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Official Written Testimony for Fiscal Year 2015

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Submitted to: United States Senate Committee on Appropriations

Testimony on: "Driving Innovation Through Federal Investments"

April 24, 2014

Summary: This written testimony is submitted on behalf of the Society for Industrial and Applied Mathematics (SIAM) to highlight the importance of federal investments in mathematics and scientific research. America faces an "innovation deficit," the widening gap between the actual level of federal government funding for research and what the investment needs to be if the U.S. is to remain the world's innovation leader. While SIAM recognizes the need for fiscal constraint and the necessity for America to live within our means, strategic federal investments in mathematics and scientific research drive economic success and job growth. Computational and applied mathematical sciences, the scientific disciplines that occupy SIAM members, are particularly critical to addressing U.S. competitiveness and security challenges across a broad array of fields: medicine, engineering, technology, biology, chemistry, computer science, and others. In addition, new techniques developed in mathematics and computing research often have direct application in industry. Modern life as we know it – from search engines like Google to the design of modern aircraft, from financial markets to medical imaging – would not be possible without the techniques developed by mathematicians and computational scientists. SIAM asks that you continue investing in critical agencies to support the projects and individuals that spur innovation, strengthen our technology and economic base, and train the next generation of mathematicians, scientists, and engineers. With this in mind, we ask that you support the National Science Foundation, Department of Energy's Office of Science, Department of Defense basic research, and the National Institutes of Health at the highest possible funding levels for FY 2015 and beyond.

Written Testimony

We are Dr. Irene Fonseca, President, and Dr. David Levermore, Vice President for Science Policy, of the Society for Industrial and Applied Mathematics (SIAM). On behalf of SIAM, we are submitting this written testimony for the record to the United States Senate Committee on Appropriations.

SIAM has approximately 14,000 members, including applied and computational mathematicians, computer scientists, numerical analysts, engineers, statisticians, and mathematics educators. They work in industrial and service organizations, universities, colleges, government agencies and laboratories all over the world. In addition, SIAM has over 500 institutional members—colleges, universities, corporations, and research organizations. Members come from many different disciplines, but have a

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common interest in applying mathematics in partnership with computational science towards solving real-world problems.

First, we would like to emphasize how much SIAM appreciates your Committee's continued recognition of the critical role of the National Science Foundation (NSF), Department of Energy (DOE) Office of Science, National Institutes of Health (NIH), and Department of Defense (DOD) basic research in supporting mathematics, science, and engineering, and enabling a strong U.S. economy, workforce, and society.

Today, we submit this testimony to highlight the importance of federal investments in NSF, DOE Office of Science, NIH, and DOD basic research in FY 2015 and beyond.

National Science Foundation

NSF provides essential federal support for applied mathematics and computational science, including more than 60 percent of all federal support for basic academic research in the mathematical sciences. Of particular importance to SIAM, NSF funding supports the development of new mathematical models and computational algorithms, which are critical to making substantial advances in such fields as neuroscience, energy technologies, genomics, analysis and control of risk, and nanotechnology. NSF also supports mathematics education at all levels, ensuring that the next generation of the U.S. workforce is appropriately trained to participate in cutting-edge technological sectors and that students are attracted to careers in mathematics and computing.

The main budgetary and programmatic components at NSF that support applied mathematics and computational science are the **Division of Mathematical Sciences** (DMS) in the Directorate for Mathematical and Physical Sciences (MPS), and **Division of Advanced Cyberinfrastructure** (ACI) in the Directorate for Computer and Information Science and Engineering (CISE).

DMS supports a broad array of activities in modeling, analysis, algorithms, and simulation that provide new ways of obtaining insight into the nature of complex phenomena, such as the power grid, software for military applications, the human body, and energy efficient building systems. Work in applied mathematics and computational science is critical to enabling effective use of the rapid advances in information technology and cyberinfrastructure. Programs in the NSF Division of Advanced Cyberinfrastructure (ACI) focus on providing research communities access to advanced computing capabilities to convert data to knowledge and increase understanding through computational simulation and prediction.

In light of these significant contributions, we urge you to provide DMS and ACI with the highest possible funding level to reverse the damaging cuts of recent years and enable critical mathematical research and investment in the computational resources and science needed to solve complex science and engineering problems.

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Department of Energy Office of Science

DOE was one of the first federal agencies to champion computational science as one of the three pillars of science, along with theory and experiment. SIAM deeply appreciates the Office of Science's support for mathematics, science, and engineering in enabling a strong U.S. economy, workforce, and society.

Our nation faces critical challenges in energy, including in energy efficiency, renewable energy, improved use of fossil fuels and nuclear energy, future energy sources, and reduced environmental impacts of energy production and use. The tools of mathematics and computational science (theory, modeling, and simulation) have emerged as a central element in designing new materials, predicting the impact of new systems and technologies, and better managing existing resources. For example, applied mathematics and computational science play a key role in predictive modeling and analysis to understand complex systems such as the energy grid, the dispersion of nuclear radiation after a disaster, and the Earth's climate system. Understanding complex systems helps mitigate these risks and facilitate the development of controls and strategies to make systems more efficient.

Extreme-scale computing, or exascale, will allow predictive modeling and simulation of complex systems far more comprehensively and accurately than is possible today. While achieving exascale computing has the potential to allow for revolutionary advances in many fields critical to solving our energy challenges, getting to exascale and realizing its benefits requires overcoming significant computing challenges, including in applied mathematics. Investments in mathematical modeling, algorithm research, and software development are essential to realizing the full benefits of this next generation of high performance computers and to transferring their capabilities to industry for broad economic benefit.

Activities within the **Office of Advanced Scientific Computing Research** (ASCR) play a key role in supporting research that begins to fulfill the needs described above. Particularly critical programs include: the Applied Mathematics program, the Scientific Discovery through Advanced Computing (SciDAC) program, and programs to maintain the pipeline of the mathematical workforce. SIAM urges Congress in FY 2015 to again restore the **Computational Sciences Graduate Fellowship** (CSGF) program, which trains doctoral students in areas of computational science that are central to the DOE mission. CSGF helps ensure the existence of an adequate supply of scientists and engineers with strong computational research experience and close ongoing ties to DOE to meet critical workforce needs. SIAM also endorses the proposed effort within the Office of Basic Energy Sciences (BES) to support computational materials research.

Department of Defense Basic Research

The Department of Defense (DOD) supports basic research essential to advancing national security and keeping our military the best-equipped and most effective in the world. Addressing complex military challenges – such as information warfare, terrorist networks, and weapons of mass destruction – requires understanding these complex systems, developing breakthrough technologies, and propelling innovation. DOD-funded basic research in mathematical and computational sciences plays a key role in overcoming these challenges through advancing modeling and simulation to understand and predict the behavior of these systems, developing techniques essential to designing new breakthrough DOD technologies, and providing new tools for managing DOD resources and controlling DOD logistics.

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Within DOD, the **Defense Advanced Research Projects Agency** (DARPA) invests in creating breakthrough technologies for national security through investments in high-risk, high-reward research. Previous DARPA investments in mathematics and scientific research have led to "game-changing" advances such as the internet and GPS. Current DARPA investments include projects to revolutionize our ability to interpret big data, understand and predict the behavior of complex networks, and analyze psychological signals to prevent and treat post-traumatic stress disorder, among many others.

Service Branch basic research is also critical to national security. For example, the **Air Force Office of Scientific Research** (AFOSR) supports basic science research in air, space, and cyber that profoundly impacts our national security capabilities. AFOSR investments in mathematics and computational sciences have led to key advances such as computational tools to design aircraft, new abilities to automatically detect targets on radar, and algorithms critical for space communication.

SIAM is deeply concerned about the proposed cuts to basic research in the President's budget request and urges Congress to restore basic research funding to the highest possible levels for FY 2015 and beyond.

National Institutes of Health (NIH)

SIAM supports sustained funding growth for the National Institutes of Health and applauds the growing investment at NIH in big data and computational training, as well as interdisciplinary research that couples the biomedical sciences with the mathematical, physical, and information sciences to further our understanding and advance the treatment of illnesses such as cancer and infectious disease.

The interface between the life sciences and physical sciences, mathematics, and engineering is increasingly important to advancing health, increasing our understanding of human biology, and promoting innovation. Systemic diseases such as cancer are challenging because they involve processes from the genome level to molecular networks inside a single cell, the tissue level and, finally, the entire person, all of which react to the external environment in a coherent fashion. In order to understand and treat these diseases, new approaches to information analysis, data, and modeling are needed to unify our understanding at each of these scales and their interactions. Developing better modeling, computational, statistical, and analytical tools to enable a better understanding of biological systems is integral to the NIH mission. SIAM supports sustained funding growth for the National Institutes of Health to address these challenges and promote health and innovation.

Conclusion

We would like to conclude by thanking you again for your ongoing support of NSF, the DOE Office of Science, NIH, and DOD basic research that enables the research and education communities to advance innovation and contribute to the health, security, and economic strength of the U.S. We need sustained annual funding to maintain our competitive edge in science and technology, and therefore we respectfully ask that you continue robust support of these critical agencies and programs.

We thank you for holding this hearing and for the opportunity to submit this testimony.