Testimony of

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"National Science Foundation Part 1: Overview and Oversight"

Chairwoman Comstock, Ranking Member Lipinski, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's (NSF) unique mission, significant impact on the economy and security of our nation. I will describe our efforts to implement provisions of the American Innovation and Competitiveness Act (AICA), and to strive for excellence in agency operations.

First, I would like to take this opportunity to thank this Committee for its work in developing the bicameral, bipartisan American Innovation and Competitiveness Act. This Act affirms NSF's long-standing, world-renowned merit review process; maximizes research opportunities; and promotes NSF's commitment to diversity in STEM fields. It also incentivizes NSF programs that encourage private-sector involvement and re-affirms NSF's commitment to entrepreneurship and commercialization.

NSF: Building a Foundation for Success

NSF is governed by the NSF Act of 1950, as amended, to "promote the progress of science." NSF supports close to 2,000 colleges, universities, and other institutions, and receives on the average of 50,000 proposals each year, of which it funds approximately 11,000 grant proposals each year. Over 200,000 proposal reviews are conducted annually. The estimated number of people directly supported by NSF at any given time is close to 300,000. This includes researchers, postdoctoral fellows, trainees, teachers, and students. NSF has also supported close to 50,000 graduate research fellows since 1952 through its flagship Graduate Research Fellowship Program. We are a lean agency with only 7% overhead. That means 93 percent of appropriated funds directly support research and STEM education, 85% of it at our nation's colleges and universities.

The Foundation's annual budget, $7.5 billion in fiscal year 2016, represents just four percent of the total federal budget for research and development, but accounts for 24 percent of the total federal support for

basic research conducted at U.S. colleges and universities, and this share increases to 60 percent when medical research supported by the National Institutes of Health is excluded. NSF is the primary source of federal academic support in many fields. For example, NSF provides 82% of the funding for academic computer science.

The cornerstone of NSF is the merit-based, competitive process that fosters the highest standards of excellence and accountability. The merit review process is one of NSF's critical business functions. Effective merit review recognizes high-quality research, including high-risk, high reward or potentially transformative ideas, empowers NSF to support such proposals, and retains the confidence and trust of NSF's external stakeholders. NSF has the latitude to support emerging fields, high risk ideas, interdisciplinary collaborations, and research that pushes – and even creates – the frontiers of knowledge. NSF uses two criteria as the basis for all proposal reviews: Intellectual Merit and Broader Impacts. The programs and practices which the hard-working and dedicated staff at NSF have created have been emulated around the world. NSF support has nurtured the creative talents of hundreds of thousands of scientists, engineers, students, and educators in every part of the U.S. NSF has supported the discoveries of some 223 American Nobel Prize winners. This represents about 70 percent of all the U.S. Nobel Prize winners since 1950.

As the nation's fundamental research funding agency, NSF is unique. Our mission is as broad as science itself. We support all fields of fundamental science and engineering (S&E), and STEM education in one agency, keeping our nation's scientific enterprise focused on the frontiers of research and education. We recognize and nurture emerging fields, encourage the most insightful ideas, and prepare future generations of scientists and engineers.

Reflection

In a few years, NSF will celebrate its 70th birthday. As we reflect on the enormous impact the agency has had on every facet of society, we can say with certainty that the results of frontier research funded by NSF have a long record of improving lives and meeting national needs. They are the very bedrock of economic growth; the path to sustainability in energy, agricultural, and environmental domains; the seeds of the next technology revolution; and the foundation for advances in medicine and national security.

From the beginning, NSF has focused on the frontier, where discoveries – and discoverers – begin. An example of frontier research is the first direct detection of gravitational waves by NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO) just last year. This historic discovery first began to be funded by NSF in the 1970's as a transformational idea to test one of the predictions of Einstein's theory of General Relativity. The sources of the gravitational waves thus far discovered have been identified as the merger of large black holes in binary systems. This interpretation could not have been made without computer modeling and simulations, performed by NSF-funded researchers on NSF-funded supercomputers. The direct detection of gravitational waves is an example of high-risk, high-reward government funding of basic research. It illustrates the importance of NSF and its role in making transformative discoveries.

This discovery last year is a beginning, not an end. In much the same way as when Galileo first turned his telescope towards the night skies or when radio astronomy transformed our view of the universe, we now have a tool to probe the most violent phenomena in the furthest reaches of the cosmos.

The majesty of discovering our universe motivates ambitious experiments, but as with all fundamental science, LIGO offers other important benefits. This science will advance education, inspiring students and developing the workforce our society requires. It has, and will continue, to lead to collaborations in engineering, computer science, and other fields. This project has already led to other unpredictable

advances, enabling technology spin-offs ranging from vibration isolation to mirror coatings to vacuum technology, that make the Nation more competitive. Significantly, industrial manufacturers were crucial partners in an effort driven by the goal of making an unprecedented measurement.

NSF has several programs to create and expand partnerships with the business community. I will briefly touch on two of these programs. **The Industry–University Cooperative Research Centers (IUCRC) Program** was created in 1973 to develop long-term partnerships among industry, academe and government. NSF invests in these partnerships to promote research of mutual interest, contribute to the nation's research infrastructure base, enhance the intellectual capacity of the engineering and science workforce, and facilitate technology transfer. NSF currently supports 77 IUCRCs involving over 200 university sites. Each center has, on average, approximately 17 industrial partners. For every dollar provided to a center from the NSF IUCRC Program approximately seven dollars are provided by the industry members and other sources. More than 2,000 students conduct research at IUCRCs each year, and approximately 30% of those students graduating each year are hired by the center's member companies. **The NSF Innovation Corps (I-Corps™) Program** enables engineers and scientists to translate new discoveries into technologies with near-term benefits for the economy and society. Eight I-Corps Nodes and 56 I-Corps Sites form a National Innovation Network that stimulates the formation of I-Corps Teams that each include a technology expert, student entrepreneur, and a business mentor. The I-Corps Nodes then provide the training for those Teams. To date more than 900 Teams have completed the I-Corps Program resulting in the creation of more than 350 startups.

NSF provides a much-needed bridge between research and discovery that would otherwise be neglected and remain untapped by the commercial marketplace. In the 1970's, research on solid modeling by NSF-funded scientists at Carnegie Mellon University led to widespread use of Computer-Aided Design and Computer-Aided Manufacturing, which together have revolutionized much of the U.S. manufacturing industry. NSF encouraged investigations into design problems that neither private firms nor federal mission agencies were willing to address because of their long-term, high-risk nature. Many more examples of NSF returns on investments can be found in the addendum to this testimony.

Leadership

During my tenure as Director of NSF I have been witness to discoveries 40 years in the making, and I have had the privilege of meeting and interacting with talented researchers and students from all over the world. In addition, I have worked with a remarkable staff dedicated to the mission of NSF. It is a privilege to lead such an agile, capable organization.

For any organization to survive and thrive it needs responsible leadership. NSF has worked closely with Congress, the community, industry, and outside experts to be responsive to the changing priorities for science, engineering, and STEM education, as well as transparency and accountability in our award process, and the management of our multi-user facilities, among other things. We appreciate the opportunity to work with this committee and others to make NSF the best it can be, and look forward to continuing to make progress.

Leadership is about looking ahead, and that is why NSF came up with "10 Big Ideas" on the cusp of a breakthrough. NSF's 10 Big Ideas focus on: (1) pushing the existing boundaries of knowledge; (2) pinpointing new opportunities to seize; and (3) closing gaps – enabling these and more big ideas to move us beyond the minimum requirements needed to keep pace with other competitive nations. They are briefly described in an attached document.

Federal investments in fundamental science and engineering and STEM training are increasingly important to help establish U.S. leadership in next-generation technologies, especially as other nations intensify their support of research, development, and education. U.S. leadership is important in part because there is unprecedented global competition for the world-class talent who generate innovative scientific ideas and make up the technical workforce.

STEM Education and the AICA

NSF is unique among agencies in its integration of education and workforce development activities with fundamental research in all areas of science and engineering. The goals of the American Innovation and Competitiveness Act of 2017 align with this integrated mission, and implementation of the STEM education provisions are well underway. NSF's investment in STEM education is in the national interest, as it is designed to establish the evidence base for the most promising education practices for building the nation's STEM workforce at scale. NSF's implementation of the STEM education provisions in AICA emphasizes the improvement of STEM education to prepare tomorrow's workforce.

NSF administers programs that are key to the preparation of the STEM workforce in strategic areas of national need. The Cybercorps: Scholarships for Service prepares students to join the Federal, state, and local governments as cybersecurity experts. The Robert Noyce Teacher Scholarship program recruits STEM majors and prepares them to be highly effective elementary and secondary science and mathematics teachers in high-need local educational agencies. Diversity, inclusion, and broadening participation in science, technology, engineering, and mathematics (STEM) are essential to the development of a strong and innovative STEM workforce for our nation. NSF INCLUDES (Inclusion across the Nation of Communities of Underrepresented Discoverers in Engineering and Science) furthers NSF's commitment to building a diverse and well prepared STEM workforce by taking a comprehensive approach to fully engaging the nation's talent in STEM in order to secure our Nation's long-term economic competitiveness.

The integration of science and education is well illustrated in such programs as NSF's Advancing Informal STEM Learning (AISL) program. AISL provides opportunities for partnership between experts in learning and communication with scientists across the NSF directorates to design and study the most effective ways of engaging broad audiences with science and engineering outside of formal education settings. And, in the NSF-wide Improving Undergraduate STEM Education (IUSE) and Research Experiences for Undergraduates programs the education experts partner with researchers in the science and engineering disciplines to provide the most effective research experiences early in an undergraduate's tenure. Increasingly we are encouraging partnerships among 2-year and 4-year institutions, and studies of the effectiveness of different approaches. Projects with course-based research experiences in introductory/first-year courses are also funded by IUSE and provide another way for a beginning undergraduate to have a research experience. And, efforts to better understand how students come to learn the important skills of computer science and computational thinking are addressed across multiple programs.

AICA provides a useful blueprint for NSF's continued critical contributions to the development of a skilled and diverse STEM workforce, and we appreciate your recognition of the leadership role expected of the agency in providing an evidence base for the improvement of STEM education through continued integration of science and education, and coordination with colleagues across agencies.

Striving for Excellence

Transparency and Accountability – Working closely with our congressional authorizers and appropriators, especially this committee, NSF has taken up the charge in promoting transparency and accountability. Indeed, NSF transparency and accountability efforts are well-aligned to Section 102 of the AICA. They assure the public value of scientific research through clear communication of the merit review process, the resultant grants that are funded, and the potential impact for our nation that can accrue from these grants.

Since NSF provides information about its processes and awards in many different ways, we created a single Transparency and Accountability web page during the past year to link to a broad range of NSF activities (see https://nsf.gov/od/transparency/transparency.jsp). This page now provides links for the public to a diverse array of information including reports to the National Science Board on NSF's merit review process, our plan for public access to the results of NSF-funded research, budget and performance reports, Committee of Visitors reports, and more.

NSF's transparency and accountability initiative has focused on increasing the clarity of the language used to describe new awards in recognition of the fact that titles and abstracts are an important way to communicate with the public. Policies were put in place emphasizing the need for each award title and abstract to clearly convey, to a broad audience, the nature and importance of the funded activity. In support of the new policies, NSF enhanced its training and internal communications on the writing of titles and abstracts. The combination of the new policy and training has begun to improve the quality of the titles and abstracts, and NSF will continue to monitor results to ensure continuing improvement. We were pleased that the AICA recognized that "the Foundation has improved transparency and accountability of the outcomes made through the merit review process."

Management of Large Facilities – The members of this Committee, the NSF Inspector General (OIG), and the expert panel assembled by the National Academy of Public Administration (NAPA) have all been helpful to the agency in identifying areas where NSF can improve and make our oversight of critical science-support facilities even stronger. The NAPA report emphasized the need for heightened accountability and oversight, particularly with respect to large-scale research infrastructure, as NSF pursues its mission to support basic research at the frontiers of science and engineering. The agency is committed to improving the rigor and oversight of its processes and deploying appropriate levels of project, programmatic, and financial management expertise.

NSF has done a substantial amount of work over the past few years and the NAPA report has allowed us to sharpen our focus over the past year in particular. I'm very pleased to report to the Committee, that NSF has fully evaluated nearly all of the NAPA recommendations and fully implemented what we consider to be the highest priority items. Only a few are still undergoing internal discussion and will require a reasonable amount of additional time to implement. This effort, and our close coordination with your staff and our OIG, has made NSF nearly fully compliant with the requirements of the American Innovation and Competiveness Act related to major science facilities. We expect that we will only have to make minor procedural adjustments related to Independent Cost Estimates and the cadence of incurred cost audits. Those procedural adjustments are now underway and, as with the rest of the COMPETES requirements, will be implemented on all current and future projects.

Conclusion

Madam Chairwoman, NSF maintains its longstanding commitment to supporting research that drives scientific discovery, maintains America's global competitiveness, and builds the modern workforce that is critical for addressing the complex challenges that face the Nation. NSF's broad portfolio positions the agency to contribute productively and rapidly to important national challenges. NSF is vital because we invest in basic research and people who make the discoveries that transform our future.

With the continued support of this committee, the community, and outside experts, NSF will continue to thrive in its mission to "promote the progress of science."