Report of the Subgroup of the CISE AC on Private-Sector Partnerships

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INTRODUCTION AND ORGANIZATIONAL CONTEXT

A partnership, a formal relationship between NSF and one or more organizations, is a strategic approach to advance NSF's and CISE's missions. Over the last several years, NSF has gained experience with partnerships in multiple sectors, public and private; CISE has led NSF by its experience with private-sector partnerships. As an organization that strives to learn from its experiences and improve its processes, CISE requested a subgroup of its Advisory Committee to provide a community perspective on CISE's current experience and direction in public-private partnerships. In this section we summarize the CISE experience and the NSF's current partnership position.

CISE EXPERIENCE

"Over the last several years, NSF's CISE directorate has led the agency in pursuing vibrant public-private partnerships that allow [CISE] to accelerate advances in the research and education that [CISE] supports. CISE's partnerships have already shown the utility of bilateral collaborations with the research arms of large multinational corporations."[1]

These mostly bi-lateral and more recently multilateral direct partnerships[2] have had multiple benefits for the CISE academic research community, including connecting researchers and students with current problems, industry expertise, and resources; accelerating research and its transition to practice; and spurring new innovations and new fields of research. Since 2014, CISE's investment of more than $173 million has been matched by private-sector partners with more than $107 million and in-kind support. Part of the CISE experience includes feedback from the community and an assessment of these activities (see the section on Challenges Experienced by CISE).

NSF POSITION[3]

Beginning in 2018, NSF set an Agency Priority Goal (APG) to "expand public and private partnerships to enhance the impact of NSF's investments and contribute to American economic competitiveness and security."

This activity created a baseline of activities and monitored progress in expanding its partnerships.

In FY2020 NSF renewed its APG to engage in public-private partnerships to enhance the impact of NSF's investments, with a specific goal: NSF will develop and pursue an agency-wide partnerships strategy, components of which will include targeted outreach, implementation of process improvements, and improvement of internal and external communications.

In FY2020 the National Science Board released its Vision 2030 report, which called "Partnerships" one of the four areas of leadership, and as part of its roadmap, it calls for partnerships to speed the path from discovery to innovation (among other values of partnerships).

During the writing of this report (March 2021), NSF unveiled its newly-updated agency-wide website on partnerships. The website contains the *NSF Partnerships: Landscape Study*, which articulates the type of partnerships NSF has experienced and lays out a set of principles for when NSF will engage in partnerships to advance its mission.

PARTNERSHIPS

For this document we will refer to a partnership as a formal relationship[4] between NSF and one or more organizations to enhance the proposed achievement of potential outcomes of research, education or innovation, with benefits to all partners.

In the "direct" partnerships developed by CISE since 2014 both CISE and the partners define the goals and contribute resources, which may include funding, researchers-in-residence, data sets, etc. The partners may provide input into the NSF-led review process.

In the CISE experience with the private sector, partnerships with industry are entered into through memorandum of understandings (MOUs). In some cases, the companies send funds to NSF; in others, NSF makes an award to the university and the company funds the project separately.

More about attributes of partnerships and benefits can be seen at NSF's Partnership website.[5] See also the section Thoughts for the Future for further discussions of partnerships.

Footnotes

[1] For more detail of CISE's recent experience and examples of partnerships, see the Context and Framing document in the Appendix. Beyond the current examples, CISE has worked in collaboration with the private sector to advance opportunities for its researchers. One example is the Gigabit Network project of the late 80s and early 90s. CISE and the Defence Advanced Research Project Agency (DARPA), through a cooperative agreement with the Corporation for National Research Initiative (CNRI), which led the major effort by approximately forty organizations representing universities, telecommunication carriers, industry and national laboratories, and computer companies to create a set of very high-speed network testbeds and to explore their application to scientific research. CNRI also worked with the US Government in so far as testbeds were established within several government laboratories. See The Gigabit Testbed Initiative, Final Report, December 1996. ***http://www.cnri.reston.va.us/gigafr/***.

[2] "Direct partnership" follows the terminology of the report NSF Partnerships: Landscape Studies, page 4 (see References) and refers to NSF having a written agreement, often a Memorandum of Understanding, to support research and educational activities of mutual benefit. In contrast, "NSF-catalyzed" partnerships result from NSF funding but are made by the principal investigator and awardee institution with the partner. The Industry-University Cooperative Research Center (IUCRC) program, and the Convergence Accelerator program are examples of NSF-catalyzed partnerships with the private sector.

[3] Another internal effort that helped clarify NSF's position on partnerships was Renewing NSF, a response the Office of Management and Budget (OMB) released Memorandum M-17-22 (April 12, 2017), titled "Comprehensive Plan for Reforming the Federal Government and Reducing the Federal Civilian Workforce."

[4] The partnership relationship could be formalized one of several ways, e.g., Memorandum of Understanding, cooperative agreements.

[5] NSF's Partnership website, ***https://nsf.gov/about/partners/***

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CHALLENGES EXPERIENCED BY CISE PURSUING PRIVATE-SECTOR PARTNERSHIP

We summarize six challenges that stem from CISE's experience to date. The appendix has more details.

- Reputational risk to the agency; for example, if NSF partners with a company that does not share similar community principles;
- Balanced approach, ensuring a level playing field for possible partnerships;
- A partner's level of engagement; for example, how engaged in review or post-award monitoring a partner should be;
- A partner's funding approach, which often comes with separate funding to the PI in the case of bilateral partnerships (i.e., NSF partners with one company);
- Intellectual property concerns, including background and foreground IP;
- Managing actual and perceived conflict of interest (COI), perhaps limiting submissions from academic PIs with industrial ties.

We note that the first two of these challenges are directly in NSF's control; the second two are part of a discussion between NSF and its partners; the fifth is a complex discussion among industry and university; and the final one, on COI, is a topic primarily for NSF; however, partnerships may introduce additional concerns and visibility.

CHARGE TO THE COMMITTEE

CISE's experiences in its private-sector partnerships have informed NSF's position. CISE has also gained knowledge from its experience and has heard feedback from the community.

This subgroup of the CISE Advisory Committee (AC) was asked to provide feedback, from the perspective of the CISE research community, on CISE's private-sector partnership experience and direction. CISE shared with the CISE AC six categories of community feedback on its partnership experiences, described below. CISE management encouraged the subgroup to think beyond these specific challenges to any other perceptions by or opportunities for the CISE community about CISE's efforts with its private-sector partnerships.

We note that a fuller discussion of partnerships extends well beyond the private-sector partnerships scope of this report. Other partnerships with NSF include other Federal Agencies, non-profit and non-governmental organizations, international funding agencies, and state and local governments. See Additional Recommendations and Thoughts for the Future for more discussion.

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GENERAL FINDING AND OBSERVATIONS

In preparing this report, the subgroup learned about CISE's considerations in developing partnerships and about NSF's activities (some noted above). The subgroup acknowledges the progress and endorses many of these activities:

- CISE's multi-year efforts to gain experience with private-sector partnerships.
- CISE's management's view that partnerships provide greater value to the community than the monetary co-investment from industry. Several categories are mentioned in the introduction. In addition, working with private-sector partnerships can help NSF promote its value to multiple stake holders in Congress and society.
- CISE's current effort to assess the tangible outcomes of its partnership experience.
- NSF's internal efforts to create tools to reduce the additional Program Officer work involved with creating (e.g., negotiating and developing Memorandum of Understandings and Management Plans that spell out how NSF and the partner will interact at all major phases of the review, selection, award, and monitoring processes) and managing the resulting processes (e.g., review, selection, award management, and post-award monitoring) of direct partnerships.
- NSF's clear articulation of principles for engaging in partnerships, in particular through its newly launched website.

GENERAL FINDING AND OBSERVATIONS

As we addressed the specific challenges raised by CISE, several themes emerged from our discussions that transcended several of these.

- Clarity in the process of partnering, both for the research community to understand choices of partners, and for industry to understand options in partnering and their advantages. We emphasize that the clearly articulated guiding principles of partnership[6] need corresponding processes, both to foster understanding and communicate principles (e.g., level playing field, shared NSF values, integrity of merit review) with the community. For example, currently, NSF's process for selecting partners is not well established or documented. There could be a perception of working with *those we know*, rather than selecting from the best.
- Active communication and engagement with industry, universities, and the academic community to understand and work to streamline processes or mitigate concerns presented by private partnerships, including Intellectual Property (IP).
- A *portfolio of partnerships* approach (see Specific Recommendations) would allow CISE to think beyond a collection of individual partnerships, to help CISE balance opportunities for the community and across current and future partnerships.
- Broadening participation in computing (BPC) and diversity, equity and inclusion (DEI) activities represent a new opportunity for CISE's efforts with private-sector partnerships. CISE's efforts to date have focused primarily on advancing research. There are likely benefits in training for those students and early-career faculty involved. However, we believe there is an unexplored opportunity to engage industry in CISE's multiple efforts in BPC and DEI activities promoted by NSF and needed by the community. We feel there are advantages to industry, and that such an effort would expand participation among universities and institutions of higher education in CISE's efforts. As noted recently by CISE Assistant Director Margaret Martonosi, to move the needle in BPC requires a broad community effort. We feel the private sector is part of this community.
- CISE's leadership and experience with private-sector partnerships is unique and will continue to inform NSF as it continues to develop partnership opportunities throughout the agency.

Footnotes

[6] Keywords for the three principles articulated in *NSF Partnerships: Landscape Study* are Benefits, Costs, Outcomes (see References).

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SPECIFIC RECOMMENDATIONS WITH CONTEXT

In this section we provide context and make recommendations in four subsections:

- Challenges from CISE
- Assessment of CISE Partnership Experience and Outcomes
- Broadening Participation in Community: A New Opportunity
- Additional Areas.

CHALLENGES FROM CISE[7]

OPERATIONALIZING RISK, COST, BENEFIT DETERMINATION

Engaging in partnerships, even thoughtfully and with a clear view of both the benefits and the risks to NSF, the partner organizations, and the research community as a whole, potentially creates additional risk to CISE and NSF. The potential risks from a reputational perspective include:

- Political considerations and perceptions in a polarized time, if a partner organization is perceived as strongly associated with either end of the political spectrum. NSF could be seen as aligning itself with those perceived politics, jeopardizing its nonpartisan position.
- Ethical concerns around the partner organization's practices, products and services, divergent interest between company's interest and research results, and their impact on society. NSF could be seen as endorsing a company's practices and portfolio that may be inconsistent with NSF's neutral status.
- The effect of problematic behaviors by organizations or individual employees and the potential for negative "reputation by association" (e.g., negative climate for underrepresented groups; claims of discriminatory hiring or employment practices; allegations of sexual harassment or racial discrimination). NSF could be put in a position where it is expected to take a position on internal organizational culture or individual behaviors.

Recommendation: NSF should establish a clear process of partnership establishment and review to he mitigate agency risk when engaging in partnership. This process should include clearly stated guiding principles[8] and a framework for assessing partnership status using a neutral process in situations that may be controversial and complex. We recommend CISE develop a broad-based internal process to review and make recommendations in such circumstances. The goal of the overall process is to balance the potential value to the community against NSF's need to maintain neutrality and a strong reputation for fairness, avoiding reactivity but emphasizing a commitment to being responsive to community needs and concerns.

We add some thoughts on process attributes. We emphasize that the process should address both partnership establishment and review. Once established, the broad-based process should be communicated to the community to ensure it is understood. We anticipate the process to be constructed to build expertise at NSF; for example, if a committee is used, it should be standing rather than ad-hoc, to learn from the cases and provide steady guidance to the process. Finally, in referring to the process as *broad-based*, we envision tapping into a breadth of scientific, ethical and legal expertise, possibly including other agencies, who understand and embrace NSF's mission.

OPERATIONALIZING BALANCE IN PARTNERSHIP OPPORTUNITIES AND PORTFOLIO

Establishing partnerships carries the real risk of NSF being seen as selecting particular organizations or categories of organizations to work with, implicitly endorsing those organizations over others. As NSF contemplates expanding its use of partnerships to build connections to the commercial sector and tap into additional resources, sources of use-inspired research questions, and possible expertise, it is incumbent to guide this growth in a way that respects key principles of equity and inclusion in both the partnering organizations and the individuals who are supported and served through the partnerships.

A key concept in our recommendation is to consider not only individual partnerships, but a *portfolio of partnerships* to help balance opportunities for the community and across current and future partners.

Recommendation: NSF should establish guidelines for what an ideal or nominal balance would be in an overall *portfolio of partnerships*. These guidelines should be publicly visible, along with the results of a periodic assessment of the current balance. In its *partnership portfolio*, NSF should:

- Ensure that the process of developing, reviewing, and selecting partnership opportunities honors NSF's longstanding commitment to community awareness, involvement, and peer review. The basic principles and process should be readily visible and understood by the community as a whole, as well as to potential partners.
- Balance large, established businesses with smaller, emerging, and startup companies. One way to create this balance could be to develop consortia or "sponsorship" arrangements that could offer access to smaller companies that are not in a position to underwrite a major partnership initiative.
- Balance "pure research" partnerships with the possibility of creating meaningful change in other areas through Broadening Participation in Computing (BPC) efforts (see below).
- Strive for a balance of equitable outcomes in terms of subdisciplines supported; gender, race, and disability status of participants; and types of academic institutions supported. This goal is an indirect one: creating and maintaining equitable outcomes will require regular collection and analysis of appropriate metrics, relative to the mix of partnerships established.

- Review on a regular frequency the benefits of individual partnerships, and the mix of partner programs, relative to the interests of NSF, the industry partners, and the supported stakeholders, namely PIs, students, and the research and education community more broadly.

One implementation approach involves establishing a standing, internal committee of diverse experiences that would develop guidelines and review the benefits of the partnerships and the overall portfolio balance.

Two additional implementation considerations for this recommendation. First, other governmental agencies have had a history of partnering with industry through clear processes. These may be useful for NSF to consider.[9] Second, as NSF engages in more partnership, it needs to anticipate and prepare for having processes to specifically address complaints or challenges by the community, for example why was my company or agency not included?

GUIDELINES FOR LEVEL OF PARTNERSHIP ENGAGEMENT AND FUNDING APPROACHES

CISE's Experience: Since Fiscal Year 2014, CISE has engaged in several private-sector partnerships, which have resulted in value to the academic research community. Most of these direct partnerships were bilateral, namely between NSF and a private-sector entity; more recently, NSF began to experiment with multilateral partnerships (e.g., National Artificial Research Institutes and the Resilient & Intelligent NextG Systems (RINGS). Each direct partnership is guided by a legally developed but non-binding Memorandum of Understanding (MOU) and an associated Management Plan. Collectively these documents address **(1)** the area of joint research interest; **(2)** special review criteria (if any) to be used in the solicitation, review and selection processes; **(3)** a mechanism for the private entity to provide input into the NSF-led review process (ranging from observing the panel reviews to holding a separate review that provides input, e.g., those deemed most relevant to the entity's need); **(4)** nature and degree of involvement with awardees after awards are made, for example attendance at PI meetings, receiving reports; **(5)** amount of funding and how the private entity's funding will be awarded, e.g., via NSF, or separately to the awardee institution; **(6)** disposition of research products and intellectual property; **(7)** joint communication with the community; and **(8)** dispute resolution and termination; among other topics.

The community is made aware of the opportunity of the partnership in a solicitation or Dear Colleague Letter, which identifies the partnership, unique aspects of review criteria, review process, and post-award administration and reporting.

To date, each of CISE's bilateral direct private-sector partnerships has been negotiated separately, allowing CISE and the private-sector entity flexibility to find a relationship best able to reflect the partnership. In many of these, the private-sector entity has funded the awardee institution in a separate stream of funding, which could be a gift to the University or a grant or contract. In some partnerships, the private-sector entity has gifted the provided the funds as an unrestricted gift to NSF, which NSF has combined with its own funding to make awards.

In the multilateral partnerships, NSF has interacted with multiple partners with the philosophy of having the MOU and Management Plan identical on key issues of process, and deciding on creating a single stream of funding for the PI (i.e., meaning the private-sector entities transferred funds to NSF to administer). The financial level of funding was allowed to vary, although NSF insisted on a threshold amount for each partner. In some cases, private-sector entities have partnered with NSF on parts of a solicitation – specific tracks or themes, for example.

For the private-sector partners and the community, it is important that NSF adheres to and protects the integrity of its merit review process, and follows its procedures for selecting, managing, and monitoring awards.

Finally, to date, NSF has adhered to not getting involved with awardees' "background IP" in its partnerships.

Recommendation: CISE should develop content to make its process of partnering known, including what is negotiable and what is fixed in the NSF processes. This content needs to be communicated, and thus support CISE's and NSF's efforts to enhance partnerships. In our discussions, we learned a great deal about the process, some of which might not be known to our community and to potential partners.

We also encourage NSF to make as clear and explicit as possible the opportunities involved in partnerships with industry, the ability of industry to discuss topics raised above, the areas where NSF places community first, and the outcomes of previous partnerships.

Furthermore, CISE needs to ensure that the community is aware of partnership opportunities and any specific additional requirements in solicitations. NSF should engage in additional announcements and publicity around these opportunities and hold "Proposer Days" or webinars to make sure that the academic community understands the opportunity and any specific review criteria or requirements associated with the solicitation.

CHALLENGES FROM CISE

Industry Expectations and Culture: Industry partners work in a culture different from academic researchers: on different time scales, adhering to different norms of openness, and often with different specific desired outcomes. Areas of different cultures between industry and academics are often apparent in awards administration, including amount of direction from the company to the PI, frequency of reporting and discussion between the company and PI, interest in using IP to protect research results, and amount of risk tolerance. In particular, IP is a challenge that universities and industry have to address. (See more in section Challenges of Intellectual Property.)

We offer several recommendations for consideration to address aspects of different expectations.

Recommendation – Technical Exchange Meetings: We encourage NSF to explore having recipients of NSF private-sector partnership awards conduct regular (quarterly, semi-annual) technical exchange meetings, between the researchers on each award and the private-sector partners. We believe that these technical exchange meetings provide benefits for the PI community through introducing students to researchers in industry, providing opportunities for junior faculty to engage in research discussions and relationship building to benefit their careers, and enhancing the meaningful exchange of ideas (both what is working well and what is not), and developing a deeper understanding of the immediate problems faced by industry.

We note that these technical exchange meetings would be in addition to any annual program PI meeting, which would also include private sector partners.

Finally, depending on how NSF implements this recommendation, guidelines could be developed for industry and PIs about these technical discussions to ensure that the positive aspects are achieved while avoiding undue burden on the PI or undue intrusion from any partner.

Recommendation – Time Horizons and Funding Streams: We encourage NSF to consider different types of models depending on the time horizon of technology transfer envisioned in the partnership, e.g., near-term (within the lifetime of the award) versus long-term. For shorter-term activities, perhaps an agreement to catalyze interactions between the PI community and the private-sector partner would allow for a faster transfer of technology. On the other hand, for longer-term time horizons of the partner's return on investment (e.g., beyond five years for the research, although nearer term for the personnel), a simplified partner MOU may be appropriate (avoiding the issues of IP). Some specific considerations and alternatives include:

- Stage research in a partnership such that NSF funds the fundamental research in the early stages and the partner funds the research in the later stage focused on technology maturation and transfer. However, this notion is not popular, and it is believed it could undermine the important nature of the fundamental research mission of NSF.
    - It is possible that parallel review processes run following NSF standards and one run by industry could give rise to additional funding opportunities outside of the solicitation. However, NSF should be careful that this does not turn into an end round around the NSF panel process. Industry partners should be committed to accepting the panel selections and carrying through on the promised funded collaborative effort.
- For long-term return on investment, NSF should consider as a default a single-funding-stream approach (currently being used with multilateral partnerships), with NSF terms and conditions. This would entail promoting the value to industry of this approach, based on the value to industry. This could expedite award administration and simplify the administration of an award. This model assumes the partner provides funds directly to NSF for use in issuing a solicitation. To further develop justification for this approach we make two suggestions:
    - In its assessment of partnerships, we suggest NSF focus on the value to the research community of separate streams of funding (as is currently done by CISE's bilateral partnerships), versus a single stream of funding; for example, are there more research products adopted by the partner under one mode versus another? Also, under separate streams of funding, have some approaches led to greater benefits to the research community?
    - We suggest that NSF review the challenges, timelines and interactions with universities in executing separate streams of funding. We believe that such an approach can introduce significant delays as university offices negotiate IP rights with industry. This delay can also delay an NSF award and or create research projects that are not aligned in time and intent.

Recommendation – Host a Workshop for Industry:
We encourage NSF to pursue a workshop or series of public discussions with industry to promote the value of partnerships and to get input collectively about approaches to craft partnerships to streamline requirements and protect interests of all parties. Such a workshop (series) may also include tech transfer officers / universities to discuss issues of IP. The goal would be to develop guidelines that could lead to the acceleration of the transfer of technology from research to the public and advancing the public good of the national investment in research, while preserving the interests of all parties. In putting together such a workshop, NSF should consider the notion of *portfolio of partnerships* in developing the attendee list. Also, in the planning of such workshops, NSF should recognize and plan accordingly that there are different categories of industry with different needs. Differences are both in terms of scale, e.g., Large, Small and Midsize, and Start-up, and in terms of focus, e.g., high-tech versus manufacturing or pharmaceutical.

CHALLENGES OF INTELLECTUAL PROPERTY

Understanding and addressing challenges around intellectual property rights are important to protect intellectual and fiscal contributions, enable a prosperous society, maintain global competitiveness, and ensure the nation's security. Identifying conditions and approaches to streamline the transfer of technology from research to society is not only a public good but also a national security imperative.

NSF is a steward of public funds and public trust. As a steward, how NSF approaches IP issues carries a great deal of weight. On the other hand, while maintaining the public trust and with an increased emphasis on accelerating the transfer of research into tangible products for society, NSF is seeking ways to streamline the process, which is currently time and labor intensive, and currently needs to be worked out on a case-by-case basis. With each partnership negotiation, opportunity gains need to be weighed against possible opportunity loss with limited labor resources.

In general, IP issues are complex. For example, rules for handling IP vary between public and private universities.

Furthermore, as software and technologies in general are becoming ubiquitous in many advances used in society, IP challenges increase. The following example will illustrate such a small portion of the complexity. With certain types of industry (e.g., large, platform companies), open source may suffice for the type of software licenses resulting from joint investments. However, in other industries, where software and underlying algorithms become part of a tool with unique capabilities, IP issues may be more challenging. These areas include the biomedical or energy fields as well as technology areas such as autonomous vehicles where it is often the case that patents and software licences from many sources are needed for successful commercialization.

Recommendation: We recommend NSF develop principles for addressing IP issues it has encountered, to help streamline the process of pursuing meaningful private-sector (and other) partnerships while maintaining its role of the steward of public trust and investments. Once developed, these principles should be shared and communicated broadly.

One approach would to be hold a workshop or workshop series to engage a cross-section of stakeholders, such as university administrative officers for research, technology management, grants and contracts; university faculty and researchers (e.g., soft-money); academic associations of universities; and others (e.g., other Federal agency representatives).

Some topics to focus discussion around principles to guide NSF's partnership development could include:

- What are the principles around background and foreground IP, where background IP is IP in existence in advance of the partnership and supplied to it and foreground IP is the IP produced during the partnership?
- What principles should be applied to non-exclusive royalty free (NERF) licensing in the private-sector partner and its subcontractors?
- What are the principles and needed negotiations to enable technology transfer, patenting, startups based on the NSF-private-public partnership (after the grant)?
- What should NSF be involved with determining vs. what should be negotiated between NSF partners and awardees?
- What have been the experiences with master agreements or agreement templates between universities and industries? How could NSF benefit from that knowledge? What role could NSF play in advancing a broader understanding of these approaches?

We note that principles will help balance NSF's dual responsibilities as public steward to promote trust and to create opportunities to accelerate responsible technology transfer. On the other hand, some private sector entities may not wish to participate in a partnership with NSF.

ASSESSMENT OF CISE PARTNERSHIP EXPERIENCE AND OUTCOMES

CISE has been engaged in various private-sector partnerships since before 2014. Currently CISE is undertaking an assessment of its partnership to better understand the outcomes of these partnership investments. We applaud CISE's assessment effort; we believe the assessment could better define and possibly quantify the value to the research community of CISE's investments with its private-sector partners. Moreover, with a documented understanding, CISE could better articulate those outcome values to the community and current and future private-sector partners.

Recommendation: We recommend CISE accelerate its review of partnerships and publish findings, which would include cost-benefit analysis (upfront costs, implementation costs, assessment costs), and address topics such as whether the partnerships are living up to their stated outcomes. Having the output from this assessment should help inform NSF in its operationalizing efforts, prospective partners about the value of a partnership, and the community about unique outcomes. Moreover, understanding the value to the community should help NSF **(1)** identify future partnerships that will maximize that value; **(2)** optimize its internal efforts in developing and maintaining partnerships; and **(3)** communicate that value to all stakeholders.

Given the nature of the partnership, we envision no one category of metrics will capture measures of adoption or translation of ideas from research to industry, either internal-to-industry considerations of the research or products. Examples of metrics might include

- Numbers of internships or hires resulting from the collaboration;
- Number of industrial sabbaticals by faculty;
- Number of startups (new companies) generated from collaboration; in particular the number of startups that survive longer than 48 months;
- Identification and quantification of show-stoppers (i.e., knowing something will not work) to allow industry to avoid spending millions on options that will not work.

Additional metrics might include:

- Acknowledgements by industry of the collaboration and of the interest in the research and results produced;
- Number of co-publications between academic and industry researchers;
- The degree to which academic researchers better understand the challenges faced by industry *and* change research focus.

BROADENING PARTICIPATION IN COMPUTING (BPC): A NEW OPPORTUNITY

To date, CISE's private-sector partnerships have focused on expanding research opportunities.

As such, these are often led by senior principal investigators, and often engage graduate students and junior faculty who can benefit from the unique research foci of the partnership.

The challenge for CISE research is that the CISE research community does not reflect the diversity of the country. We are losing opportunities to engage large segments of our population. Furthermore, as a nation, the need gap for workers skilled in information technology and computational understanding is increasing, which will have significant deleterious effects.

As mentioned above, we see a win-win-win (public, industry, academics) opportunity for CISE to develop partnerships, including private-sector partnerships, that address directly the challenge to broaden participation in computing.

Recommendation: We strongly recommend that broadening participation in computing (BPC) goals should be considered as essential elements of a strong *partnership portfolio*. These BPC components should explicitly address and work to mitigate issues and challenges related to various forms of underrepresentation in computing (including but not limited to gender, racial, and disability-related disparities), and BPC goals and impact should be included in the guidelines for assessing the overall mix of partnerships.

BPC-related activities could be incorporated into the partnership portfolio in two ways: **(1)** establish expectations or incentives for research-focused partnerships (existing and future) to include BPC components and **(2)** identify new partnerships that have BPC/DEI at the center of the program opportunities.

To facilitate these new partnership directions, we recommend the creation of a steering committee, including members from both industry and academia, to identify specific best practices and program goals for both types of programs. In order to prevent proliferation of programs, which could lead to a corresponding duplication of effort, we recommend that both of these types of BPC partnership efforts should be aligned with existing and planned opportunities where possible. Specific attention should be placed on:

- Growing student-focused programs, including NSF-funded programs such as ***CSGrad4US*** as well as other national initiatives such as the Graduate Education for Minorities (***GEM***) fellowships,[10] through sponsorship opportunities (underwriting program costs or particular program-related events), and by identifying specific programmatic roles (internships, mentoring opportunities, and the like) for NSF industry partners.
- Partnering with industry-, nonprofit- and foundation-sponsored BPC-focused initiatives and regional partnerships such as Gender Equality in Tech (GET) Cities, Girls Who Code College Loops, and Black in AI to amplify and connect these activities with the NSF CISE community.
- Incentivizing and encouraging industry engagement with national outreach and K-20 educational initiatives such as CSforAll, ECEP, CUE, and BPC Alliances. The model that was used to create BPC Alliances – including the very successful and sustained NCWIT, AccessComputing, and STARS Computing Corps – could be built upon with an increased focus on industry investment and leadership in BPC initiatives.
- Expecting partnership organizations to commit themselves to advancing diversity, equity, and inclusion in the technology fields. The ASEE Engineering Deans pledge could serve as a model for this type of commitment.
- Emphasizing partnerships that would develop and expand research infrastructure and increase student research opportunities at minority-serving institutions (MSIs) and women's colleges.
- Exploring partnership consortia that support primarily undergraduate / community college / regional university pathways, broadening the reach of "who gets to do computing" and expanding pathways to graduate school for a wider range of students.

As noted above, to move the needle on NSF's BPC efforts will require the entire community to work together. Industry has as much to gain as academia by the success of a concerted BPC effort. Finally, we envision the partnerships with industry to be one of many approaches taken by CISE and NSF to broaden participation in computing.

ADDITIONAL AREAS

INDUSTRY ENGAGEMENT IN INTERNATIONAL PARTNERSHIPS (MAKING THEM THREE-WAY)

Many industries have offices or research centers in various countries or regions of the world. NSF also has partnerships with several countries. In discussions with industry, exploring this topic might be a multi-way win.

WORKSHOPS TO CATALYZE INDUSTRY PI COLLABORATION

Consider workshops, faculty retreats, tours through company's facilities, or other venues to catalyze industry PI collaboration. These might be industry problem infused idea labs, or perhaps something like the convergence accelerators. Attributes could include a shorter-term time horizon to return on industry investments. NSF's involvement could bring a new set of PIs to the industries (beyond industries knowledge network), greater diversity of researchers, and students to be exposed to real-world problems.

PARTNERSHIPS WITH NON-PROFIT ORGANIZATIONS

The subgroup's focus has been on private-sector partnerships. However, in early, far-ranging discussions of the group, the non-profit sector was often cited as potential partners for NSF and CISE. The *NSF Partnerships: Landscape Study* gives several examples, one with CISE, of such partnerships. We believe there are growing opportunities to reflect CISE research's broad impact on all disciplines supported by NSF. We note many non-profits have specific focus on other disciplines where CISE could play a role. Also, we are excited by the possibility of developing new areas of research, developing between CISE and SBE, in which a non-profit (e.g., foundation) in partnership with NSF might help launch new directions. Anecdotal information suggests that non-profits are interested in partnering if they can see a clearly defined, unique role for their contribution.

We strongly encourage CISE to pursue partnerships with non-profit organizations that allow them to contribute uniquely. We also believe that foundations are likely to be interested in CISE's focus on "socio-technical systems," given actions taken by multiple foundations to build the field of "public interest technologists."

Footnotes

[7] Note, we have combined the challenges of partner engagement and partner funding approach into one discussion. Moreover, the subcommittee left the COI challenge to NSF to resolve, given that NSF has a long history of considering COI as part of its overall approach to proposal processing.

[8] NSF recently posted *NSF Partnerships: Guiding Principles*: ***https://www.nsf.gov/pubs/2021/nsf21202/nsf21202.pdf***

[9] One example is US Agency for International Development (AID), which as an invitation to co-create on its website. See ***https://www.usaid.gov/gda/global-development-alliance-annual-program***.

[10] GEM Fellowship Program, ***https://www.gemfellowship.org/***

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THOUGHTS FOR THE FUTURE

During the process of developing this report and discussing it with members of the CISE Advisory Committee, several other ideas arose, that were both beyond the scope or timeframe of this subgroup and represented topics worthy of future discussion. We document these here.

BEYOND PRIVATE-SECTOR PARTNERS

As noted above, there are many other types of institutions with which NSF has partnered, e.g., other Federal Agencies, non-profit and non-governmental organizations, international funding agencies, and state and local governments. As CISE considers these different entities, we encourage CISE to be mindful of the values brought by the institutions, and flexible to their modes to contribute to advance NSF's mission. In particular, not all entities may be able to provide funds, yet can provide valuable testbeds or learning opportunities.

OTHER MODELS FOR ENGAGING INDUSTRY

There are programs in the European Union, such as the Horizon 2020 program or its successor Horizon Europe[11], in which university researchers, together with industry partners, apply for and receive funding. NSF and CISE may wish to explore this approach in the future to address new opportunities.

DEFINITION OR CATEGORIES OF PARTNERS

As NSF advances its partnership portfolio, there may be either different types or different descriptors for its partnerships. It may be valuable to attract partners by creating terminology to better describe the relationship between NSF and the partner. For example an entity may be an awardee but also put in significant additional resources to advance a goal (e.g., develop a testbed) for the benefit of the national research community.

[11] More about Horizon Europe can be found at *https://www.openaccessgovernment.org/horizon-europe-eu-research-innovation/104737/*

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FINAL THOUGHTS

As NSF and CISE continue to develop their partnership activities, we encourage CISE management to cultivate partnerships beyond the transactional activities of individual solicitations and MOUs. There is value to NSF in engaging members of the partner in NSF's review process independent of the partnership to grow their understanding of NSF. As CISE develops its partnership process and as it engages with both existing and new partners to seek input on processes, it should raise the value of long-term partnerships, to build trust between institutions.

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REFERENCES

NSF and NSB

- NSB Vision 2030 2020-15. ***https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf*** (June 2020)
- NSF Website on Partnerships: ***https://nsf.gov/about/partners/*** (updated March 2021)
- NSF Partnerships: Landscape Study: ***https://www.nsf.gov/pubs/2021/nsf21201/nsf21201.pdf***
- NSF Partnerships: Guiding Principles: ***https://www.nsf.gov/pubs/2021/nsf21202/nsf21202.pdf***
- NSF FY 2020 Annual Performance Report. ***https://www.nsf.gov/pubs/2021/nsf21038/nsf21038.pdf***. Reports on NSF Progress in Striving for its Agency Priority Goal to Expand Public Private Partnerships

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- Patel, S, Jennifer Rexford, J, Zorn, B, Morrisett, G, Industry Working Group, Computing Community Consortium (CCC). ***Evolving Academia/Industry Relations in Computing Research***, June, 2019. ***https://cra.org/ccc/wp-content/uploads/sites/2/2019/06/Evolving-AcademiaIndustry-Relations-in-Computing-Research.pdf***

  The report is summarized in Computing Research News August 2019, Vol. 31/No.7/, CCC Staff and B. Zorn. See ***https://cra.org/crn/2019/08/evolving-academia-in dustry-relations-in-computing-research/***.

  Note: This report captured the changing academic-industry landscape, such as needs regarding faculty access to industrial resources, exposure of faculty and students to problems in industrial settings. These changes raise both opportunities and complexities, and can have longer-term impact.

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APPENDIX

CISE Advisory Committee (AC) Subgroup on Private-Sector Partnerships Context and Framing Questions – Nov. 30, 2020

Over the last several years, NSF's CISE directorate has led the agency in pursuing vibrant public-private partnerships that allow us to accelerate advances in the research and education that we support. CISE's partnerships have already demonstrated the utility of bilateral collaborations with the research arms of large multinational corporations (e.g., with ***Intel Labs***, ***VMware***, Inc., and ***Amazon***), large consortia [e.g., with our $100 million public-private partnership with over 35 leading wireless companies and associations to support a set of ***Platforms for Advanced Wireless Research (PAWR)***; the ***National Artificial Intelligence Research Institutes***], and nonprofits (e.g., with the ***Partnership on AI*** and ***Simons Foundation***). These collaborations have helped define new research directions based on current trends and challenges in the private sector; have connected faculty and students with relevant partner expertise; and have matched funding and in-kind contributions to enhance and accelerate our investments. By one metric, since FY 2014, CISE has matched more than $173 million of its own resources with more than $107 million in funds and in-kind support from the private sector. CISE's partnerships have spurred new innovations, accelerated the transition of research results into practice, and cultivated experiential learning and career pathways for students.

Having said that, CISE's experience with partnerships has also revealed challenges, including:

- Reputational risk to the agency – the partner's status in the public sphere can impact the research community's and broader public perceptions of the partnership and funding program. (Note that NSF has taken the perspective of being open to partnering with any organization, assuming the presence and clarity of shared goals and values.)
- Balanced approach – More generally, questions have surfaced about potential perceptions of NSF "choosing winners" or emphasizing certain technology approaches by virtue of with which companies it enters into partnerships. How can CISE best approach questions of balance between "technology incumbents" (often embodied in larger companies) and emerging or disruptor technologies (for which partner resources might be scarcer)?
- Questions about partners' level of engagement – what are best practices regarding when a partner can be involved in facets of establishing and running a funding program? What should be their involvement regarding defining/drafting the funding opportunity? Observing the NSF-led merit review process? Selecting awardees? Facilitating post- award engagements such as researchers-in-residence?

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- Questions about partners' funding approaches – the partner can provide an unrestricted gift to NSF and NSF in turn makes and manages the full award; or the partner can provide their funding directly to the awardee, so that NSF and the partner each make and manage a part of the award. In the latter case, the partner may choose to provide the funding as a gift (with no indirect cost recovery on the partner's share of the funds) or through some contractual arrangement (including certain terms and conditions).
- Issues pertaining to intellectual property (IP) – the Bayh-Dole Act provides the Federal Government with an optional non-exclusive, royalty-free license on any federally-funded research outputs, and NSF extends this right to all private partners. In some cases, NSF and the partner have also opted to require research results to be made openly available. However, some open-source licensing approaches have been more researcher-friendly. Some partners have also requested other approaches, including access to background IP (something that NSF has not granted). While clearly documented to awardees, the variations in IP and licensing expectations have the potential to add complexity for researcher awardees.
- Challenges in managing actual and perceived conflicts of interest (COI) – NSF has generally precluded partners on a given program from also submitting proposals to that program. As individual faculty increasingly take on multiple roles, this can cause complications.

The CISE AC Subgroup on Public-Private Partnerships comprises expertise from academia, industry, and nonprofits. Drawing upon this expertise, NSF's CISE directorate seeks input from this subgroup on the above questions and challenges – specifically, as representatives of the research community that NSF/CISE serves, what are perspectives on and perceptions of public- private partnerships, including matters of reputational risk to NSF, partners' level of engagement, funding models, IP, conflicts of interest, and the like? What recommendations does the subgroup have for strengthening CISE's public-private partnerships, particularly the aspects described above, so as to maximize scientific benefit and mitigate community concerns?

Beyond the above, NSF's CISE directorate also seeks input about how to strengthen partnerships. Are there other known mechanisms and/or incentive models (e.g., adjustments to tax policy) that would facilitate public-private partnerships?

The CISE AC subgroup is encouraged to refer to relevant recent reports, such as ***the work of the Computing Research Association's (CRA) Committee on Industry/Academia Interactions***.