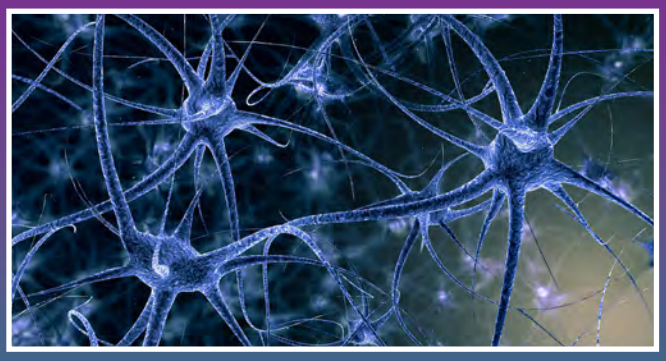
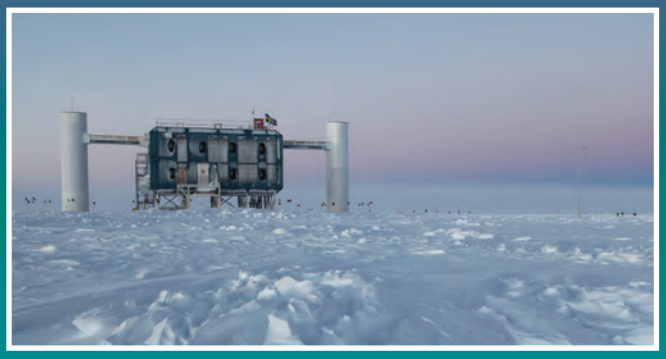
NSF PARTNERSHIPS: LANDSCAPE STUDY






National Science Foundation

NSF PARTNERSHIPS: LANDSCAPE STUDY — EXECUTIVE SUMMARY

Public and private partnerships contribute to NSF's goal of being a global leader in research and innovation. Partnerships can accelerate discovery by expanding the kinds of questions that can be addressed; enabling access to expertise, infrastructure, or sites; and building broader communities of researchers. This, in turn, can accelerate translation of research results to products and services, and enhance preparation of the future workforce to benefit society and grow the American economy.

The Landscape

NSF currently engages in direct external partnerships with other U.S. federal agencies, with industry, private foundations, non-governmental organizations (NGOs), and with international organizations. Most of these partnerships are formalized through Memoranda of Understanding (MOUs) between NSF and the partner(s). Beyond this, NSF stimulates partnerships indirectly through its many programs that require or encourage grantees to work in collaboration with non-academic entities. In these cases, any partnering agreements are held between the NSF grantee and its partner(s) and not by NSF itself.

It is important to note that partnership approaches vary across NSF's Directorates and Offices. For example:

- Many of the partnerships within the Directorate for Computer and Information Science and Engineering are with industry, involving companies and industry consortia.
- The Directorates for Mathematical and Physical Sciences (MPS) and Geosciences (GEO), in addition to establishing research partnerships, often establish partnerships for use of facilities. Correspondingly, both also have many MOUs with other U.S. government agencies as well as with foreign science agencies.
- The Directorate for Biological Sciences (BIO) has a broad suite of MOUs with interagency, international, and NGO partners.
- The Directorate for Engineering (ENG) has multiple interagency and international MOUs. ENG also stimulates indirect partnerships by incentivizing grantees to work with industry and other non-academic entities.
- Most of the MOUs involving the Directorate for Education and Human Resources (EHR) are clustered in the Division of Graduate Education (DGE) to support student internships at other federal agencies and abroad.
- The research divisions of the Directorate for Social, Behavioral, and Economic Sciences (SBE) have many research partnerships with other federal agencies codified in Interagency Agreements (IAAs). In addition, the National Center for Science and Engineering Statistics (NCSES), positioned within SBE, uses interagency and international partnerships via contracts for survey design and data collection.
- The Office of Polar Programs (OPP), within the Directorate for Geosciences, manages the U.S. Antarctic Program and plays a key role in coordinating Arctic research on behalf of the nation, and thus establishes partnerships for research, logistics and facilities in support of polar science.
- The Office of International Science and Engineering (OISE), within the Office of the Director, works closely with the Directorates to establish international partnerships.
- The Office of Integrative Activities (OIA), within the Office of the Director, primarily catalyzes indirect partnerships through its support of the Science and Technology Centers, the Established Program to Stimulate Competitive Research (EPSCoR), and the Convergence Accelerators.

Observations

- Every partnership is unique and requires an investment of time and effort to understand a potential partner's priorities, capabilities, and constraints to confirm that there is sufficient common ground and benefit to all sides.
- Not every potential partner is a suitable partner for NSF. Contributions of and benefits to NSF and its partners may not be identical but should not be asymmetric; the potential outcome of a partnership should be greater than what could be achieved by working alone.
- Importantly, nearly all successful partnerships start with a personal, trusted relationship between individuals within the partner organizations. Building this trust takes time.
- At NSF some partnerships start based on the opportunity presented by individuals' shared interests, experiences, and relationships. It is important to nurture these opportunities but ground them firmly in the broader strategic picture.
- All partnerships have a lifecycle, which should be built into a partnership agreement at its outset with clear metrics for sunsetting so there is clarity of expectations on all sides.

Conclusion

NSF has deep, rich experience in building partnerships across all the areas of science, engineering, and education it supports. While some, such as in large facilities, are the result of high-level strategic planning, many others have been built in an entrepreneurial fashion by NSF staff. In the future, the need for partnerships is likely to become ever more compelling. To optimize the process of establishing and managing partnerships, NSF is now focused on codifying and disseminating partnership principles, developing tools that streamline the mechanics of building partnerships, and strengthening the NSF culture of partnership through shared practices. With these actions NSF will be well poised to sustain its role as a global leader in research and innovation, and in nurturing the next generation of scientists and engineers.

INTRODUCTION

NSF aims to be a global leader in research and innovation. Public and private partnerships contribute to this goal. Private industry, foundations and non-profits, together with other federal agencies and international funding organizations bring additional expertise, resources and capacity to NSF-funded research. This, in turn, supports discovery and innovation, translation of research results to products and services, and enhances preparation of the future workforce to benefit society and grow the American economy.

Building partnerships is an increasingly high priority across the federal government, and its importance is highlighted as a key element of leadership for NSF in the National Science Board's Vision 2030. In its Fiscal Year (FY) 2020 budget submission, NSF identified 'Developing an Agency-wide Partnerships Strategy' as its Agency Priority Goal for FY 2020 and FY 2021. Previously, the agency established 'Expanding and deepening public and private partnerships' as one of the four pillars of its agency-wide Renewing NSF initiative.

NSF has always engaged in a wide range of partnerships, recognizing that they deliver significant mutual value. Partnerships can accelerate discovery by expanding the kinds of questions that can be addressed; enabling access to unique expertise, infrastructure, or sites; and building broader communities of researchers. Partners engage with NSF for these same reasons, and to gain access to NSF's world-class merit review process, grantee community, as well as the future workforce.

Every partnership is unique; however, there are some common challenges, and not every potential partner is a suitable partner for NSF. Because no two organizations have identical missions, NSF must work with each potential partner to understand their priorities, capabilities, and constraints to confirm that there is sufficient common ground and benefit to all sides. This takes time and effort, but there is risk of additional delays and diluting goals if the NSF's and partners' priorities are not sufficiently aligned up front. Every partnership will likely face logistical and policy challenges that require flexibility and negotiation. Contributions of and benefits to NSF and its partners may not be identical but should not be mutual. In short, the potential outcome of a partnership should be greater than what could be achieved by working alone.

To aid in decision-making as new partnerships are considered, NSF has developed **Guiding Principles** Guiding Principles are relevant regardless of the specific context; however, as new partnerships are envisioned it is important to understand the NSF context. This Landscape Study will sketch out the contours of NSF's existing partnership landscape, provide some noteworthy examples and observations, and identify the key steps NSF is taking to grow its capacity for partnerships into the future.

NSF PARTNERSHIP LANDSCAPE

NSF currently engages in *direct* external partnerships with other U.S. federal agencies, with industry, private foundations, non-governmental organizations (NGOs), and with international organizations. Beyond this, NSF stimulates partnerships indirectly through its many programs that require or encourage grantees to work in collaboration with non-academic entities (Fig. 1). In these cases, any partnering agreements are held between the NSF grantee and its partner(s) and not by NSF itself.

FIGURE 1 SCHEMATIC OF NSF PARTNERSHIPS

Many of NSF's direct partnerships are formalized through Memoranda of Understanding (MOUs) or other signed agreements, while others are informal. Informal partnering can include, for example, joint sponsorship of workshops or exchanging in-kind resources in joint support of facilities, logistics, or infrastructure. In addition, many proposed partnerships are considered, but for a variety of reasons (political, legal, financial, etc.), do not result in partnership activities.

From FY 2016-2019, NSF executed nearly 200 agreements for partnerships on research, education, logistics, and infrastructure. The majority of these were with other U.S. federal agencies, and nearly a third were with science funding agencies in other countries. To a lesser degree, NSF established agreements with companies, foundations, and NGOs.

Focusing first on NSF's *direct* partnerships with other organizations, it is important to note that the partnership approaches across NSF vary with the type and breadth of science, engineering, and related education supported by the different Directorates and Offices. For example:

- The Directorate for Computer and Information Science and Engineering (CISE) creates many formal partnership agreements, accounting for 25 percent of NSF's MOUs during FY 2016-2019. Many of the CISE partnerships are with industry, comprising 12 active collaborations involving 8 unique companies and three industry consortia.
- The Mathematical and Physical Sciences (MPS) and the Geosciences (GEO) Directorates often establish partnerships not only for research, but also for use of facilities, and correspondingly both also have many MOUs with other mission-focused U.S. government agencies and with foreign organizations.
- The Biological Sciences (BIO) Directorate has a broad suite of MOUs with interagency, international and NGO partners, primarily for research cooperation.
- The Engineering (ENG) Directorate has multiple interagency and international MOUs. ENG also has programs which stimulate *indirect* partnerships in the communities it serves, by incentivizing grantees to build partnerships with industry and other non-academic entities.
- Most of the MOUs involving the Directorate for Education and Human Resources (EHR) are clustered in the Division of Graduate Education (DGE) to support student internships at other federal agencies and abroad.
- The research divisions of the Directorate for Social, Behavioral, and Economic Sciences (SBE) have many research partnerships with other federal agencies codified in Interagency Agreements (IAAs). In addition, the National Center for Science and Engineering Statistics (NCSES), positioned within SBE, uses interagency and international partnerships via contracts for survey design and data collection.
- The Office of Polar Programs, positioned within the GEO Directorate, manages the U.S. Antarctic Program and plays a key role in Arctic research on behalf of the nation, and thus establishes partnerships for research, logistics and facilities in support of polar science.

- The Office of International Science and Engineering (OISE), within the Office of the Director, works closely with the Directorates to establish international partnerships.
- The Office of Integrative Activities (OIA) catalyzes partnerships primarily indirectly through its support of the Science and Technology Centers, the Established Program to Stimulate Competitive Research (EPSCOR), and the Convergence Accelerators.

TYPES OF PARTNERS

Other federal agencies: Interagency partnerships are useful to advance shared interests and goals among agencies, through coordination and cooperation that amplify expertise and reduce process redundancy. For example, partnerships bring the research communities supported by different agencies together and can streamline the PI community's access to the federal proposal review process. Interagency partnerships also facilitate information and resources sharing and boost research productivity and broader impacts. These partnerships provide agencies with ways to fund pieces of complex projects that fulfill each agency's specific mission in working towards shared scientific goals.

NSF has hundreds of ongoing interagency engagements, reflecting extensive shared interests, some of which take the form of program partnerships or co-funded projects. For example, jointly conceived, interdisciplinary programs that link NSF's foundational research with complementary expertise supported by agencies with specific target missions can enhance the ability to address national needs. Examples of such partnerships between NSF and other federal agencies are in Box 1. NSF also partners with other federal agencies for use and operations of facilities, and on logistics (Box 2). While these partnerships can be vulnerable to changing internal priorities and funding appropriations, their terms are otherwise often straightforward.

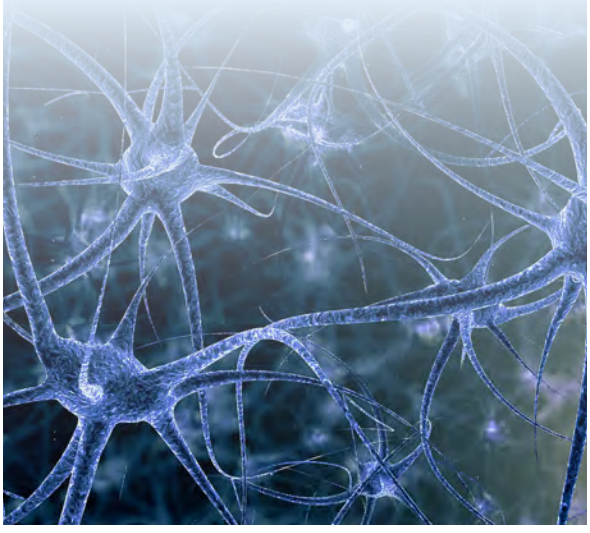
Some of these activities are codified in MOUs, and if funds flow to or from NSF, they are also captured in Interagency Agreements (IAAs), which support financial transactions between federal agencies. In terms of numbers of joint programs, to date, NSF most frequently partners with the National Institutes of Health (NIH), the Department of Energy (DOE), the Department of Agriculture (USDA), NASA, and the National Oceanic and Atmospheric Administration (NOAA) all civilian mission agencies with strong research branches.

BOX 1

NSF INTERAGENCY PARTNERSHIP EXAMPLES

Collaborative Research in Computational Neuroscience (CRCNS): Building on theory, methods, and findings of computer science, neuroscience and other disciplines, this program supports collaborative activities to advance understanding of nervous system function, mechanisms underlying nervous system disorders and computational strategies used by the nervous system. The program began in 2001, and in addition to NIH, includes international partnership with Germany, France, Israel, Japan, and Spain. The program significantly leverages the $5-10M annual NSF investment; with partner contributions added, the total program budget is $30-40M.

NSF/DOE Partnership in Basic Plasma Science and Engineering: The Partnership was created in 1997 to foster opportunities in plasma physics through coordination of NSF and DOE funding opportunities. It provides a single, unified location from which funds for basic plasma science research can be requested. NSF takes the lead in organizing and overseeing the review process, in which the DOE/Office of Science/Fusion Energy Sciences program officers also participate. NSF and DOE Program Officers then decide which proposals will be declined, which will be funded by NSF, and which by DOE. Funding levels are determined by the combined resources of the participating NSF and DOE partners and varies from year to year.



Other countries: International partnerships are useful when priorities are aligned between or among research communities in the U.S. and another country(ies) and when such partnerships clearly benefit the U.S. An added value of these collaborations is often science diplomacy – when the partnership aligns with higher-level U.S. foreign policy priorities while also advancing NSF's research and education priorities. NSF supports collaboration in almost any country in the world when it enhances the proposed research. Direct NSF international partnerships tend to be with countries that have well-developed science agencies and infrastructure, transparent NSF-like review processes, the ability to fund their side of joint projects, and a history of collaboration with the U.S.

The benefit to the U.S. of international collaboration is usually framed in terms of access, as they can provide the U.S. research community access to expert collaborators with complementary expertise or working on topics of mutual interest. They also afford access for U.S. researchers to unique facilities, infrastructure, field sites, logistical support, and data sets (Boxes 2 and 3). Importantly, international partnerships provide opportunities for U.S. students and faculty to gain cross-cultural research experiences that will serve them well as their careers progress, contributing to the ability of the future US scientific workforce to work successfully on collaborative projects in international settings.

NSF's international partnerships at the level of research and education programs leverage different countries' intellectual capacity and infrastructure in the pursuit of collaborative science (Box 2A). In most cases these programs may involve more than one country, but the U.S. is involved in all funded

BOX 2

EXAMPLES OF INTERNATIONAL RESEARCH PARTNERSHIPS

A. NSF-Centered Research and Education Programs

The Ecology and Evolution of Infectious Diseases (EEID) program is managed by NSF, led by the BIO Directorate with participation by GEO and SBE. EEID includes interagency (NIH and USDA) partners, as well as bilateral partnerships with the United Kingdom, Israel, and China. The program supports interdisciplinary teams working to understand the dynamics of infectious disease transmission within and across species in all biological environments, including marine and terrestrial, wildlife, agricultural, and human clinical systems. Because infectious diseases transcend geographic borders, international collaboration not only brings greater expertise to bear on research questions, but also increases researcher access to data and unique sites. NSF funds the U.S. researchers working in NSF science areas, NIH and USDA support U.S. researchers in their mission space, and international partners fund their researchers. In FY 2019, the program budget included $11 million from NSF, $7.5 million from NIH, $5.5 million from USDA, plus up to $9 million from the international partners.

B. Multilateral Consortia

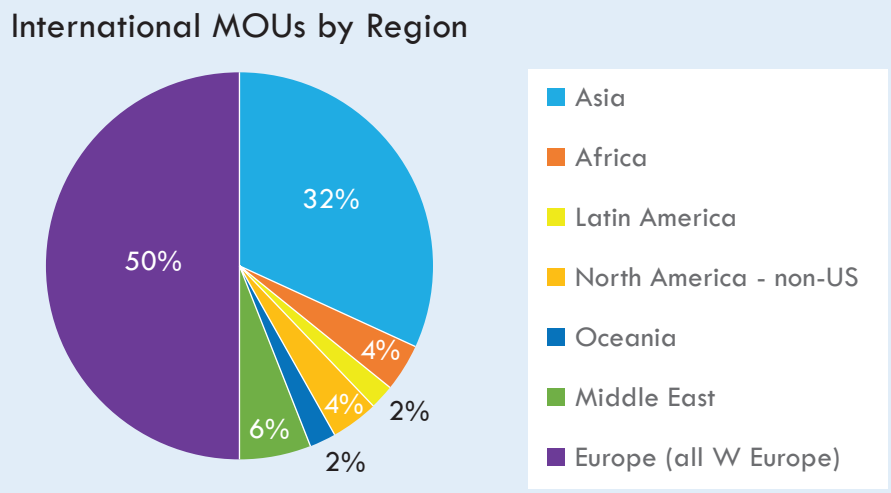
The Belmont Forum began as an informal consultative group among funders of global change research and has grown into a partnership of more than two dozen national and regional member and partner institutions. All commit to encouraging international transdisciplinary research on understanding, mitigating and adapting to global environmental change, and they do so through joint calls for proposals known as collaborative research actions (CRAs). The selection of the CRA topic and of expert reviewers is agreed upon by the Belmont Forum members. Members may participate in all CRAs or a subset based on interest. Each proposal must include participants from at least three participating partner organizations in at least three different countries. For projects that are recommended for funding, each country funds its own researchers. The coordinated funding allows international, multidisciplinary research teams to overcome challenges inherent in international collaboration as they submit a single proposal for cutting edge research that goes through a single merit review. The multilateral consortium with the shared Belmont Forum vision and CRAs serves as a multiplier, expanding impact beyond what individual members could achieve on their own. NSF has participated since the Forum was established in 2009.

projects. In these types of arrangements, NSF supports U.S.-based PIs and their costs, while foreign collaborators and their costs are supported by their country's corresponding science agencies. The result is greater scientific output at less cost to each participating country.

Sometimes international collaborations are best accomplished through multilateral consortia, an arrangement where funding agencies from multiple countries share a platform, outside the agency structures of any one country, for reviewing research proposals and conducting projects. In these cases NSF does not manage the program, and is not involved in every funded project, but accepts the consensus of a multilateral group. This approach is taken when there is an area of research that is of interest to many countries and a desire for flexibility in how teams are formed, with no requirements for any one country to be involved in funded projects. See Box 2B for an example.

Fully 75% of NSF's international partnerships established in FY 2016-2019 were with countries in Europe and Asia (Fig.2). When scientific goals involve working in less developed countries without established research funding mechanisms, creative partnership approaches, for example, via the U.S. Agency for International Development's Partnerships in Enhanced Engagement in Research (PEER) program, can increase the chances of success.

FIGURE 2 NSF MOUS WITH GLOBAL REGIONS, FY 2016-2019



Beyond the level of collaborative research projects, NSF engages in international partnerships at many of the nearly two dozen large facilities it operates. Considerations driving partnership include the overall cost of these facilities, the location and/or international treaties, and access to observation time. Examples are in Box 3. In each of these cases, the U.S. is the lead partner. In other cases, such as the European Organization for Nuclear Research (CERN), NSF is a contributing partner.

BOX 3

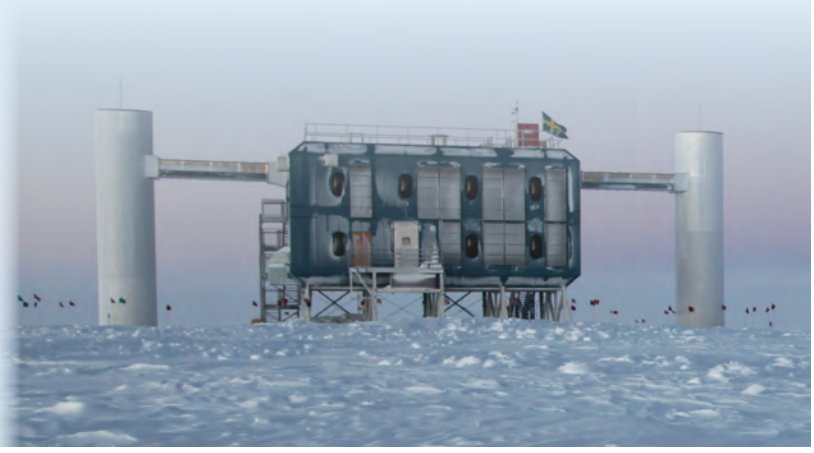
NSF MAJOR FACILITIES—INTERAGENCY AND INTERNATIONAL PARTNERSHIP EXAMPLES

NSF supports nearly two dozen large facilities, which are designed to serve the national and international science community at a scale requiring major investments. In many cases, the science overlaps with the missions of other federal agencies, and thus involves interagency partnerships. For example:

- **National Center for Atmospheric Research (NCAR)** - NASA, the National Oceanic and Atmospheric Administration (NOAA), the DOE, the Department of Defense (DOD), and the Federal Aviation Administration (FAA), as well as non-federal sources
- **Academic Research Fleet (ARF)** - Office of Naval Research (ONR) and NOAA

In other cases, the facility involves international partners (sometimes in addition to interagency and other partnerships). In some cases, the partnership is primarily due to scientific interest. In other cases, the facility itself is outside of the United States, potentially in an area with complicated logistics. For example:

- **IceCube Neutrino Observatory** - located under the U.S. Amundsen-Scott South Pole Station in Antarctica, a broad science collaboration, currently consisting of 52 institutions in 12 countries (U.S., Germany, Belgium, Sweden, Australia, Canada, Denmark, Japan, New Zealand, South Korea, Switzerland, and the United Kingdom)
- **National Radio Astronomy Observatory (NRAO)**
  Atacama Large Millimeter/Submillimeter Array (ALMA) - ALMA is supported by an international partnership, comprising the U.S. and its partners Canada and Taiwan, the European Southern Observatory (ESO), and Japan and its partners Taiwan and South Korea. The array is located in the Chilean high desert near San Pedro de Atacama.
- **NSF's National Optical-Infrared Astronomy Research Laboratory (Formerly NOAO)** - Gemini Observatory operates twin 8.1-m optical/infrared telescopes, one in the northern hemisphere on Mauna Kea, Hawaii, and the second in the southern hemisphere on Cerro Pachón, in Chile. Managed by the Association of Universities for Research in Astronomy (AURA), NSF acts as the Executive Agency on behalf of the international partners, which now include Canada, Brazil, Argentina, Chile, and the Republic of Korea. The U.S. is currently the majority partner with about 65 percent of the available observing time on the two telescopes, and holds six of thirteen seats on the Gemini Board.



Private foundations and NGOs: The robust not-for-profit sector is a uniquely American asset and a rich source of partnership opportunities. While private foundations account for only a small fraction of funding for scientific research in the U.S., their support is often aimed at underserved areas and their funds can be quite flexible. Foundations see themselves as providing risk capital to pilot new approaches because they are not bound by as many internal constraints as government agencies. Compared to NSF they may have a shorter cycle of interest on a given topic, and may choose to partner with NSF to ensure that piloted activities can be sustained long-term or taken to a larger scale. See Box 4 for examples. Ultimately, given the mission and approach of private foundations and NGOs, it is important for NSF, when working with these partners, to discuss and establish plans for sustainability. This is particularly important if the partnership is for infrastructure, as opposed to research.

In addition to funding projects of common interest, foundations and other NGOs can provide in-kind support for joint activities involving NSF by hosting or convening events that can catalyze new research areas and bring broad communities of researchers together who might not otherwise meet. This in-kind support is difficult to measure but is highly valuable. Each foundation has its own culture and motivation; the foundation community is not monolithic.

BOX 4

EXAMPLES OF FOUNDATION/NGO PARTNERSHIPS:

NSF-Simons Foundation

The purpose of the NSF-Simons Foundation Research Centers for Mathematics of Complex Biological Systems (MathBioSys) is to enable innovative collaborative research at the intersection of mathematics and molecular, cellular and organismal biology, to establish new connections between these two disciplines, and to promote interdisciplinary education and workforce training. The Simons Foundation's mission, to advance the frontiers of research in mathematics and the basic sciences, is quite compatible with NSF's, and the program now supports four centers, with the Simons Foundation and NSF contributing equally. The program involves both the MPS and BIO Directorates.

NSF and Partnership for AI

In an effort to bring together the CISE and SBE communities to explore high-risk/high-reward sociotechnical artificial intelligence (AI) systems research, NSF works with the Partnership for AI (PAI). NSF and PAI are providing joint support for Early-concept Grants for Exploratory Research (EAGERs). For example, a few of the funded projects are now researching how to counter lack of data or system designs to ensure AI systems do not yield disproportionate results for underserved populations.

NSF and Cancer Foundations

Between 2014 and 2016 an innovative public-private partnership between NSF, Stand Up To Cancer (SU2C), the V Foundation for Cancer Research, The Lustgarten Foundation, Breast Cancer Research Foundation and Bristol-Myers Squibb was established. The partnership was aimed at funding transformational, theoretical biophysics that could have a significant impact on cancer research and treatment. The partnership funded an NSF Ideas Lab, which brought together a group of participants with expertise in several research areas to work in teams over a five-day intensive workshop and develop proposals that employed physics-based approaches to cancer. Following the workshop, select teams were invited to submit proposals to a competition for funding. Three awards that used interdisciplinary research methods to understand and treat cancer were funded by NSF through the MPS/PHY Physics of Living Systems Program, and another was funded by Stand Up to Cancer.

Industry

Advancing public-private partnerships is part of the NSF strategic plan to enhance the impact of the agency's investments. NSF's direct partnerships with private industry have been relatively limited to date, but are growing. They bring the rich resources of industry to bear to accelerate basic research; speed the transition of basic research to the market; and support the development of workforce resources (Box 5).

While there is often clear alignment of such activities with the NSF mission, and industry can bring significant resources to pursue shared opportunities, working directly with private industry partners can introduce risks for the agency because of the perception that interests of industry partners in the for-profit marketplace may exercise undue influence. In other words, it may appear that NSF is the research arm of the industry partner. These risks include intellectual property considerations, as well as influence on decision making in the merit review process and on NSF's portfolio management. NSF must also carefully avoid granting a competitive advantage to specific companies and, as with any potential partner, consider carefully any reputational risks that an association with a company or industry might bring. Early market research, broad outreach, and due diligence review of potential industry partners are critical steps to manage and minimize risks and identify best options for implementation. In some cases, informal or indirect partnering with industry may be preferable.

BOX 5

NSF-INDUSTRY PARTNERSHIP EXAMPLES

A. In 2018, NSF and the Boeing Company announced a new partnership through which Boeing invested $11 million to accelerate training in critical skill areas and increase diversity in STEM fields. Of the total, $1 million was a gift to NSF INCLUDES to increase the number of women in STEM and address the needs of women returning to the STEM workforce, especially veterans. Boeing was the first company to contribute at a national level to NSF INCLUDES.

The remaining $10 million Boeing gift supports a new EHR initiative to accelerate education and "upskilling" in critical areas for the Nation's engineering and advanced manufacturing workforce – the Production Engineering Education and Research (PEER) program (NSF 19-557). The PEER initiative supports foundational research arising from the design, development, and deployment of creative online curricula. It provides learners with skills in five focal areas: model-based systems engineering, software engineering, mechatronics, data science, and artificial intelligence. The majority of projects funded to date have focused on distance learning, a particularly timely topic. Roughly 3,000 students (graduate and undergraduate) as well as 130 faculty members have benefited each year from PEER initiative awards.

B. NSF has partnered with Intel on joint program solicitations over a period of several years, on topics such as cyber-physical systems security and privacy, foundational microarchitecture research, and machine learning for wireless networking systems. Intel and NSF work together to craft the solicitations, Intel participates in the review process, and award decisions are made jointly. Intel and NSF each provide support to awardees through separate funding instruments. The benefit to Intel is access to a wider range of top researchers in their areas of interest. The interest to the NSF is in encouraging academic researchers to address use-inspired problems, and in expanding the experience of students to qualify them to enter a broader range of careers.

NSF-CATALYZED (INDIRECT) PARTNERSHIPS:

Many NSF programs, particularly those addressing large, complex scientific or societal needs, require or encourage grantees to engage with external stakeholders with complementary expertise and resources. These indirect, NSF-catalyzed partnerships are university or PI-led and can help carry out the full spectrum of the award's stated goals in research, knowledge transfer, education and workforce training. Through these partnerships, the PIs leverage NSF funds to attract additional resources (financial or in-kind) that expand the award's activities, which may include increased opportunities for student work-force training and, in some cases, sustainability of the award's activities after NSF funding ends. See Box 6 for examples of these programs.

BOX 6

NSF-CATALYZED PARTNERSHIPS EXAMPLES

- Science and Technology Centers (STC)
- Engineering Research Centers (ERC)
- Science of Learning Centers (SLC)
- Smart and Connected Communities (S&CC)
- Industry-University Cooperative Research Centers (IUCRC)
- Advanced Technological Education (ATE)
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Established Program to Stimulate Competitive Research (EPSCoR)

OBSERVATIONS: WHAT WE HAVE LEARNED

Relationships matter and take time

Nearly all successful partnerships start with a personal relationship between individuals within the partner organizations. This is time-consuming but necessary to build trust, align goals, and ensure relational resilience. This trust, and associated candor, are necessary to identify and negotiate differences between agency policies and culture that might otherwise prevent a partnership from forming. It can take years to build this trust, but it can be accelerated through joint workshops or other opportunities for interaction that broaden the connections between communities and incubate collaborative possibilities.

Both working-level champions and broad engagement are essential

Even when organizational leaders agree that a partnership would be valuable, a working-level, persistent and passionate "champion" is necessary on both sides, especially in situations in which senior leadership may not remain constant. Though initiating a partnership depends on this personal stake, successfully sustaining a partnership over time requires broad ownership and engagement; it cannot be tightly held or "siloed" but must draw in colleagues and leadership.

Opportunities must be grounded in strategy

'Opportunism' is often seen as an opposite to "strategy." As an agency that values bottom-up, community-driven initiatives, NSF has built its reputation on the ideas of scientists, engineers, and educators who framed questions around the *opportunity*, afforded by prior knowledge and available methods, pursuing discovery without a clear view to eventual strategic application. At NSF some partnerships start based

on the opportunity presented by individuals' shared interests, experiences, and relationships. Because all partnerships require significant staff effort and because each new partner adds more complexities and potential constraints, it is important to nurture these opportunities but ground them firmly in the broader picture of whether the candidate partner is uniquely positioned to help advance the goals of a potential partnership.

Establish a partnership's lifecycle at the outset

There comes a time when a partnership has run its course. It can happen due to a change in scientific priorities for either partner, loss of a champion willing to put in the time and effort to keep the relationship strong, changes in government, changes in policy or resources, or other factors. Trying to sustain a faltering partnership rarely succeeds for long and may damage future efforts. The most important issue is for both sides to understand when the costs outweigh the benefits of a particular partnership, making the partnership unsustainable. Ideally, this lifecycle should be built into a partnership agreement at its outset with clear metrics for sunsetting so there is clarity of expectations on all sides, and a partnership's continuation or end can be planned.

CURRENT OPPORTUNITIES and ACTIONS

Partnerships require significant time and intellectual capital, as well as strategic foresight, in their development. NSF is focusing significant effort on establishing guidelines, processes and tools to more efficiently develop, implement, and manage partnerships. The result will ultimately be growth in the number and scope of partnerships to maximize the scientific, economic, and societal impacts of NSF investments.

Being a learning organization

NSF expects the quality and number of its partnerships to grow. To prepare for this, NSF will take steps to prioritize learning from our past experiences and sharing this learning within NSF even as we work together to innovate for the future. First steps include: providing guiding principles and guiding questions for consideration of partnerships, implementation of a partnership portal, and establishment of an NSF community of practice for sharing intelligence, and for collective learning to enhance partnership building.

Guiding Principles

The landscape of NSF's partnerships is complex, reflecting the breadth of the science, engineering, and educational activities that NSF supports. Yet the basic principles that guide partnerships at all levels are the same: considering factors that make a partnership advantageous and considering how it will be implemented.

- In FY 2020, NSF codified these **Guiding Principles** that serve as a basis for assessing which potential partnerships should be pursued.

A Partnerships Portal

- NSF staff tend to be entrepreneurial, seeking and exploiting opportunities to extend NSF's reach through partnerships. Without direction, instructions and best practices, this can lead to a cottage industry where individuals re-invent processes and sacrifice efficiency. In FY 2020-2021 NSF will create a suite of tools and documents that establish replicable procedures to identify and create partnerships, centralize the tracking of partnerships. For example, an 'MOU Builder' will streamline creation of MOUs between NSF and partnering entities.
- During FY 2020-2021, NSF will also standardize its method for identifying and 'counting' partnerships. It will develop tools and metrics to track and evaluate partnerships, best practices, and results of these efforts.

Sharing intelligence and collective learning

The upside of a cottage industry for partnerships is the multiplicity of creative solutions to similar challenges. Yet currently there is little opportunity for such expertise and experiences to be shared across NSF's Directorates to strengthen our culture of partnership.

- During FY 2020-2021, NSF will establish an agency-wide Community of Practice where those engaged in partnerships throughout NSF can share their experiences and contribute to honing the resources that are available and help others to develop productive and robust partnerships. Furthermore NSF will develop partnership training modules for new and existing staff.

CONCLUSION

NSF has deep, rich experience in building partnerships across all the areas of science, engineering, and education it supports. While some, such as in large facilities, are the result of high-level strategic planning, many others have been built in an entrepreneurial fashion by NSF staff. In the future, the need for partnerships is likely to become ever more compelling. To optimize the process of establishing and managing partnerships, NSF is now focused on codifying and disseminating partnership principles, developing tools that streamline the mechanics of building partnerships, and strengthening the NSF culture of partnership through shared practices. With these actions NSF will be well poised to sustain its role as a global leader in research and innovation, and in nurturing the next generation of scientists and engineers.

Cover Images Credits: Sanja Karin Music/Shutterstock.com (top, left); USAID (top, right); Sven Lidstrom, IceCube/NSF (middle, left); Photo by Andrew Kelly/NY Hall of Science (middle, right); Kathy F. Atkinson/University of Delaware (bottom, left); University Communication/University of Nebraska-Lincoln (bottom, right).

APPENDIX

RENEWING NSF

NSF Partnerships: Guiding Principles

The National Science Foundation (NSF) engages in partnerships with other federal agencies, industry, foundations, non-profits, and international funding agencies and organizations. Partnerships offer opportunities to amplify economic and societal benefits for the United States, such as accelerating discovery and the transition of research to practice. Partnering can also generate significant costs and risks for the agency, which must be carefully considered prior to embarking on any new partnership.

FACTORS TO CONSIDER WITHIN THE RISK, COST, AND BENEFIT LANDSCAPE

BENEFITS | The benefits of the partnership to all parties should be clear and aligned with NSF's mission and applicable policies.

COSTS | The costs (e.g., resources, time, effort) and risks to the agency (e.g., public perception, reputation) should be considered and a determination made that the value of the partnership outweighs any potential cost and risk factors.

OUTCOMES | A partnership should enhance the proposed achievement or potential outcomes of research, education, or innovation in one or more of the following ways:

a. Expand or accelerate the achievement of research, education or innovative outcomes (including transition of research to practice);
b. Enable NSF and/or the U.S. research community to achieve what would not be possible in the absence of the partnership;
c. Provide unique training and/or research experiences for students, trainees;
d. Provide access to and/or share resources and/or expertise needed to support research and education; and/or
e. Coordinate and reduce redundancy across the U.S. research portfolio.

IMPLEMENTATION FACTORS TO BE CONSIDERED

AUTHORIZATION | Formal and informal partnership approaches have different approval requirements. Thoughtful consideration of the goals and resources needed can help identify the most appropriate options.

RESOURCES | Prior to initiating a partnership activity, the resources (e.g., human, financial, technological) required and, at minimum, the strategy for identifying the necessary resources should be identified.

CONTEXT | Potential partnership opportunities should be coordinated, where appropriate, with any existing NSF agreements with the partner organization as well as the interests of other stakeholders within NSF.

OVERSIGHT | Partnership arrangements should include a plan to monitor progress, identify and manage issues that arise, evaluate the partnership's successes and challenges, and assess appropriate next steps (e.g., sunsetting, continuing, or expanding) for the partnership.