



**Testimony of
Dr. Dan Arvizu, Chair
National Science Board**

**Before the Subcommittee on Research and Technology House Committee on
Science, Space, and Technology
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Introduction

Chairwoman Comstock, Ranking Member Lipinski, and members of the Subcommittee, I appreciate the opportunity to speak with you in support of the National Science Foundation's Fiscal Year 2017 Budget Request. I am Dan Arvizu, Chair of the National Science Board (NSB, Board). NSB is the governing board of the National Science Foundation (NSF) and an independent advisor to Congress and the President. I have served on the Board since 2004 and as its Chair since 2012.

For 65 years NSF has demonstrated, in a manner consistent with its statutory mandate, that federal support for the progress of science, including research without a known application at the time of its initial pursuit, is squarely in the Nation's interest. NSF-funded research generates fundamental knowledge that has changed our understanding of the world around us, led to advances and applications that have improved our economy and quality of life, enhanced our health, and helped secure our national defense. As a result, our Nation's global leadership in science and innovation has served as a building block for competitiveness and prosperity.

Today, NSF continues to seed our Nation's science and technology ecosystem. It does this in two ways. First, NSF funds meritorious discovery research via Federal assistance grants and cooperative agreements in *all* science and engineering fields. Science usually advances slowly and incrementally through a persistent grind of repeated testing, revising of theories, and lessons learned from failures. But over a long period, each of our Directorates can point to those rare "Eureka!" moments, often accompanied by a long-tail of commercial applications, interdisciplinary insights, and sometimes even new fields of research.

Second, NSF facilitates the education and training of a STEM-capable U.S. workforce. It accomplishes this through research assistantships, fellowships, and other similar direct opportunities. But the positive impact of NSF investments is much broader than this. Because NSF supports discovery research at numerous institutions ranging from research-one public and private universities to community colleges, students with diverse interests have opportunities to learn from and work with NSF-supported faculty. NSF support of discovery research in STEM education and learning also yields tremendous benefits for students of all ages and backgrounds. Together, these investments in knowledge- and human-capital development make possible the mission-oriented science pursued at other agencies and the innovations developed by the private sector.

Chairwoman Comstock, on behalf of the Board and the science, engineering, and education communities that we represent, I'd like to thank this Subcommittee for its longstanding support of NSF's mission and, in turn, our Nation's leadership in science and technology. The NSB takes seriously its responsibility to provide strong governance and stewardship of this taxpayer investment to enable our Nation to push the frontiers of science and engineering research and education. We recognize that these are tough fiscal times, and we do not take your support for granted.

Future Vision

As a governing body, one of NSB's most important functions is identifying areas of future opportunity. We want to ensure that NSF and the Nation are positioned to bring about scientific and economic advances akin to those associated with the Internet in the 1980s and 1990s and with nanotechnology in the past two decades. To remain the world leader in research and innovation, we must continue to be driven by the best ideas from scientists, push the frontiers, and invest wisely – but without fear of failure.

Although we recognize the constrained budget environment, the Board feels strongly that support for potentially *transformative* research in all fields of S&E must remain among our highest priorities. The decisions we make today and their effect do not occur in isolation. Numerous other countries have come to recognize the enormous returns on investment in S&E and now rival U.S. preeminence in many areas. China, for example, has nearly tripled the number of high performance computing (HPC) systems on the most recent "TOP500" list, while the number of systems in the United States has fallen to the lowest point since 1993. While global competition can help spur innovation, if we cede our leadership position, we will fail to reap the full economic and societal benefits that scientific progress offers.

Seizing these opportunities requires the type of unwavering, long-term commitment to scientific discovery that has served our Nation well over the past half century. The first direct detection of gravitational waves by the Advanced Laser Interferometer Gravitational Wave Observatory (LIGO) was the result of a forward thinking vision. The scientific community, NSF, Congress, and the Administration made this vision a reality through decades of work and over a billion dollars in unflinching federal support. And today, more than ever in the history of humankind, we have the tools, knowhow, and understanding to tackle some of the most daunting challenges facing our world. The question before us is do we have the will to capitalize on these emerging opportunities, despite the obstacles we face.

One particularly promising opportunity is in the area of information and computational science. Advances in machine learning have combined with big data to give us an entirely new tool set, creating new areas of research and the ability to solve problems that have long defied solution. Deep neural nets that mimic human thoughts have solved problems that – just 5 years ago – were called "too hard." We've come a long way since IBM-Deep Blue used brute computational force to defeat Chess Master Gary Kasparov almost 20 years ago. Recently, DeepMind, a British artificial intelligence company acquired by Google in 2014, just completed a startling 4-1 win over one of the best Go players in the world by using neural networks and reinforcement learning which more closely resembles human decision-making. This is something fundamentally new in the way programs are created; computers are using data and simulation to program themselves to recognize and classify patterns. While impressive in their own right, the impact of these innovations aren't confined to "gaming" or the computer and information sciences.

In the next decade, the growth of big data and empirical modeling will transform discovery science, much like calculus changed physics and computers changed engineering. These tools will let researchers tackle questions that eluded us in a pre-big data world. These include questions in the social, behavioral and economic sciences that have proved to be among the hardest questions in all of science to crack. In the near future, we will be able to run simulations and make predictions about these kinds of complex systems, providing immensely powerful tools to policy makers and companies, and benefits to all Americans.

To understand the magnitude of the opportunity before us, consider an example of how these emerging tools have begun to transform my own field of electric power. Our electricity system used to be simple, with one-way power flow from central generation stations through transmission and distribution lines supplying power to commercial and residential consumers. However, this system has become vastly more complex and distributed to meet the needs of today's and tomorrow's consumers, evolving into something quite different than the grid Thomas Edison envisioned. Electricity is moving from a commodity to a service, and our system requires two-way power flows, new power electronics, a myriad of sensors and control points, and a systems architecture built on layers of models, real-time feedback, simulations, and predictions. Providing energy has moved from electrical engineering equations to a complex system of smart, connected components that balance bulk generation with variable, distributed resources, storage, increased balancing areas, demand-response, and dynamic pricing.

Many of the tools that will be necessary to manage this complexity to create a more efficient, clean, reliable, secure, and low cost power system are under development today. Increased investment in research will enable these tools to be developed more quickly. Research into how people interact with energy systems, especially, will allow us to meet the future needs of consumers who will increasingly focus on the services energy provides and not just the commodity of electricity.

In my field, as in many others, our Nation's ability to compete globally requires a renewed commitment to keeping our edge in these promising areas of computing and data science. NSF and other agencies are already laying some of the groundwork to seize these enormous opportunities. We're making investments in HPC and building platforms for large data sets, including through the interagency Networking and Information Technology Research and Development (NITRD) program. The Foundation has embraced many of the recommendations from the 2015 *PCAST Report to the President and Congress Ensuring Leadership in Federally Funded Research and Development in Information Technology*¹, particularly those related to workforce, high-capability systems, and data-centric computing. In its FY 2017 request, NSF is proposing new investments targeting opportunities in large-scale data management and analysis, including through the Data for Scientific Discovery and Action (D4SDA) and Resource Implementations for Data Intensive Research in the Social Behavioral and Economic Sciences (RIDIR) programs.

FY 17 Budget Request

Since the Director's testimony covers the noteworthy highlights of NSF's FY17 request, I will not repeat them here. I do, however, want to call your attention to a significant near-term risk to the Foundation. NSF's ability to promote the progress of discovery science and foster a STEM-capable workforce starts with the health of our own workforce and organization. Each and every

¹ https://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/nitrd_report_aug_2015.pdf

day, NSF's scientific, professional and administrative staff execute every stage of the merit review and award process. Underpinning their success is a technological and physical infrastructure to manage administrative processes and provide high-quality customer service. These critical functions are supported by the Agency Operation and Awards Management account (AOAM). Over the past several years, AOAM accounted for about 4% of NSF's actual budget, remaining flat for five years even as our staff's workload has steadily increased. During almost my entire tenure on the Board, we have highlighted that the AOAM account remains under-resourced. I bring this concern to your attention again this year, as I fear consequences of this shortfall will soon be evident.

In FY 17, the pressures associated with the move to Alexandria are highlighting our already-impending "silver tsunami." Like many science and engineering heavy industries, many people in our workforce were inspired to careers in research by the national challenge of the space race. A significant proportion of NSF's workforce is now eligible for retirement, and NSF management expects the move to Alexandria will hasten the decision of many to retire. If NSF is to fulfill its mission, we need to retain our best staff, replace retirees with talented newcomers, and provide existing staff with the resources to execute their duties at a level commensurate with the degree of trust Congress and the American public has afforded us. Fully funding of AOAM at \$373 million is essential to the professionalism of our operations.

As for the National Science Board, we request \$4.38 million, a 0.2% increase from the current fiscal year. This proposed budget enables the Board to fulfill its oversight responsibility of NSF's performance and fiscal integrity, its statutory obligations regarding the MREFC account and *Science and Engineering Indicators*, and to work with the Director to capitalize on the opportunities arising from the expanding frontiers of scientific knowledge. The increase will support document management. The Board, through its Audit and Oversight Committee chaired by Dr. Ruth David, also works with the agency's Office of the Inspector General to ensure that American taxpayer dollars are managed responsibly.

Focus Areas for Future Board Activities

Transparency and Accountability

The Board continues to monitor the Foundation's progress on transparency and accountability. We believe the Director has achieved great results to date in this effort, and we support continued vigilance in implementing her new approach. We review frequent status reports and per a Board resolution passed last year, NSF will provide the Board with a formal update during our May meeting.

Assessing the U.S. science and engineering enterprise

Access to high-quality data on STEM education and workforce and the associated thoughtful analyses of it provide enormous value for a wide range of constituencies. These data answer the question "How are we doing?" and are essential to decision-makers across government, business, and industry. The National Science Board and its Committee on Science and Engineering Indicators (SEI) together with NSF's National Center for Science and Engineering Statistics provide comprehensive, authoritative, and relevant data and analyses on the state of the U.S. S&E enterprise. .

SEI continues to spearhead efforts to make its signature report, the congressionally-mandated

Science and Engineering Indicators (Indicators) report, more useful, accessible, and timely. In 2016, the Board debuted a fully digital version of *Indicators*, giving users greater capability to explore and understand the data. The committee also made innovations to its *Indicators*-related resources, including a soon-to-be released interactive infographic that allows users to explore how the United States compares with other nations in S&E. In the coming weeks, the Board will debut the first of a series of short, policy “companion briefs” that draw on *Indicators* data to answer timely S&E policy questions. The Board will produce these briefs on a regular basis, and we look forward to Congress' input on S&E-related topics of particular interest.

Oversight of NEON

The National Science Board continues to monitor closely the status of the National Ecological Observatory Network. The Board carefully vetted the process NSF used to select a new management entity and has requested that NSF provide regular status reports on project progress over the next year. The Board is committed to good stewardship of taxpayer dollars, and is working with the Director to ensure project success, but is also prepared to make tough decisions should efforts to get the project back on track prove unsuccessful.

Implementation of National Academy of Public Administration Report Recommendations

The Board is working closely with the Director to take actions on the recommendations of the jointly commissioned National Academy of Public Administration report. As you heard during Dr. Buckius' testimony in February, the Foundation and the Board are taking the report and its findings seriously. We agree with the intent of all recommendations and are aggressively implementing action to meet those intents.

Conclusion

Just over 65 years ago, Dr. James Conant, the-then Chair of the newly formed National Science Board acknowledged that the creation of NSF was a bold new experiment, one that would require continued vision, patience, and sustained investment. As he wrote, “No one should expect to be able to assess in a short interval of time the value of the money spent on scientific investigations. Even in the field of applied science, research is in the nature of a long-term investment.” As I come to the conclusion of my second and final term on the Board, I am more convinced than ever that our long-term national investment in fundamental science is of profound importance to ensuring our future health, security, and prosperity. As we look toward FY17, the 65th anniversary of the first NSF grants, my Board colleagues and I would like to thank you for continuing to partner with us in pursuing the bold, but essential quest to advance the “endless frontier.”