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on
The President's Fiscal Year 2015 Budget Request
for the National Science Foundation

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Chairman Wolf, Ranking Member Fattah, and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's fiscal year (FY) 2015 Budget Request.

The President's FY 2015 Budget Request reflects wise stewardship of federal funding through innovative, targeted investments during these times of constrained budgets. The Request totals $7.255 billion, an increase of $83.08 million (1.2 percent) over the FY 2014 enacted level. The FY 2015 Request provides robust support for core programs in fundamental research and education in all fields of science and engineering. This investment moves our nation forward by connecting the science and engineering enterprise with potential economic, societal, and educational benefits in areas critical to creating high-quality jobs, growing the economy, and ensuring national security.

An additional $552.0 million is proposed through the Opportunity, Growth, and Security Initiative (OGSI) for NSF, recognizing that additional investment in FY 2015 can spur economic progress, promote opportunity, and strengthen national security. At NSF, OGSI will ensure strong support for core activities that transform the frontiers of learning and discovery. The additional investment provided through this initiative will accelerate progress in broad areas of science and engineering that address clearly defined national priorities, such as advanced manufacturing, clean energy, cybersecurity, cognitive science and neuroscience, and STEM workforce development.

NSF is the only federal agency with a mandate to support research and education in every discipline. The results of frontier research 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. Sustained momentum in NSF's core programs is essential for progress in science and engineering. NSF's broad scope uniquely positions us to integrate the natural sciences and engineering with social, behavioral, and economic sciences to address the complex societal challenges of today. For all these reasons, the FY 2015 Budget Request provides increased support for the core fundamental research programs across NSF.

NSF: Building a Foundation for Success

NSF has played a significant role in U.S. prosperity, and in the education and development of the nation's science and engineering workforce. For decades, NSF has supported scientists and engineers in their pursuit of world-changing discoveries and innovation that, in turn, created opportunities for private sector growth and for Americans to have good jobs.

Since 1952, the first year that NSF awarded research grants, 212 Nobel Prize recipients have received NSF funding at some point in their careers for their work in physics, chemistry, medicine, and economics. Today, their transformative work addresses society's grand challenges in the areas of energy, environment, and health, as well as national and economic security.

The United States has a long history of investment in and deployment of technological advances derived from advances in basic research facilitated by NSF. For example, research funded by NSF at the National Center for Atmospheric Research and universities was instrumental in the development of Doppler radar, which benefits most Americans regularly through improved weather forecasting. NSF-supported fundamental research in physics, mathematics, and high-flux magnets led to the development of today's magnetic resonance imaging (MRI), employed ubiquitously throughout medicine.

Furthermore, 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 was willing to encourage investigations into design problems that neither private firms nor federal mission agencies were willing to address.

While discovery and innovation underpin our global leadership in science and engineering, and consistently provide pathways for entrepreneurs, these activities are also first and foremost human endeavors. Thus, they demand the development of a highly skilled science, technology, engineering, and mathematics (STEM) workforce. NSF strives to ensure that students from diverse backgrounds, including women, underrepresented minorities, and persons with disabilities, have sufficient opportunities to engage in empowering learning experiences and

inspiring research, no matter their economic circumstances. Sustaining such a world-class workforce is critical.

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. It is crucial that we measure up due to unprecedented global competition for the world-class talent who generate innovative scientific ideas and make up the technical workforce. Despite the constrained budget environment, we must make reasonable investments to secure our nation's future prosperity.

NSF will continue its role as the nation's innovation engine. The fuel for that engine is fundamental research. Scientific research, with its long-term perspective, strong emphasis on disciplinary excellence, and multi-disciplinary interactions, is a critical foundation for both transformational science and economic competitiveness. For all these reasons, the FY 2015 Budget Request provides robust support for the core fundamental research programs across NSF.

The NSF FY 2015 Budget Request

Budget Rationale

The FY 2015 Budget Request for the National Science Foundation continues the tradition of a thoughtful and strategic balance between core research activities both within and across disciplinary boundaries and activities that address emerging areas and clearly identified national priorities. Bolstering and advancing the types of core investments that have been central to the agency's past success reflects a wise stewardship of NSF's federal funding and ensures a strong return on taxpayer investment. In addition, specific investments identified for FY 2015 align NSF's portfolio with overarching challenges and opportunities facing the Nation. This balanced approach ensures that NSF will continue to foster research that catalyzes the development of scientific discovery, promotes creation of new knowledge, and builds human capacity for the workforce of tomorrow.

2014-2018 Strategic Plan

Integral to FY 2015 budget request is the NSF Strategic Plan for 2014-2018: *Investing in Science, Engineering, and Education for the Nation's Future*. The goals and strategies outlined in the plan build on lessons learned from NSF's past successes and continue to uphold NSF's mission: "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...."

The plan presents the following goals, which guide this FY 2015 Budget Request:

- "Transform the Frontiers of Science and Engineering" aims to expand and explore the frontiers of human knowledge to enhance the power of the Nation to meet its challenges,

and to create new paradigms and capabilities for scientific, technological, and economic leadership in an increasingly fast-paced, competitive world.

- "Stimulate Innovation and Address Societal Needs through Research and Education" strives to focus NSF's research communities on opening up new avenues to address high priority national challenges, as well as encourages formation of partnerships with industry, other agencies, and international counterparts to leverage resources and build capacity.

- "Excel as a Federal Science Agency" focuses on efficiently and effectively executing the agency's responsibilities and achieving the flexibility and agility required to meet the quickly evolving challenges associated with the first two strategic goals.

Cross-Foundation Investments

The emergence of NSF's major cross-Foundation investments is the result of years of NSF support for fundamental research across all fields of science and engineering. This enduring base of knowledge and discovery positions NSF to contribute to areas of vital national importance.

Cognitive Science and Neuroscience is a $29.0 million investment that draws together under one framework ongoing cognitive science and neuroscience research and NSF's contributions to the Administration's Brain Research through Advancing Innovation and Neurotechnologies (BRAIN) Initiative. Improved understanding of the brain will promote brain health; enable engineered solutions that enhance, replace, or compensate for lost function; improve the effectiveness of formal and informal educational approaches; and lead to brain-inspired smarter technologies for improved quality of life.

Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS) aims to integrate a number of science and engineering activities across the Foundation – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems. It addresses pressing technological challenges facing the Nation and promotes U.S. manufacturing competiveness. CEMMSS is aligned with key interagency activities, including the Administration's Materials Genome Initiative, Advanced Manufacturing Partnership, and the National Robotics Initiative. While funding declines from the previous year, NSF maintains a strong overall investment in CEMMSS, at $213.20 million in FY 2015.

Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) accelerates and transforms the process of scientific discovery and innovation by providing advanced cyberinfrastructure and new capabilities in computational and data-enabled science and engineering (CDS&E). In FY 2015, NSF will continue to lead the Big Data program that strives to enable breakthrough discoveries and innovation in science, engineering, medicine, commerce, education, and national security. Decreases in CIF21 in FY 2015 are primarily a result of shifting investments in the cross-directorate Computational and Data-Enabled Science

and Engineering program to other targeted programs. In FY 2015, NSF will invest $124.75 million in this program.

Science, Engineering, and Education for Sustainability (SEES) aims to increase understanding of the integrated system of supply chains, society, the natural world, and alterations humans bring to Earth, in order to create a sustainable world. In FY 2015, SEES enters a transition period toward sunsetting in FY 2017. At $139 million in FY 2015, SEES continues to support important scientific and societal contributions during the phase-down period and will make significant progress towards achieving programmatic goals through projects currently underway.

The **Secure and Trustworthy Cyberspace (SaTC)** investment aims to build the knowledge base in cybersecurity that enables discovery, learning and innovation, and leads to a more secure and trustworthy cyberspace. Through a focus on long-term, foundational research, the SaTC investment in FY 2015 of $99.75 million will develop the scientific foundations for cybersecurity research for years to come. SaTC aligns NSF's cybersecurity investments with the four thrusts outlined in the national cybersecurity strategy, *Trustworthy Cyberspace: Strategic Plan for the Federal Cybersecurity Research and Development Program.* Funding for SaTC declines in FY 2015, principally because a component program, the CyberCorps: Scholarships for Service (SFS), decreases by $20.0 million.

Priorities and Highlights

Advanced Manufacturing research holds tremendous potential for significant short-term and long-term economic impact by promising entirely new classes and families of products that were previously unattainable. In FY 2015, NSF's investment emphasizes several emerging opportunities including cyber–physical systems, advanced robotics research, scalable nanomanufacturing, sensor and model-based smart manufacturing, educational activities to support training the next generation of product designers and engineers, and industry-university cooperation. In FY 2015, NSF will invest $150.70 million in these activities.

Clean Energy investments of $361.95 million that will lead to future clean energy and energy efficient technologies are seen throughout the NSF portfolio, both in core research programs and targeted investments such as BioMaPS and SEES. Specific activities include research related to sustainability science and engineering, such as the conversion, storage, and distribution of diverse power sources (including smart grids), and the science and engineering of energy materials, energy use, and energy efficiency.

Innovation Corps (I-Corps) improves NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and downstream technological applications. In FY 2015, NSF will invest $24.85 million to continue to support for I-Corps Nodes and I-Corps Sites to further build, utilize, and sustain a national innovation ecosystem that augments the development of technologies, products, and processes that benefit the Nation.

National Robotics Initiative (NRI) is a concerted program to provide U.S. leadership in science and engineering research and education aimed at the development of next generation robotics,

conceived as robots that work beside, or cooperatively, with people in areas such as manufacturing, space and undersea exploration, healthcare and rehabilitation, military and homeland surveillance and security, education and training, and safe driving. NRI is an interagency effort supported by NSF, the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), and the U.S. Department of Agriculture (USDA). In FY 2015, NSF will invest $28.50 million in this program.

Research at the Interface of Biological, Mathematical, and Physical Sciences (BioMaPS) is a collaboration among the Directorates for Biological Sciences, Mathematical and Physical Sciences, and Engineering that seeks to discover fundamental knowledge at the intersections of these established disciplines. This $29.27 million activity will produce critical knowledge needed to catalyze the development of new technologies essential to the Nation's prosperity and economic competitiveness and will advance emerging areas of the bioeconomy, as described in the Administration's *National Bioeconomy Blueprint*.

NSF aims to increase the operational efficiency of **U.S. activities in the Antarctic** by continuing progress on a multi-year commitment toward more efficient and cost-effective science support as recommended by the U.S. Antarctic Program (USAP) Blue Ribbon Panel (BRP) report, *More and Better Science in Antarctica through Increased Logistical Effectiveness*. Emphases include safety and health improvements, investments with positive net present value, and facilities renewal at McMurdo and Palmer stations. Additionally, NSF aims to plan and execute more effective observational approaches to the Antarctic science community, as outlined in the 2011 National Research Council report, *Future Science Opportunities in Antarctica and the Southern Ocean*. In FY 2015, NSF will invest $18.50 million in this area.

Science, Technology, Engineering, and Mathematics (STEM) Education

NSF's STEM education investment, centered in the Directorate for Education and Human Resources (EHR), supports bold programs and innovative projects that lead to impact by meeting the needs of end-users – students, teachers, researchers, and the public. This request continues the trajectory of those investments and furthers NSF's key role as an innovator and a leading funder of STEM education within the federal portfolio.

In keeping with the Administration's priorities and the strategic goals for STEM education as described in the National Science and Technology Council's Committee on STEM Education Strategic Plan, NSF's key investments for FY 2015 focus on areas where NSF is the identified lead in STEM education, notably graduate education and undergraduate education, and they also emphasize the need to strengthen foundational STEM education research. Four key activities in FY 2015 include:

The **Graduate Research Fellowship (GRF)** program is a national-level competition that supports the outstanding scientists, engineers, educators, and entrepreneurs of the future. The ranks of NSF Fellows include numerous individuals who have made transformative breakthroughs in science and engineering research, with 30 Fellows having been honored as Nobel laureates. In FY 2015, this $333.44 million investment will provide 2,000 new awards

and the stipend level will be increased from $32,000 to $34,000. The development of additional targeted opportunities for Fellows to enrich their professional growth will continue.

NSF Research Traineeships (NRT) enters its second year in FY 2015 at $58.20 million. NRT identifies priority research themes that both align with NSF priority research activities and have strong potential in areas of national need where innovative practices in graduate education can be developed. NRT investments aim to advance the research agenda of these themes, as well as develop and conduct research on new approaches and models for educating the next generation of scientists and engineers. NRT funding also includes $7.0 million for a new track that will invite proposals for design, innovation, and research in graduate student training and professional development. Funding level shown above includes $20.32 million for continuing grant increments for the Integrative Graduate Education and Research Traineeship Program (IGERT), which transitioned to NRT in FY 2014.

The **Improving Undergraduate STEM Education (IUSE)** program is a more extensive coordination of NSF's undergraduate STEM education investments within a framework designed to accelerate improvement and measurable impact in undergraduate STEM education. IUSE is built upon a knowledge base accumulated from decades of research, development, and best practices across the Nation in STEM undergraduate education, and it integrates theories and findings from education research with attention to the needs and directions of frontier science and engineering research. In FY 2015, NSF will invest $118.48 million in this program.

Research Experiences for Undergraduates (REU) Sites and Supplements, an investment of $75.13 million, will continue to provide early opportunities to conduct research for students in their first two years of college, as recommended by the President's Council of Advisors on Science and Technology (PCAST) in their report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*.

World Class Scientific Infrastructure

The world-class equipment and facilities that NSF supports are essential to the task of discovery. In FY 2015, NSF requests funding to continue construction of three projects: the Daniel K. Inouye Solar Telescope, the Large Synoptic Survey Telescope, and the National Ecological Observatory Network. Funding concludes in FY 2014 for two projects, the Advanced Laser Interferometer Gravitational-wave Observatory and the Ocean Observatories Initiative.

The **Daniel K. Inouye Solar Telescope,** formerly known as the Advanced Technology Solar Telescope, will enable study of the sun's magnetic fields, which is crucial to our understanding of the types of solar variability and activity that affect Earth's civil life and may impact its climate. The FY 2015 investment is $25.12 million.

The **Large Synoptic Survey Telescope** will produce an unprecedented wide-field astronomical survey of our universe, including the deepest, widest-field sky image ever. This survey will

change every field of astronomical study, from the inner solar system to the large scale structure of the universe. The FY 2015 investment is $79.64 million.

The **National Ecological Observatory Network** will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. The FY 2015 investment is $96.0 million.

Excellence in Operations

To "Excel as a Federal Science Agency" is an internally focused strategic goal that seeks to integrate mission, vision, and core values to efficiently and effectively execute our activities and provide the flexibility and agility required for all aspects of its operations. It entails blending strong scientific leadership with robust organizational leadership, both characterized by vision and flexibility, and also supporting the staff with the information and other resources that are essential to carry out the agency's activities. This goal incorporates a culture of continuous improvement to ensure effective, inclusive, and accountable programs and merit review processes that provide the greatest value for taxpayer dollars.

Staffing
In FY 2015, NSF will work towards full utilization of its established FTE allocations, which remain unchanged from the FY 2014 Request at 1,352 FTE. The additional FTE will be utilized to address the agency's highest priority workforce needs.

Future NSF
The Agency Operations and Award Management (AOAM) account includes $30.04 million for Future NSF, a multi-year effort associated with NSF's upcoming headquarters relocation. This includes funding for the project management office, IT requirements (including wiring, IT set-up, and infrastructure), and build-out related items such as furniture and filing systems.

Efficient Management

NSF's FY 2015 Request follows a thorough examination of programs and investments across NSF to determine where the potential exists for more innovative investments. In addition to last year's proposals, this Request includes three terminations, one reduction, and one lower-priority program elimination, totaling $26.49 million.

Science of Learning Centers (-$11.99 million)**:** the SLC program has been a ten year cross-foundation activity, supported by the Directorates for Social, Behavioral and Economic Sciences; Biological Sciences; Computer and Information Science and Engineering; and Engineering. The program supported six large-scale, long term centers that created the intellectual, organizational, and physical infrastructure needed for the advancement of Science of Learning research. Four of the six existing centers reached the end of their ten-year funding cycle at the end of FY 2014; the remaining two centers reach a planned sunset at the end of FY 2015. Funding for Science of

Learning research will continue within SBE through a program of the same name which is not center-based.

Enhancing the Mathematical Sciences Workforce in the 21st Century (EMSW21) (-$4.31 million) is a Division of Mathematical Sciences (DMS) workforce program offering that has accomplished its original goals. A replacement program is currently in development to better meet current national needs for the training of the next generation of researchers in the mathematical and statistical sciences.

University Radio Observatories (URO) (-$1.19 million) has been superseded scientifically by the Atacama Large Millimeter/submillimeter Array (ALMA), and thus the MPS/AST Portfolio Review recommended terminating this program. Individual university-based observatories will have opportunities for funding through the Mid-Scale Innovations Program in MPS/AST.

The **Network for Earthquake Engineering Simulation (NEES)** program (-$8.0 million) is reduced because two NSF-supported studies recommended support for a smaller "second generation NEES" instead, which will allow additional investments to be made in research that addresses engineering strategies to design for and mitigate against multiple hazards. This rebalancing of facilities and research programs provides a more efficient and effective strategy to meet the needs of the civil and earthquake engineering-related research communities.

The **Virtual Astronomical Observatory (VAO)** (-$1.0 million) is a lower priority program for NSF. VAO will be transitioned to a new joint NSF/NASA program as operational reviews have shown that the current activity is not meeting the needs of the community in an efficient and cost-effective manner.

Conclusion

With intense global competition for knowledge and talent, we must focus our attention on finding the sophisticated solutions that will ensure a prosperous, secure, and healthy future for the nation and the world. Robust NSF investments in fundamental science and engineering research and education have returned exceptional dividends to the American people, expanding knowledge, improving lives, and ensuring our security. To keep those benefits flowing, we need to constantly replenish the wellspring of new ideas and train new talent while serving as good stewards of the public trust. That is the fundamental and continuing mission of NSF.

Mr. Chairman and members of the Subcommittee, I hope my testimony explains how the Foundation plays a vital role in ensuring that America remains at the epicenter of the ongoing revolution in research, innovation, and learning that is driving 21st century economies. More than ever, the future prosperity and wellbeing of Americans depend on sustained investments in our science and technology. NSF has been and continues to be central to this endeavor.

This concludes my testimony. I thank you for your leadership, and I will be pleased to answer any questions you may have.