and Information Science and Engineering Minority-Serving Institutions Research Expansion Program (CISE-MSI)
• Cloudbank DCL
• NSF FutureCloud

Summary Information

- Computer and Information Science and Engineering (CISE) Graduate Fellowships (CSGrad4US) - DCL
- Research Experiences for Undergraduates (REU) Sites
- Research Experiences for Teachers (RET) Sites
- Expanding AI Innovation through Capacity Building and Partnerships (ExpandAI)
- Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES)
- ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions (ADVANCE)
- Historically Black Colleges and Universities - Excellence in Research (HBCU-EiR)
- National Science Foundation Research Traineeship Program (NRT)
- CISE Community Research Infrastructure (CCRI) -- changed to Community Infrastructure for Research in Computer and Information Science and Engineering (CIRC) effective Sept 2023
- Campus Cyberinfrastructure (CC*)
- Mid-scale Research Infrastructure-1 (Mid-scale RI-1)
- Mid-scale Research Infrastructure-2 (Mid-scale RI-2)
- Industry-University Cooperative Research Centers Program (IUCRC)
- Computer and Information Science and Engineering Research Initiation Initiative (CRII)
- Faculty Early Career Development Program (CAREER)
- EAGER, RAPID, Conference
- Principles and Practice of Scalable Systems (PPoSS)
- Pathways to Enable Open-Source Ecosystems (POSE)
- National Artificial Intelligence (AI) Research Institutes
- Future of Semiconductors (FuSe)
- Formal Methods in the Field (FMitF)
- Expeditions in Computing
- National Discovery Cloud for Climate (NDC-C) DCL
- International Partnerships
    - NSF-NSERC partnership (Canada)
    - NSF-GACR partnership (Czech Republic)
    - NSF-DFG partnership (Germany)
    - NSF-DST partnership (India)
    - NSF-MeitY partnership (India)
    - NSF-BSF partnership (Israel)
    - NSF-SFI-DfE partnership (Republic of Ireland / Northern Ireland)
    - NSF-JST partnership (Japan)
- NSF-IITP partnership (South Korea)

Division: Division for Computer and Network Systems (CNS)

Directorate: Computer and Information Science and Engineering (CISE)

Number of actions reviewed:
190
Awards:
95
Declinations:
93
Other:
2

Summary Information
Total number of actions within Program/Cluster/Division during period under review: 11,089 AWD: 2722 DCL: 8237 Other: 130
Manner in which reviewed actions were selected: The NSF recommends 5% of the total portfolio be available to COV members for review. Sampling data consists of competitively reviewed proposals (awards and declines) as well as proposals that were returned without review. A random sampling of all FY 2019-2022 proposals reviewed or returned without review in the division was achieved using Excel macros designed to randomly sample within an excel list based on the proposal program coding and proposal status. Due to the large volume of proposals received in the CNS division, approximately 1.7% of the portfolio has been made available to the COV. If any additional proposals are requested by the COV they will be provided. CISE has randomly generated a sample of 190 out of 11,089 proposals, which is an aggregate of 1.7% across all fiscal years under review. COV members have been assigned to review proposals based on their areas of expertise and the complexity of proposals and programs in each area, while avoiding any declared conflicts of interest.

COV Membership

Table 2 - COV Membership

Role	Name	Affiliation
COV Chair or Co-Chairs:	Athina Markopoulou H.J. Siegel	University of California, Irvine Colorado State University
COV Members:	Mustaque Ahamad Roch Guerin John C. Hale Samee Khan (through 9/22) T.V. Lakshman Deborah Shands Janos Sztipanovits Nitin Vaidya	Georgia Institute of Technology Washington University in St. Louis University of Tulsa Mississippi State University Nokia Bell Labs SRI International Vanderbilt University Georgetown University

MERIT REVIEW CRITERIA

An understanding of NSF's merit review criteria is critical to answer some of the questions on the template. Reproduced below is the information provided to proposers in the Grant Proposal Guide about the merit review criteria and the principles associated with them. Also included is a description of some examples of broader impacts, provided by the National Science Board

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.

- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These broader impacts may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.

- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities. These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of two National Science Board-approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. Both criteria are to be given full consideration during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (NSF's Proposal and Award Policies and Procedures Guide provides additional information for use by proposers in development of the Project Description section of the proposal.) Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.D.2.d, prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit**: The Intellectual Merit criterion encompasses the potential to advance knowledge; and

- **Broader Impacts**: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to:
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

3. Examples of Broader Impacts

The National Science Board described some examples of broader impacts of research, beyond the intrinsic importance of advancing knowledge (NSB-MR-11-22). "These outcomes include (but are not limited to) increased participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education at all levels; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a globally competitive STEM workforce; increased partnerships between academia, industry, and others; increased national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education. These examples of societally relevant outcomes should not be considered either comprehensive or prescriptive. Investigators may include appropriate outcomes not covered by these examples."

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, returns without review, and withdrawals) that were *completed within the review period (generally the prior four 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.

Summary of Findings and Recommendations
CNS COV

CNS is the Computer and Network Systems Division of CISE. The portfolio of CNS includes a rich suite of core programs (such as NeTS and CSR), several exciting and successful cross-cutting programs (such as SaTC, CPS, S&CC), and EWF that includes CSGrad4US and several other educational activities. During the past decade, the Computer Science (CS) community has contributed tremendously, and at an accelerated pace, to society via the transformative power of IT everywhere. CISE is leading this development and CNS – the systems and networking division – is a key enabler for digital transformations in science, technology and society. Our subcommittee found that, overall, despite limited resources, the division is successfully achieving its mission and meeting and exceeding its goals and objectives. During our subcommittee's deliberations, the following key recommendations came up. Most of them concur with the general observations across the 2023 COV, and are elaborated upon in the rest of our report.

First, there is natural contention for resources between core and cross-cutting programs. Core programs support foundational research, provide continuity, and capture organically the evolution of the field, as expressed by the submissions coming from the community. Cross-cutting programs also capture exciting multi- and cross-disciplinary initiatives, and are inherent to CNS, as the systems division. CNS enables and supports all emerging developments in computing, communication, storage, cybersecurity, computing infrastructure, cyber-physical systems, and CS education and workforce development. Examples include recent AI breakthroughs and the communications technologies that kept our society online and functioning during COVID. The budget allocated to core programs accounts for a small part of the total CNS budget, remains flat, and cannot keep up with the growth in the field and the community. One metric of this growth is the significant increase in CNS CAREER proposal submissions, from 2019 to 2022. The COV CNS subcommittee recommends that the core programs continue to be supported at a healthy level, and that they should be carefully balanced against other initiatives. As part of this balancing effort, it would be good to clarify the processes by which programs get prioritized, and to explain to the community the quantitative metrics that inform such decisions.

Second, the accomplishments of CNS, and of the entire CISE community, could be better communicated to the rest of NSF, the public, and the congress. In addition to the reports and publicly available project outcomes, CISE could consider additional methods, such as science writers, highlights in the website, newsletters, and possibly "test of time" awards for the achievements of the NSF funded PIs. The PIs are incentivized to promote and communicate their work, and can contribute to creating the content.

Third, building partnerships with industry is a great initiative, particularly for CNS (e.g., through RINGS), and should be continued, enhanced, and grown further. One suggestion is to try to get engagement, in addition to funding, that is a unique contribution of industry, such as access to resources (data, testbeds, labs) and the involvement of key industry people. At the same time, and while the benefits of industry partnerships are undeniable, they are typically complex to establish and manage. This translates into a significant added workload on NSF personnel, both on the administrative side and on program officers. It is, therefore, essential that growth in industry partnerships be accompanied by corresponding growth in NSF administrative resources to facilitate their management.

Fourth, we discussed two aspects of broadening participation in computing. One aspect is educational: we commend CNS for leading the CISE-wide Educational and Workforce (EWF) program, which should continue but with care in regards to the workload for division staff. The second topic we discussed was the need to understand if and which institutions (e.g., non-R1 institutions, depending on geography – partly addressed by EPSCoR) and faculty are still not participating, or may not even be aware of NSF/CISE opportunities. It needs to be recognized

that potentially excellent research that is not funded due to limited NSF funds or because of lack of proposal

submissions from non-R1 institutions represent lost opportunities to enhance science and engineering that can advance society.

Fifth, the subcommittee agrees that the NSF merit review process is the gold standard. Suggestions for further improvements are provided in parts I and II of report, and include the following: providing flexibility for in-person panels; encouraging junior people's participation in panels and familiarize them with the NSF processes; mechanisms to improve consistency of expertise and quality of reviews; provide more information on the rationale for the funding decisions (currently in the - review analysis) to the PIs, especially junior PIs (e.g., via the currently underused PO Comments section); facilitating rebuttal and response to reviewer concerns, as well as maintaining some memory in the review process for resubmissions.

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**.**

Table 3 - Quality and Effectiveness of the Merit Review Process

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? The review methods for all proposals, in the sample of jackets provided to the CNS COV, looked appropriate for those proposals. Almost all proposals were reviewed by panels, and we found the use of panels, the selection of panelists, and the number (three to five) and quality of reviews to be generally appropriate. Most proposals received multiple substantive reviews and sufficient panel discussion. Very few proposals had no panel discussion (NPD), when the review scores were below an established level, but sufficient feedback was still provided to the PI. In the few EAGER and RAPID jackets reviewed, POs (Program Officers) reviewed the proposals and provided detailed feedback to the PI; the POs had the expertise required in those cases. The use of site-visits was appropriate for the large proposals it was applied to. Finally, in terms of virtual vs. in-person panels, there were no comparative data provided to us. During the COV visit, there was discussion and a recommendation to allow for flexibility to use all modes of operation, with the intention to bring back some level of in-person panel participation, especially for the benefit of junior PIs.	Yes
2. Are both merit review criteria addressed **a) In individual reviews?** **b) In panel summaries?** **c) In Program Officer review analyses?** In all of the jackets reviewed by the CNS COV, both Intellectual Merit (IM) and Broader Impact (BI) were addressed in almost all of the individual reviews and always in the panel summaries. In specific review analyses written by Program Officers (POs), both IM and BI were also addressed. As expected, the NDP proposals lacked panel discussion or review analysis, and boiler-plate language was used, but the merit review criteria were sufficiently addressed in the reviews.	Yes

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? In the jackets reviewed by the CNS COV, the majority of the individual reviews provided substantive comments to explain their assessment of the proposals. E-jackets that included a lower quality individual review typically included at least three substantive individual reviews or a more substantive panel summary. However, there was variability in the expertise of reviewers and in the quality of reviews, especially in inter-disciplinary panels. To improve review quality and consistency, we recommend: (i) developing sample reviews and a tutorial to educate new reviewers; (ii) introducing mechanisms to rate the quality of reviews and incentivize diligent reviewers (e.g., with a "best reviewer" recognition), as practiced by many conferences today; and (iii) reminding reviewers to make their ratings consistent with their substantive comments. Another suggestion to consider is revamping the requirements for the evaluation of "Results from prior NSF support" to encourage attention to reproducibility/repeatability of research products and improve accountability in delivered research outcomes.	Yes, in the majority of reviews
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? In the jackets reviewed by the CNS COV, the majority of the panel summaries provided a coherent synthesis and distillation of the opinions expressed in the individual reviews and in the discussion. Panel summaries sufficiently described the main points of agreement and disagreement (e.g., "One panelist found, however…") among panelists, and justified the basis and rationale for the final rating in the panel recommendation. Panel summaries often provided useful recommendations as well. It is worth noting that, on average, the quality of panel summaries appeared higher than the quality of individual reviews. This indicates the effectiveness of the attention and guidance panelists receive from Program Officers (POs) and re-affirms the value of holding panels as an effective mechanism for merit review.	Yes, definitely.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
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.]** In the jackets reviewed by the CNS COV, the majority of the Review Analyses (RAs) written by POs provided thorough rationale for the award/decline decision. When proposals were rated as "Low Competitive" or "Non-Competitive" or were not discussed in a panel, the standard decline RA provided only a generic explanation for not funding the proposal. In several cases where panelists raised substantive concerns about specific aspects of otherwise highly rated proposals, the PD contacted the PI and responses to questions were documented in diary notes or correspondence. In most of the cases, the PO concurred with the recommendation of the panel summary. In the few cases where the PO did not concur, or was not able to fund a competitive project due to other considerations (such as portfolio balance or budget constraints), the jacket provided sufficient documentation of the rationale and the process. In fact, our COV found the information in the RA so interesting and informative, that we recommend that it might be worth communicating the non-confidential parts of it to the PIs, especially junior PIs, e.g., through the currently under-used PO-comment mechanism.	Yes

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
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.]** The combination of reviews and panel summary was typically sufficient to convey to the PIs the rationale for the decision, and often even constructive recommendations for improvement. For some of the awarded proposals, the correspondence between the PO and the PI, asking for clarification on issues raised in the panel reviews, also contributed to clarifying the rationale behind the final decision. There were, however, instances where the rationale would not be clear to the PI without access to the additional insight gained from the RA (Review Analysis). The RAs are not available to the PIs because they sometimes contain confidential information. One recommendation is to consider using the PO Comments to provide to the PI non-confidential information from the RA. It would be especially beneficial to provide the PIs additional explanation of the decision in instances where the decline decision diverges from the panel's ranking of the proposal as competitive.	Yes
7. Additional comments on the quality and effectiveness of the program's use of merit review process: The division makes good use of the merit review process to assess the quality of individual proposals, as we discussed in several questions above. There is, as always, room for improvement in ensuring consistency in the quality of reviews and in the expertise of reviewers, as discussed in response to questions I.3 above. It would be beneficial to all involved to further clarify: (i) how funding decisions weigh portfolio balance considerations, in addition to merit review-based assessment, (ii) other influences that impact the discretion of the Program Officer (PO), and (iii) the scope of the PO's discretion in potentially overriding panel recommendations.	

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**.**

Table 4 - Selection of Reviewers

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? We found that the formal qualification of the panelists was appropriate. However, not all panelists were experts in the specific topics of proposals they reviewed. Finding appropriate expertise was particularly challenging in cross-cutting programs where program goals explicitly required substantial contributions in more than one discipline. Despite the aforementioned challenge, we found that, in all proposals we reviewed, there was at least one reviewer (and often multiple reviewers) with sufficiently deep expertise to shape the panel discussion effectively. This is a testimony to the excellent work of POs that they found at least one panelist who was expert in the essential disciplines and topics of the proposal. While review panels in core and cross-cutting programs (such as SaTC) have sufficient expertise to evaluate the proposals, in education and outreach programs, such as REU/RET/CSGrad4US, the reviewers did not always have the unique perspective that these programs require (e.g., not having participated in such programs). The panels seem to have a good mix of seniority levels, which is good for training and networking of junior panelists. We discussed the possibility of further training of first-time or junior reviewers, e.g., by showing them examples of good and bad reviews, or training videos of panel discussions – see also question I.3 above.	Yes, at least some in every proposal.
2. Did the program recognize and resolve conflicts of interest when appropriate? In all jackets we reviewed, there was no evidence for any CoI violation. All CoIs were resolved by using declared CoI documentation before the panel, or during the panel if an undiscovered conflict was detected. Information was a little hard to find, although included in the review analysis or context/process statements, often in boiler-plate language. Although we believe CoIs were properly handled, it might be possible to further streamline the process and documentation.	Yes

SELECTION OF REVIEWERS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
3. Additional comments on reviewer selection: We recognize that finding qualified reviewers for the large number of proposals in CISE and CNS is a challenging task. This challenge is compounded by the fact that NSF tries to balance reviewer representation across research areas, seniority levels, geographical areas, and institutions. The COV, beyond our subcommittee, discussed the possibility of keeping some memory in the review process, which could expedite or inform resubmissions, but we came up with no concrete recommendation. We recommend paying special attention to selecting junior researchers, training them, and encouraging them to attend in-person panels.	

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

Table 5 - Management of the Program Under Review

MANAGEMENT OF THE PROGRAM UNDER REVIEW
1. Management of the program. The CNS sub-committee identified the following points while observing the management of the programs within the CNS division. See also related responses to questions III.3, IV.1, IV.4. **Program Portfolio:** CNS has a wide-ranging portfolio of research programs, including core programs (NeTS, CSR), exciting cross-cutting programs (SATC, CPS, S&CC, CSGrad4US and others), and initiatives with other divisions within NSF, sometimes leading (EWF, Research Infrastructure), sometimes joining other divisions. CNS successfully manages its program portfolio, adds new programs aligned with national priorities, collaborates with other agencies to secure additional funding, and reviews and sunsets existing programs. **Core vs. Cross-cutting:** Under limited resources, there is naturally a contention between core and other programs. Core programs support foundational research, provide continuity, and capture organically the evolution of the field, as expressed by the submissions coming from the community in a bottom-up way. Cross-cutting programs also capture exciting research priorities that emerge within the CISE community and align with the division's role as the systems division of CISE. In that role, CNS enables and supports all IT and computing developments (including but not limited to the recent breakthroughs in AI, and the technologies that kept our society online during COVID), via computing, communication, storage, cybersecurity, and other disciplines. There was an extensive discussion about budget allocation of core vs. other programs. We recommend that NSF maintain a healthy level of support (in terms of budget and staff) for core programs and balance it against the specialized programs. See also questions IV.1, IV.4. **Need for Quantitative Metrics:** NSF periodically reviews programs to decide which ones to continue and which to sunset. We recommend clarifying the criteria and establishing quantitative metrics for starting or ending programs, and for prioritizing allocation of funds among core vs. specialized programs as well as among divisions. **Program Officers Workload:** The effectiveness of the programs relies on Program Officers (POs) who oversee proposal review and selection and funding allocation. The POs raised concerns about their workload and its impact on management of programs, especially given the growth in the community, the increasing number of proposals handled, the coordination required for cross-cutting programs, and the recently shifting guidelines for in-person vs. online work. **Performance During COV Review Period:** It is important to note that this COV reviews a period that overlaps with COVID. CNS has been successful in making timely decisions on proposals during the COVID-19 pandemic. However, it was unclear how operational changes during this period have impacted the overall management and proposal submission patterns. **Management Plans:** Each program solicitation has a management plan that outlines procedures for planning, budgeting, staffing, proposal processing, review, monitoring, and assessment. These plans are developed by POs and approved by Division management. Periodic reviews are conducted by CISE leadership every two to three years or as needed. **In summary,** the need for transparency in the criteria for program initiation and discontinuation is to be looked into. There is also a call to maintain healthy core programs and balance them against specialized programs. However, the importance of cross-cutting programs and their management within CNS is to be acknowledged.
2. Responsiveness of the program to emerging research and education opportunities. Programs are shaped through a combination of top-down priorities (often aligning with national and NSF priorities) and bottom-up themes emerging in both the core programs (through organic submission of proposals) and through

specialized programs. For launching new research programs, NSF receives community input through mechanisms such as NSF-funded workshops and POs interacting with the community in conferences and in PI meetings, which underscores the importance of community engagement in shaping program development. CISE/CNS POs also actively engage in leadership roles within strategic planning coalitions, such as NITRD, to ensure the integration of emerging research and education priorities into forthcoming programs.

Two particularly agile mechanisms to support emerging research and educational opportunities are through the RAPID and EAGER programs. The RAPID (Response Research) and EAGER (EArly-concept Grants for Exploratory Research) mechanisms were highlighted for their capacity to swiftly address emerging challenges in research and education.

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

It was observed that the CNS research portfolio is guided by (i) internal deliberations and budget constraints, in NSF and CISE, (ii) external opportunities, including national priorities and joint funding initiatives with other divisions and the industry, and (iii) recommendations from the research community. See also related discussion in questions III.1 (prioritization of programs) and III.2 (response to emerging research and education opportunities) above.

NSF's "Strategic Plan" provides qualitative guidance on priorities, highlighting important directions and grand challenges that should shape NSF's priorities. It underscores the importance of training the future workforce and addressing underrepresentation of certain communities. Several CNS solicitations seem aligned with the goals and priorities of NSF and the national priorities (e.g., NITRD), but it is not clear how priorities are assessed and documented.

Program planning is influenced by both top-down priorities and bottom-up themes, eventually shaped and executed by the program officers who seem to have significant latitude at their discretion. One recurrent observation and recommendation is the need for clarifying and documenting this process and introducing quantitative metrics to (i) assess the success of existing programs, (ii) prioritize and plan new programs, and (iii) inform resource allocation among core and specialized programs. This would help better inform the decisions of program officers.

The CNS COV emphasized the growing role of computing in various scientific and engineering fields, necessitating cross-cutting programs and breakthroughs, and the increasing responsibility of CNS – as the systems division – to enable and support these breakthroughs. The CNS COV suggests continuing use of mechanisms discussed in the previous question, new "visioning" workshops, and university-industry forums to explore emerging research directions. As a side benefit, the CNS community will benefit immensely through the use of in-person re-engagement after the COVID-19 pandemic.

See also discussion in questions III.1, IV.1, IV.4.

4. Responsiveness of program to previous COV comments and recommendations.

The CNS COV reviewed the response to the previous COV comments and recommendations. Overall, we found that CISE took previous COV recommendations seriously and took concrete steps to address them. We make the following observations with respect to the previous recommendations and how CISE addressed them.

#1 Increase overall funding to CISE: The previous COV emphasized the growth in computer science as well as the increase cost of research, and requested an increase in the CISE budget to keep up with these trends and to maintain US' competitiveness. Our COV agrees and believes that the need for increased budget is even more urgent today, exacerbated by the accelerated pace of technology (e.g., the recent advent of generative AI), the increased costs of research (e.g., by the unionization of researchers, spreading across US universities), and the stiff international competition (e.g., in the semiconductors area). At the same time, CISE's budget has effectively stayed flat during the review period, which is an effective decrease when accounting for inflation.

Therefore, this most important recommendation has not been addressed, and we would like to re-iterate and request

MANAGEMENT OF THE PROGRAM UNDER REVIEW

a much-needed budget increase. CISE in general, and CNS in particular, are commendable for partnering with industry through matching funds, which is an innovative approach to raising funds, but comes with administrative burdens.

#2 Program Re-alignment or Sunsetting: CISE has partially addressed this recommendation by establishing a standardized process and deadlines for program sunsetting or review, providing program examples in alignment with COV concerns. However, this COV recommends further improving and documenting this process by establishing quantitative metrics and criteria for informing Program Officers' decisions with respect to sunsetting/starting/funding programs. See also questions III.2 and III.3, above.

#3 CAREER Program Adjustment: CISE has responded by expanding funds to accommodate increased junior faculty submissions to the CAREER program and supporting researchers without startup packages (with CRII), acknowledging the need for ongoing monitoring and adjustments within its control. Increasing the minimum budget for these early career (and other small) grants should be considered, given the increasing cost of academic researchers (driven by their unionization).

#4 Clarification of "Broader Impacts": CISE has led efforts to clarify "broader impacts" in the research community, making information accessible on the NSF website, aligning with the COV's intentions.

#5 Underrepresented Groups: Previous COVs requested that CISE develop and evaluate initiatives to promote participation of underrepresented groups in research, proposal review and in the computing pipeline. During the review period, CISE has initiated and invested in several programs (such as BPC, CISE-MSI, expand programs) to enhance participation of underrepresented groups in research and education. We recommend to also consider measures to support representation in later career stages.

With respect to representation in the reviewing process, the Data Book provides statistics on the panel reviewers (their institutions, demographics, and geographical diversity). This enables monitoring the diversity of the panel composition and the effectiveness of any initiative meant to improve that diversity. The CNS COV also discussed "who we are still missing" from the computing and reviewing pipeline: the statistics computed are only on the people who are already informed and have chosen to participate in the process, while there may still be other populations to reach out to (e.g., in non-R1 institutions).

#6 Rolling Proposal Deadlines: CISE has addressed the recommendation by already implementing rolling proposal deadlines, in many programs, with positive outcomes for various stakeholders. If there are unintended consequences resulting from this switch, they should be explored.

#7 Reviewer Selection Practices: CISE has established best practices for pre- and post-panel processes instead of pursuing a checklist approach for documenting "competitive declines," making a reasonable response to a difficult request. CISE also maintains data for panel reviewer statistics (on institutions, geographical diversity and demographics), which were made available through the Data Book, and which can be relied on to continue monitoring current practices.

#8 Data Presentation: CISE's involvement in an NSF-wide data presentation change and the introduction of the COV data dashboard were viewed as a great start. It is recommended that continued enhancements be undertaken to the dashboard to provide further insights for improved operation and planning.

#9 Tools for Reducing Workload: While CISE is to be commended for enhancing its own data and analytics capability, significant gaps remain in systems used for proposal review management and PI communication systems, highlighting the need for NSF-wide IT upgrades to empower staff and reduce workload issues.

#10 Rotator Recruitment: It was previously recommended that IPA positions be made more attractive for potential candidates, by allowing them to maintain or resume their research programs. It seems that multiple classes of positions can be used to attract qualified rotators, IPA being one of them, and mechanisms are put in place to allow for personal development and remote work. Several outstanding researchers have joined NSF during the review period.

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The strongest obstacle, for current and potential IPAs, seems to be the changes in remote work policies, which may be outside the control of CISE. NSF could consider different rotator funding vehicles and associated categories and establish clear rules, codified in the agreements, that can be depended upon throughout the duration of the rotators' appointment.

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

Table 6 - Resulting Portfolio of Awards

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? The answer is a resounding "yes." CNS is home to core (e.g., NeTS, CSR) and cross-cutting programs (e.g., SaTC, CPS, S&CC). As the systems division within CISE, CNS is inherently inter-disciplinary: it provides the systems breakthroughs and infrastructure that enable and support all digital transformations of all aspects of science, technology, and society (including AI, and the online systems we relied upon during COVID). CNS also leads the Education and Workforce Program (EDW) across CISE. CNS's interdisciplinarity is evident in its budget. CNS has also a very significant volume of cross-funding, both in projects from other directorates or CISE divisions that it contributes to as well as co-funding it receives from other directorates and CISE divisions for its own projects. In particular, a significant portion of the CNS's outgoing co-funded awards go to other directorates outside CISE. Conversely, the incoming funding is another indicator of interdisciplinarity: the largest 3 cross-cutting programs (SaTC, CPS and S&CC) receive as incoming funds a noteworthy portion of the total CNS budget. One concern that this CNS COV has is the ability of CNS to maintain a healthy level of support for its core programs. Currently, the CNS budget and number of awards is significantly higher for cross-cutting than for the core programs. The split was approximately one (core) to four (cross-cutting) in 2019 and 2020 and approximately one to seven in 2021 and approximately one to six in 2022, which is low. We recommend that CISE should consider increasing support for CNS core programs, to continue creating the advances that will eventually branch out into collaborations with other areas. Related to that is also our recommendation for quantitative metrics to assess and prioritize programs. See also questions III.1, III.3, IV.4.	Yes, definitely

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
2. Are awards appropriate in size and duration for the scope of the projects? From the data available, funding levels seem to be on par with the requested amounts with only a small average gap, although it is unclear how significant these differences are compared to the size of the project. The data related to project duration did not raise any major concern. One observation is that although the funding level for small proposals was increased to $600k, overall funding levels are mostly flat when adjusted for inflation. This fails to account for increased cost of graduate students, postdocs, and research expenditures (e.g., due to the impact of unionization trends across the country, and the growing needs for computational infrastructure). We recommend to regularly examine and consider adjusting the award levels to keep up with those increases.	It appears so.
3. Does the program portfolio include awards for projects that are innovative or potentially transformative? Innovation is one of the review criteria, so it is explicitly assessed and taken into account during the review process. Although exit surveys indicate that panelists considered only few proposals to be "potentially transformative," there were nevertheless several proposals that were identified as such. The term "transformative" may be difficult to interpret, and the CS community is known to be self-critical and hold itself to a high standard.	Yes, some.
4. Does the program portfolio include inter- and multi-disciplinary projects? CNS itself is inherently inter-disciplinary and is responsible for several inter-disciplinary programs, such as SaTC, CPS, and S&CC. The number of cross-cutting awards dominates the number of core awards, possibly a little too much, i.e., by a factor of 4-7, consistently in every year of the review period. CNS also receives a significant volume of cross-funding from other directorates or CISE divisions that co-fund some its projects. This clearly indicates synergies of CNS with other disciplines. Please see longer discussions in response to question III.1, III.3, and IV.1 above. Two related and recurrent recommendations throughout our report are: (i) to support healthy levels of core CNS programs, and balance them against exciting cross-cutting programs, and (ii) to introduce quantitative metrics for assessing programs and establishing funding priorities.	Yes, definitely.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators? From the data available, the number of awards seems to follow the number of proposal submissions across states. However, the absolute number of submissions and their success rates vary across states. For example, the percent of projects awarded in 2022 varies from state to state by a factor as high as 10 while the per-capita awards (using state populations) can also vary across states by a factor of three. These differences can be attributed to a variety of reasons including the population sizes, numbers of higher-ed institutions and big R1 universities in each state. The CNS COV subcommittee found that the submission rate from EPSCoR states is often significantly lower than that from non-EPSCoR states. At the same time, the award rate within EPSCoR states is commensurate with its submission rate. The low submission rate may indicate the potential for better targeting potential PIs from EPSCoR states to make them aware of funding opportunities and assist them in pursuing them. This observation relates to the more general issue about whether/how CISE can understand what communities are still missing, i.e., how to identify potential PIs who do not even apply to CISE/CNS, thus would not be captured in the statistics of submissions and awards. Another suggestion was to investigate PIs migrating from a small (perhaps an EPSCoR) institution, after securing CRII or CAREER, to a bigger institution (perhaps a non-EPSCoR) institution, and how this affects geographical equity.	Yes, but there are differences among states.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
6. Does the program portfolio have an appropriate balance of awards to different types of institutions? The funding rates are very similar across different institutions (except for two-year institutions), which indicates a lack of bias in how decisions are made as a function of institution type. As expected, the majority of awards go to PhD-granting institutions. Up to one fifth go to EPSCoR states in any given year. There is evidence of growth in funding rates and percentage of awarded projects to MSIs (Minority Serving Institutions). For example, the number of awards to MSI institutions has increased by 6.3% from 2019 to 2022, even though the number of submitting MSI institutions remains almost the same over the same period. Furthermore, the awarded percentage for MSIs is now on-par with submission percentage rates. Overall, these are signs of diversification. More self-study is needed to disentangle the effect of different factors (e.g., there are institutions with close to 100K enrollment that are designated as MSI, and big R1 institutions in an EPSCoR state), and identify who is still missing from the pipeline (i.e., PIs and institutions not even applying, thus not accounted for in the data). It would also be interesting to see what programs have seen an increase in EPSCoR co-funding besides CAREER and CRII.	Yes, but more self-study is needed.
7. Does the program portfolio have an appropriate balance of awards to new and early-career investigators? The number of CAREER proposals submitted to CNS has increased by more than 50% during the review period, which is the highest percentage growth in CISE, and reflects the growth in the field. The funding rate for CAREER CNS proposals has also been increasing for both the new PIs and the previously funded PIs, which demonstrates the CNS commitment to the growth of the program, specifically for early-career researchers. CAREER awards are, as expected dominated by early career researchers (0-7 years from PhD). The data seems to also indicate a growing number of submissions by and awards to more experienced researchers (8-20 years post the degree date). This is a bit surprising and may indicate a shift in academic career starting age in computer science, e.g., because of a postdoc or a previous position in industry. The CRII proposals are only submitted by early-career PIs, as expected. The number of submissions has decreased because of a change in eligibility, limiting submissions to non-R1 institutions. At the same time, the program funding rate has increased.	Yes.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
8. Does the program portfolio include projects that integrate research and education? *Observations based on the sample of jackets we reviewed:* The majority of regular projects, in the sample we reviewed, sought to integrate the proposed research in some form of curriculum development, although very few were making education as their main focus. Most proposals were focused on research with an educational extension, typically falling under the Broader Impact. We also reviewed some samples of purely education proposals (e.g., funded by CSGrad4US). *Observations based on the CNS portfolio:* CNS provides anchoring of such programs outside the CAREER program, or BPC plans for large projects, through REU, RET, and CSGrad4US. REU site proposals are an effective vehicle to offer research opportunities to students who may have been exposed to the topics as part of curriculum development efforts. CNS leads the Education and Workforce Program for the entire CISE and also provides outgoing funding to EDU. Finally, based on the personnel count in reports, CNS trains thousands of graduate students, postdocs, and undergraduates per year.	Yes.
9. Does the program portfolio have appropriate participation of underrepresented groups[1]? The percentage of PIs from underrepresented PIs is small and did not change much from year-to-year. Relative percentages between submissions and awards are consistent across demographic categories, which is good. There is no significant change in the number of submissions or awards for underrepresented groups over the last years. It may require additional investigation to understand how the demographics are changing, if at all, with the recent growth of new faculty in CS. This might be difficult due to the large number of PIs who do not respond to demographics questions, especially race (approximately 46% in 2022 and rising from 25% in 2019), which makes it hard to make firm conclusions. Beyond PI demographics, other metrics for assessing participation of underrepresented groups are the statistics about relevant initiatives (BPC, MSI, ExpandAI awards, etc.) that have been discussed in earlier sections. In particular, MSI participation was found to have increased – see question IV. 6 above.	Difficult to assess.

[1] 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.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
10. Is the program relevant to national priorities, agency mission, relevant fields, and other constituent needs? Include citations of relevant external reports. For most proposals in the sample we reviewed, one could identify one or more matches to national priorities (Wireless, AI, Cyber Security, Information Integrity, STEM education, and workforce training). The cross-cutting programs that CNS oversees are another example of its ability to rapidly contribute to relevant fields (e.g., SaTC for cybersecurity, or participation in AI institutes). Its ability to quickly stand-up compute resources and initiatives following COVID-19 offers a prime illustration of the benefits of that agility.	Yes, broadly.
11. Additional comments on the quality of the projects or the balance of the portfolio: Please see summary and recommendations in the beginning of the CNS COV report.	

OTHER TOPICS

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

N/A

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.**

N/A

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

N/A

4. **Please provide comments on any other issues the COV feels are relevant, bearing in mind that COV reviews do not include assessment or evaluation of the outcomes or long-term impacts of program investments.**
5. A significant part of funded research goes to support personnel such as graduate research assistants and postdoctoral fellows. There is a wave of unionization of graduate students and academic researchers across the country. This has led to a significant increase in the cost of these researchers on NSF grants, as

high as 40%. This started at the University of California but is rapidly spreading in universities across the nation. NSF and CISE might want to consider this issue, which is here to stay and will affect all PIs and our ability to remain competitive unless the awards increase to match the cost. For example, it might be worth revisiting the funding levels of small grants, CAREER awards, and NSF GRFPs.**NSF would appreciate your comments on how to improve the COV review process, format, and report template.**

The Committee of Visitors is part of a Federal Advisory Committee. The function of Federal Advisory Committees is advisory only. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the Advisory Committee, and do not necessarily reflect the views of the National Science Foundation.

Report for the Division of Information and Intelligent Systems (IIS)

CORE QUESTIONS and REPORT TEMPLATE
for
2023 NSF COMMITTEE OF VISITOR (COV) REVIEWS

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 starting in July 2023. Specific guidance for NSF staff describing the COV review process is described in the COV Policy (2023 Update) and COV Procedures (2023 Update), available on InsideNSF.

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 NSF. COV reviews provide NSF with external expert judgments on (1) assessments of the quality and integrity of the merit review process and program operations and (2) program-level technical and managerial matters pertaining to proposal decisions.

The program(s) under review may include several sub-activities as well as NSF-wide activities. The organizational unit convening the COV ("the organizing unit") may instruct the unprCOV 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 but providing more detailed information.

The organizing unit may add questions relevant to the activities under review. Copies of the report template and the charge to the COV should be provided to OIA prior to forwarding to the COV. To provide COV members adequate time to read and consider the COV materials, including proposal jackets, COV members should be given access to the materials in the eJacket COV module a minimum of four to six weeks before the scheduled meeting of the COV members. Before providing access to jackets, (1) the Conflict of Interest and Confidentiality briefing for COV members must be conducted and (2) the organizing unit has received signed COI and Confidentiality Statements (NSF Form 1230P) from each COV member. The briefing for COV members is also an appropriate time to summarize the scope of the program(s) under review and answer questions from COV members about the template and process.

Suggested sources of information for COVs to consider are provided for each item. As indicated, resources for NSF staff preparing data for COVs include the COV Dashboard in Enterprise Reporting and Enterprise Information System (EIS) –Web COV module. Section 7 of the COV Procedures document on InsideNSF describes other sources of information that may be appropriate for a COV.

For programs using 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. These suggestions will not be appropriate for all programs.

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. COV reviews do not include assessment or evaluation of the outcomes or long-term impacts of program investments. Discussions leading to answers to the Core Questions will require study of confidential material such as declined proposals and reviewer comments. ***COV reports must 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 https://www.nsf.gov/od/oia/activities/cov/covs.jsp.

2023 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Table 1 - Summary Information

Summary Information
Date of COV: September 20-22, 2023
Program/Cluster/Section: AI Research Institutes Big Data Science &Engineering CRCNS-Computation Neuroscience Cyberlearn & Future Learn Tech Fairness in Artificial Intelli FRR-Foundationl Rsrch Robotics FW-HTF Futr Wrk Hum-Tech Frntr HCC-Human-Centered Computing HDR-Harnessing the Data Revolu Hurricane Harvey 2017 Info Integration & Informatics IntgStrat Undst Neurl&Cogn Sys NRI-National Robotics Initiati Robust Intelligence S&AS - Smart & Autonomous Syst Smart and Connected Health
Division: Information and Intelligent Systems (IIS)
Directorate: Computer and Information Science and Engineering (CISE)
Number of actions reviewed: 225 **Awards:** 115 **Declinations:** 109 **Other: 1**
Total number of actions within Program/Cluster/Division during period under review: 10,678 **Awards:** 2,023 **Declinations:** 8,541 **Other:** 114
Manner in which reviewed actions were selected: The NSF recommends 5% of the total portfolio be available to COV members for review. Sampling data consists of competitively reviewed proposals (awards and declines) as well as proposals that were returned without review. A random sampling of all FY 2019-2022 proposals reviewed or returned without review in the division was achieved using Excel macros designed to randomly sample within an excel list based on the proposal program coding and proposal status. Due to the large volume of proposals received in the IIS division, approximately 2.1% of the portfolio has been made available to the COV. If any additional proposals are requested by the COV they will be provided. CISE has randomly generated a sample of 225 out of 10,678 proposals, which is an aggregate of 2.1% across all fiscal years under review. COV members have been assigned to review proposals based on their areas of expertise and the complexity of proposals and programs in each area, while avoiding any declared conflicts of interests.

COV Membership

Table 2 - COV Membership

Role	Name	Affiliation
COV Chair or Co-Chairs:	Sonia Fahmy (COV Chair) Tanya Berger-Wolf (IIS co-Chair) Worthy Martin (IIS co-Chair)	Purdue University The Ohio State University University of Virginia
COV Members:	Anita Raja Gloria Washington Ishwar Sethi James Pustejovsky Kavita Bala Lydia Tapia Raja Kushalnagar Steven Zucker Will Dabney	Hunter College, CUNY Howard University Oakland University Brandeis University Cornell University University of New Mexico Gallaudet University Yale University Google Deep Mind

MERIT REVIEW CRITERIA

An understanding of NSF's merit review criteria is critical to answer some of the questions on the template. Reproduced below is the information provided to proposers in the Grant Proposal Guide about the merit review criteria and the principles associated with them. Also included is a description of some examples of broader impacts, provided by the National Science Board

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.

- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These broader impacts may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.

- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities. These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of two National Science Board-approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. Both criteria are to be given full consideration during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (NSF's Proposal and Award Policies and Procedures Guide provides additional information for use by proposers in development of the Project Description section of the proposal.) Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.D.2.d, prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit**: The Intellectual Merit criterion encompasses the potential to advance knowledge; and

- **Broader Impacts**: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to:
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

3. Examples of Broader Impacts

The National Science Board described some examples of broader impacts of research, beyond the intrinsic importance of advancing knowledge (NSB-MR-11-22). "These outcomes include (but are not limited to) increased participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education at all levels; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a globally competitive STEM workforce; increased partnerships between academia, industry, and others; increased national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education. These examples of societally relevant outcomes should not be considered either comprehensive or prescriptive. Investigators may include appropriate outcomes not covered by these examples."

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, returns without review, and withdrawals) that were *completed within the review period (generally the prior four 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.

General Observations:

The division of Information and Intelligent Systems (IIS) is at the forefront of national priorities and NSF leadership in emerging technologies, leading the areas of growth in Artificial Intelligence (AI), data and information science, robotics, human-machine partnership, smart and autonomous systems. IIS also leads many interdisciplinary initiatives of CISE in computational neuroscience, smart health, and in many other cross-cutting programs. Overall, the committee commends IIS on establishing a fair, equitable, and functional process for supporting research and workforce development in the areas that intersect with IIS scope and collaborating across CISE and NSF.

IIS leadership is evident in the increased percentage of CAREER applications to the division, which is also the indicator of the growth of the early-career scientists within the IIS community. However, the overall funding to the division remained constant, leading to the drastically declining funding rate of the core proposals, now the lowest of CISE. This raises the concern that the core foundational research is underfunded and constrained, potentially leading to a dangerous drop-off in core research. This may already be evident in the decline of the number of proposals submitted by senior researchers, exposing the senior brain drain of the field.

To support and strengthen the IIS leadership at the forefront of CISE research and workforce development, we recommend exploring agile dynamic funding mechanisms for rebalancing CISE and NSF budgets that appropriately resource the division proportional to the changing national priorities and demands.

The committee has noted the high independence of program officers and panels in making funding and co-funding decisions. Overall, the IIS COV subcommittee found that IIS has a highly functioning review system and a collaborative and collegial decision-making process. While in agreement that panel independence is generally a good idea there were some concerns raised about uniformity in panels and programs, particularly in providing sufficient and substantive feedback, decisions on crossover and interdisciplinary proposals, and initiation of new research. It was noted that the process overall works well most of the time and for most of the cases but where it has a potential to falter is at "the edges" of the distributions, impacting disproportionally the early career researchers, non-research institutions, underrepresented minorities, uniquely interdisciplinary proposals or those innovating at the intersections of research, education, diversity.

To support a more agile, responsive, equitable, and inclusive review process, we recommend more streamlined mechanisms for training, coordination, guidance, and collaboration for program directors and staff. We suggest having more memory in the system both in terms of best practices as well as the institutional memory, particularly in the form of better technology tools for automating processes and cross-referencing data. Additionally, to address the difficulty of consistently finding appropriate and diverse sets of panelists and reviewers, one of the possible approaches could be getting commitments from reviewers for a year or two in advance, while encouraging them to serve on at least one panel annually.

The committee unanimously agreed that enhancing diversity and inclusiveness remains a challenge and that more could be done at various stages of the proposal pipeline including who submits the proposals, what is in the proposals (particularly addressing the Broader Impacts, see below), who reviews, who gets awarded, how the impacts are measured.

To increase the diversity and inclusiveness, program officers should increase direct engagement with minority, specialized, and non-R1 institutions in the form of direct visits, targeted regional workshops, mentoring, and seed grants to encourage more submissions, as well as continue the practice of supplements to existing large grants to encourage collaboration, mentoring, and outreach programs.
We also recommend making the senior personnel (non-PI/co-PI) visible on the front page, abstracts, and searchable databases. This will provide credit and visibility to the entire team, particularly for larger proposals and will often result in more credit to junior researchers as well as team members from a variety of institutions and careers. We also recommend increasing process flexibility overall, including flexible panel formats (a mix of in person and virtual) and moving to multiple but fixed deadlines (e.g., 3 to 4 per year) for proposals.

While the Broader Impacts sections are interpreted in many ways across NSF, in much of IIS-relevant research the societal impacts are much more integral to the intellectual merit than in many other research areas. We commend the research community on incorporating societal impacts intrinsically into the research agenda. The panel reviewers, however, sometimes do not appropriately value or have insufficient expertise to evaluate the societal impacts that are likely to result from the proposed research. Moreover, other aspects of broader impacts, particularly those related to diversity, equity, inclusion, and accessibility, are sometimes overlooked.
To appropriately evaluate and value the broader impacts of IIS research we recommend developing more detailed guidelines for reviewers, as well as including panel or ad-hoc reviewers with appropriate expertise, to ensure a more balanced evaluation of societal impacts and the more traditional intellectual merit.

The COV members consistently noted the dedication, passion, and high expertise of NSF staff. It was repeatedly noted that NSF staff is willing to go above and beyond in their duties. The COV deeply appreciates the work and service of NSF staff. It is also clear, however, that NSF staff are overworked

and under-resourced. There are too many unfunded mandates, not enough staff (including administrative positions), and increasing demand to do more (fund more programs, more community engagement, more coordination, more in-depth reviews, more mentoring, etc). The current state is not sustainable.

To meet the unprecedented and urgent demands of US research leadership in CISE and to support the mission of NSF, we recommend to substantially increase NSF, especially CISE, funding, increase staff, improve hiring process, tools and automation, leverage existing organizations and resources within and outside NSF through partnerships.

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**.**

Table 3 - Quality and Effectiveness of the Merit Review Process

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? Overall, the panel felt that all the review methods were appropriate. Concerning the number, there were sufficient reviewers generally, including when multiple panels were involved or when interdisciplinary reviewing was required. In such cases, both panels generally did excellent jobs. Concerning ad hoc reviewing, some proposals had ad hoc BPC expert reviewers to do a full evaluation of the broader impacts. Some minor issues did arise when cross-program reviewing was required. It was suggested that some guidance or standards for proposals that move from one panel to another. Several proposals were weakly reviewed in one division, and then passed over to another program, where they were more positively reviewed, and then recommended for funding. In general, however, the criteria for measuring fairness and appropriateness of reviewers for specific proposals indicate good calibration across panels. While generally impressed with the reviewer quality, the IIS COV felt that the mix of the reviewers could include more HBCU faculty or faculty from minority, specialized, or non- R1 universities. Most of the awarded proposals did not have a panel with anyone with that expertise, but the research projects were geared towards understanding all types of humans, specifically within HCC. Of the jackets provided to the IIS COV, only a small percentage of the panels had reviewers from these institutions. Another issue raised was that the depth of reviewing as is evidenced by the publicly available information, did not always scale entirely with the budget associated with the proposal. The IIS COV suggests that there is room to improve the utilization of review resources in this regard. The COV Data Book indicates most panels have moved to virtual format since 2021, with a small handful of the panels being held in-person. Additionally, there have been mostly virtual site visits since 2021. Ad Hoc reviews are rarely used. Given this emphasis on panel review, the consistency and makeup of the panel is critical to the outcome of the review process. The analysis of proposal jackets informs this emphasis, with a clear contribution of senior, industry, and more junior researchers. However, there should be careful consideration of individual contributions that may occur during an online format. Open discussion by all parties in a welcoming format is critical to make sure all voices are heard.	YES

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
2. Are both merit review criteria addressed **a) In individual reviews?** **b) In panel summaries?** **c) In Program Officer review analyses?** The reviews (a) and panel summaries (b) in almost all cases address the strengths and weaknesses of the intellectual merits well. Many addressed the broader impacts clearly as well. However, there were a handful of reviews and summaries where the broader impacts seemed to be treated as an after-thought. The review analyses (c) consistently more effectively addressed the merit considerations by the panel. The IIS COV suggests that panelists continue to be more educated on how to evaluate broader impacts. Another suggestion is to have ad-hoc reviewers or experts with BPC expertise provide their feedback that the panelists could use in their evaluation. It would be helpful if there was a standard format suggested for the reviews so that the strengths and weaknesses could be clearly distinguished. While the NC proposals typically received a short summary, the COV felt it might be useful to have more constructive summaries for NC CAREER and first-time PI proposals, so that junior faculty have more feedback.	YES
3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? It was observed that most review panels were instructed "to be sure that your review prose justifies your rating". To that end, many of the reviews have substantive comments on the proposed research. However, a non-trivial number of reviews were rather generic, sometimes with most of the review being quotes from the proposal, rather than informative summarization and consolidated analysis. One suggestion is that there should be a review component labeled, "Justification of rating," and maybe make it a condition of assigning "accept" on the review. For proposals that end up just below the funding level, it is very frustrating for the PIs to have occasional reviews with mostly generic content, particularly when the prose of the review does not seem to align with the rating. While these cases are note common, we suggest more care would be given for the borderline proposals for each review to justify the rating. NSF performs considerable behind-the-scenes review management. It would be helpful and extremely informative to have more transparency regarding what the procedure is, documenting how such situations are operationalized and handled.	YES

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Most panel summaries did provide a rationale for the panel consensus and gave reasons, so overall the IIS COV response is positive for this question, with most COV members answering Yes. However, there were some concerns raised: • Some panelists noted that that in some cases rationales were unclear. • Most panels reported on intellectual merit and broader impacts. But there was a panel summary that did not mention them at all (though individual reviews did). Consistency in making sure the panel summaries include these two criteria is important. • When panel summaries are in consensus but don't match the original scores from reviewers, because reviewer scores are variable and sometimes uncalibrated (even if their text is consistent), it is important to explain this context to the PI. • In some proposals rebuttals were requested, but it was not clear what was the situation that justified asking for a rebuttal. The directors clarified that rebuttals were not typically asked for, but were done to help the PM finalize their decision of funding when a proposal was likely to be funded.	MOSTLY
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.] In many cases, the provided information was sufficiently to support the rationale for the decision, with the review analysis and panel discussion documents called out as being especially informative for this purpose. That said, how informative they were varied from proposal to proposal, with COV members highlighting several instances where things were less clear. • In some panels the scores given seemed at odds with the language of the reviews and discussion themselves. For example, panels giving VVV, but in reading reviews and summary it is clear that the reviewers were not as impressed. This was partially attributed to differences in panel guidelines, and there are attempts to normalize across panels, such as through the program officer's team meetings to discuss the	YES

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
results of the panel and talk about the panel discussions to reach a decision. . • The relative importance of intellectual merit and broader impact was not clear in the rationale for the decisions. • In some cases, the proposal was ranked competitive, not HC, and yet was funded, without sufficient documentation of the rationale for the decision. There were a number of cases where the process involved some additional iteration involving the PI that was typically not clearly reflected. • In some cases, the panel summary showed that they were supportive but unconvinced or lacking some additional information. Here, some questions were asked of the PI and on the basis of these responses, the proposal was funded. This iteration was not accurately reflected in the summary, but was available in the jacket. • The rationale for award recommendation is not sufficiently outlined for proposals that were allowed to address one or two reviewer concerns and were rated competitive in IIS HCC. Example reviewers and the panel summary noted the proposal was lacking on key research background and some letters of collaboration. However, the proposer was allowed to get these documents and address these concerns, and the proposal was recommended for funding. One recommendation from the IIS COV is to improve guidelines for panels to facilitate calibration. Per the comments to Question 3, NSF performs considerable behind-the- scenes review management. It would be helpful and extremely informative to have more transparency regarding what the procedure is for responding to concerns/weaknesses that have been identified in the review, in order to make additional review requests and processes clearer. It would be helpful to begin the on-boarding of the COV with a walkthrough of the Management Plans given by someone knowledgeable in the processes (such as a Division Director)	
7. Additional comments on the quality and effectiveness of the program's use of merit review process: Beyond the comments above on the overall process and methods it was not clear to the COV reviewers how reviews and decisions were calibrated across panels. They noted that some panels were harsher than others, and the funding recommendations were not necessarily consistent across panels. This could cause some areas of research being starved out compared to others. The Division Director provided feedback that a lot of discussion happens post-panel among the various program directors to calibrate the decisions. It would be helpful and extremely informative to have more transparency regarding what the procedure is and the Management Plan.	

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**.**

Table 4 - Selection of Reviewers

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? The reviewers on the proposals examined were deemed, for the most part, to have reviewers of appropriate expertise. This was particularly noted on the panels that the COV deemed challenging to review, including proposals reviewed by two programs, proposals in programs where reviewers were required that cross expertise areas (e.g., hardware and software), proposals in interdisciplinary programs where reviewers had a wide range of expertise from varying relevant disciplines. When discrepancies to this pattern were noted, e.g,, there was not a clear relation to the PIs area, there was an indication of disagreement in the reviews demonstrated through high-variance of review comments. It was also noted that the panel makeup also included experts that crossed institutional boundaries and that captured researchers at varied stages in their careers. A drawback was noted that some states have much less representation on NSF panels, possibly due to institutional size. However, due to this small base of reviewers, some states see highly variable representation on panels from year to year. Some concerns were raised that occasionally reviewers could have been biased to favor an application area versus the foundational research due to the lack of an expert in the foundational research area on a panel. Addressing this is challenging for interdisciplinary programs, like those out of IIS.	YES
2. Did the program recognize and resolve conflicts of interest when appropriate? Overall, yes, the program diligently and successfully recognizes and resolves conflicts of interest, with multiple examples of the process being triggered by: • Collaborators and Other Affiliations Document (COA) document being used to identify conflicts and determine tentative list of reviewers. • COAs are consistently used to match reviewers to proposals • When a COI is discovered after review is submitted, COI marked in NSF database and not released or used in decision making. • If appearance of rather than the actual COI are identified, CISE COI officials are consulted to provide guidance on moving forward.	YES

SELECTION OF REVIEWERS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
3. Additional comments on reviewer selection: Data provided to the COV indicate that strong efforts are made to utilize gender diverse pool of reviewers. However, it was also noted that diversity within an individual panel is highly variable. Also, ethnic diversity of reviewers was very low. The COV determined that there were two reasons for this. First, there is low representation of underrepresented minorities in several research areas covered by IIS. Despite this, it is critical to strive for diverse representation on every review panel. Second, the data collection on reviewer demographic has only recently begun to be a required question to reviewers. While reviewers can choose to not report, the active participation in the question encourages better data collection. The COV appreciates this change in data collection, and supports that this data should continue to be collected and monitored for the next COV review.	

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

Table 5 - Management of the Program Under Review

MANAGEMENT OF THE PROGRAM UNDER REVIEW
1. Management of the program. The program on the whole is well managed. The number of proposals received by IIS has shown about 30% drop in last three years. One possible explanation for this appears to be the switchover to having no deadlines. The switchover to no deadlines, while promoting a faster turnaround of ideas, also poses problems in assembling panels, particularly thematic ones. The committee recommends that NSF looks into the effect of the lack of deadlines on the number and demographics of submissions. It may be worth investigating also the effect of deadlines vs no deadlines on the quality of submissions by looking at the ratio of proposals not eligible for funding to the total number of submissions, and the change in institutions applying for funding. The committee also suggests considering a hybrid approach consisting of quarterly (or triannual) deadlines in place of no-deadlines. The dwell time for most proposals seems to be within the GPRA goal of six months. However, there are several awarded and declined proposals where the dwell time stretched to about a year. While in some cases, the longer dwell time may be due to waiting for funding to become available, the workload on the program personnel also appears to be a factor. The committee recommends NSF monitor dwell times more proactively to ensure almost all proposals are dealt-in within 6 months.
2. Responsiveness of the program to emerging research and education opportunities. There are two levels at which CISE can react to emerging research opportunities. The first is rapid deployment of resources through the EAGER and RAPID grant mechanisms. Many EAGERs are not fundable through the existing solicitations. In this case proposers often interact with Program Directors to check whether a proposal is suitable and often submit summaries and, if appropriate, the proposals are funded. This strategy led to 100% of EAGERS being funded in 2020-2022. More long-term responses to new programs, driven either bottom-up or top down, have been slower. Management issues have been reported, such as identifying the source of the funding and whether existing program directors can handle the additional load. We recommend that the procedures for creating and executing new programs be streamlined.

MANAGEMENT OF THE PROGRAM UNDER REVIEW

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

The IIS COV raised a concern regarding the low funding rate and decline in proposal submissions in IIS.

As the computing landscape and societal impact of AI changes, greater resources need to be committed to IIS to continue adequate core research funding as well as cross-disciplinary research, the IIS COV feels that the funding decisions for allocation per division should be aligned with present societal and research demands.

4. Responsiveness of program to previous COV comments and recommendations.

IIS has addressed most of the previous recommendations under its purview well. For instance, the COV was provided detailed reviewer demographic data as requested in the previous COV review which was very helpful.

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

Table 6 - Resulting Portfolio of Awards

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? The IIS COV did not understand the Data Book information concerning co-funding, as the tabled data was unclearly presented. Extensive conversation with the NSF staff clarified some but not all of the data. Some of the data on the disciplinarity of the proposals is not collected or collectable by NSF. Since its inception IIS has encouraged and funded interdisciplinary research within its core programs and in collaborative programs across CISE, NSF and other agencies. The levels of funding for the three core programs, HCC, III, and RI, have slightly increased over the 2019-2022 span and the proportions per program have remained stable. However, the numbers for funded proposals have gone down substantially over the four years, particularly for HCC. Funding levels for the programs: NRI, Smart Health, Secure & Trustworthy Cyberspace, and Cyberlearn & Future Learning Tech have remained steady. New initiatives in AI Institutes, CSforAll, Fairness in AI, CPS, and Broadening Participation in Computing, are appropriately growing in funding levels. At the budgetary level, there is some data about "ingoing" and "outgoing" co-funding. Some of that data remains confusing and raises a concern about the impact on IIS core programs of outgoing co-funding, as balanced against incoming co-funding. We are concerned about the impact of new initiatives that come as unfunded mandates to provide co-funding for cross-program or cross-agency research. Recommendation: Establish a mechanism for rebalancing CISE (and NSF) budget to more fully take into account the evolving national priorities and demands to assure that the core programs are not getting shortchanged by having to absorb funding for new research areas.	Probably. Available data are confusing or insufficient

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
2. Are awards appropriate in size and duration for the scope of the projects? Generally, the awards were of appropriate size and duration for the projects' scope, but in many cases, there was a significant gap between the requested amount and the total award. There were concerns that fewer proposals were being funded and when funded the amount received was less than requested. Additionally, it was noted that in cases where reviewers suggested the need for a larger budget given the scope of the proposal the award amounts appeared to never be larger than requested. Recommendation: Along these lines, it was observed that the overall funding levels across divisions need more calibration, as the number of proposals coming into IIS has increased disproportionately (as measured by the proportion of CAREERs) among the divisions and funding levels have not kept up with this change in proportion. These issues were identified as contributing factors for why funded proposals were funded below requested amounts.	MOSTLY
3. Does the program portfolio include awards for projects that are innovative or potentially transformative? The program portfolio generally includes awards for projects that are innovative or potentially transformative, given that they are a key element of merit review. However, the weighting appeared to differ by program. For instance, in the CAREER proposals surveyed, innovation and transformation of the field appeared to have higher weight relative to the rest of the intellectual merit during proposal review, while in other programs, e.g., small core proposals, the proposals appeared to have lower transformative factor weighting relative to that of the CAREER proposals. It would be advantageous to have guidelines for the weights by program in terms of how much transformative impact it is expected to have.	YES
4. Does the program portfolio include inter- and multi-disciplinary projects? Overall, the portfolios show evidence of support for interdisciplinary programs and the resulting funding of some percent of those. Some programs, e.g., CRCNS, were exceptional in their support of interdisciplinary research. In general, however, the process of reviewing and funding interdisciplinary proposals is not well specified or uniform across programs. While there should be freedom to do so "when needed", the IIS COV felt that more guidance and some explicit coordination is needed.	YES

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
5. Does the program portfolio have an appropriate geographical distribution of Principal Investigators? The geographical distribution of awards appears appropriate. However, efforts can be made to improve the success rates of the states having a lower success rate to likely improve the diversity of the funded projects overall. While looking at the data, a trend of declining number of reviewers was observed. The IIS COV suggests exploring ways of recruiting more reviewers particularly from institutions less represented in the current reviewer pool.	YES
6. Does the program portfolio have an appropriate balance of awards to different types of institutions? The program portfolio has an appropriate balance of awards to different types of institutions. R1 institutions received the majority of funding, as would be expected. However, during the past 4 years there were small deviations. A few awards went to institutions that made the institution type more diverse. The COV further observed an upward trend in awards to Masters institutions, which is encouraging. EPSCoR states receive 20% of the funding, which seems acceptable.	YES

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
7. Does the program portfolio have an appropriate balance of awards to new and early-career investigators? NOTE: A new investigator is an individual who has not served as the PI or Co-PI on any award from NSF (with the exception of doctoral dissertation awards, graduate or post-doctoral fellowships, research planning grants, or conferences, symposia and workshop grants.) An early-career investigator is defined as someone within ten years of receiving his or her last degree at the time of the award. It is encouraging to note that early- and mid-career awards are increasing. The best practices leading to this should be continued. However, the IIS COV notes that the trend in the number of *senior* career submissions and awards has been decreasing during the past 4 years. This is concerning. It could lead senior researchers to other grant sources, or could contribute to the brain drain from universities to industry. The COV suggests that CISE investigate the reasons behind this trend. Once this information is available, CISE should consider appropriate rebalancing mechanisms, if necessary. Continued decline in senior researcher funding threatens to unbalance the community representation. There is a technical issue here as well. IIS has a goal of funding 20% of CAREER submissions, but since the number of these submissions has increased significantly, this is absorbing increasingly larger fractions of the budget. Again, this raises concerns about balancing the budget and the award portfolio.	YES
8. Does the program portfolio include projects that integrate research and education? The COV members observed that some of the strongest proposals were those that explicitly integrated the core research into directed educational goals, with specific objectives aimed at creating, and maintaining, student interest either through curricular development or research participation. Medium and CAREER proposals were identified as most often having strong integration between research and educational components, although some proposals were called out as overemphasizing teaching at the expense of research. Some COV members suggested that the geographic diversity of the projects and sites that integrate research and education were limited, and identified this as a potential area of improvement. The cost-of-living in some locations was discussed as a significant challenge for increasing the number of REU sites. A potential complimentary recommendation would be to focus sites in under-represented, and often lower-cost, locations.	YES

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
9. Does the program portfolio have appropriate participation of underrepresented groups[1]? Despite the efforts and clear desire, the participation of underrepresented groups in the program portfolio show little to no change over the years. The COV notes that there is still a data collection problem, since only in the last few years were PIs required to answer a series of demographic questions on gender, ethnicity, and disability status. While there is an option to not respond, there is a better response rate due to the requirement to participate in the questions. Additionally, it is noted that the rate of awarding proposals from underrepresented groups is aligned with the overall funding rate. That observation should not be the justification for curtailing extensive efforts in increasing high quality submissions from underrepresented groups. There are new proactive efforts that aim to address these rates. For example, new programs that target funding at MSIs and institutions serving persons with disabilities, should have some impact. However, this COV recommends additional efforts targeted to improve representation. Getting underrepresented PIs from these institutions more familiar with NSF programs, program directors, and funding processes is critical. One suggestion is to increase the number of regional visits to develop programs to enhance the number and quality of proposals from these underrepresented PIs. Additionally, visits by PDs to conferences aimed at underrepresented PIs, where meetings and/or workshops could occur. Another possibility is to require large center grants to provide funding and grow collaborations with MSIs and institutions serving persons with disabilities to help them grow in research. (It is noted that this is beginning through the ExpandAI program.) Any efforts to strengthen outreach and mentoring programs, including those that bring PIs to NSF, are critical to improving these numbers.	NO

[1] 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.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE

10. Is the program relevant to national priorities, agency mission, relevant fields, and other constituent needs? Include citations of relevant external reports.
 	
NSF's mission is "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes (NSF Strategic Plan for 2018 to 2022.pdf). Overall, NSF is "leading the world in discovery and innovation, STEM talent development and delivery of benefits from research" (NSF Strategic Plan 2022-2026.pdf). CISE, and more specifically IIS contributions, play a key role and are highlighted in every part of the 2018-2022 plan, indicating the program's relevance to the NSF's mission and contributions. NSF's mission also aligns with the national priorities, as translated into the NSF budget priorities, to which CISE contributes fundamentally:
• Emerging Infrastructure for Economic and National Security
  ○ **CISE contributions:** AI, advanced wireless, semiconductors, cybersecurity
• Creating Opportunities Everywhere
  ○ **CISE contributions, through various programs and mechanisms:** K-12, REUs, returning (grad) students (CSGrad4US), EPSCoR, research experience for teachers (RETs), Broadening Participation in Computing, CISE Education and Workforce, CISE MSI Research Expansion, IUSE, CS4ALL.
• Resilient Planet
  ○ **CISE contributions:** Global Centers, PIPP, Smart and Connected Health
• Research Infrastructure
  ○ **CISE contribution:** foundational contributions to every aspect of modern research infrastructure, from hardware and cyber infrastructure to data analytics and AI
 	
IIS portfolio is well aligned with the national priorities, agency mission, and relevant fields. In fact, IIS is the key contributor to many of the programs, particularly AI. IIS's leadership in emerging areas is reflected in growing participation in IIS programs by early career PIs, e.g., the number of IIS CAREER proposals is twice that of all other CAREER proposal submissions at CISE.
 	
Recommend: We strongly recommend adjusting funding levels for IIS proportional to the demand and leadership of IIS in strategically important areas such as AI and robotics. Moreover, strategic initiatives and mission-aligned mandates should be directly funded.
	YES

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
11. Additional comments on the quality of the projects or the balance of the portfolio:	

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.
4. Please provide comments on any other issues the COV feels are relevant**,** bearing in mind that COV reviews do not include assessment or evaluation of the outcomes or long-term impacts of program investments.
5. NSF would appreciate your comments on how to improve the COV review process, format, and report template.

The Committee of Visitors is part of a Federal Advisory Committee. The function of Federal Advisory Committees is advisory only. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the Advisory Committee, and do not necessarily reflect the views of the National Science Foundation.

Worthy Martin
Co-Chair