Mathematical Sciences in the FY 2005 Budget

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Highlights

- Federal support for the mathematical sciences is slated to grow from an estimated $362.41 million in FY 2004 to an estimated $374.45 million in FY 2005, an increase of 3.3 percent. This rate of increase is less than half of the rate of increase from FY 2003 to FY 2004.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would receive only a 0.9 percent increase, for a total of $202.25 million in FY 2005 compared to an estimated $200.41 million in FY 2004.
- The Defense Advanced Research Projects Agency (DARPA), a Department of Defense (DOD) agency, would grow by 7.0 percent, while the Army Research Office (ARO) mathematical sciences budget would increase by 5.3 percent. The National Security Agency (NSA) budget, although small compared to other DOD agencies, would grow by 16.7 percent.
- The Department of Energy (DOE) Applied Mathematics Division would receive a 29.6 percent increase, the largest percentage jump of all the agency budgets for the mathematical sciences.

Introduction

The mathematical sciences are funded through the National Science Foundation; the Department of Defense, including the National Security Agency; the Department of Energy; and the National Institutes of Health (NIH). In 2005 the majority of support for the mathematical sciences from all these agencies would come from the NSF, contributing 54.0 percent of the total. The DOD accounts for 21.3 percent of the total, with the NIH supplying 16.9 percent, and the DOE 7.8 percent. The NSF accounts for the majority of the support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to the research and development missions of these agencies.

The DOD has five programs supporting mathematical sciences research and related activities: the Directorate of Mathematics and Space Sciences within the Air Force Office of Scientific Research (AFOSR); the Mathematical Sciences Division within the Army Research Office; the Mathematical, Computer, and Information Sciences Division within the Office of Naval Research (ONR); the Applied and Computational Mathematics Program within the Defense Advanced Research Projects Agency; and the Mathematical Sciences Program within the National Security Agency.

The DOE funds mathematics through its Applied Mathematics program within the DOE Mathematical, Computational, and Computer Sciences Research program. The National Institutes of Health funds mathematical sciences research primarily through the National Institute of General Medical Sciences (NIGMS) and through the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

Several other agencies have small amounts of funding for mathematics research as it relates to agency missions. These agencies include the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and the National Institute of Standards and Technology (NIST).

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Trends in Federal Support for the Mathematical Sciences

The FY 2005 estimated aggregate spending for mathematical sciences research and related activities would be $374.45 million, a potential increase of 3.3 percent over FY 2004 estimated spending. The increase for the NSF would be the lowest in several years, severely impacting the overall federal support for the mathematical sciences. The increase at the DOE for FY 2005 would be a healthy 29.6 percent increase over the FY 2004 level. Other pleasant surprises would be the 7.0 percent increase at DARPA, the 5.3 percent increase at the ARO, and the 16.7 percent increase at the NSA.

In recent years, the NIH has increased support of the mathematical sciences. This is not surprising given the many areas where the mathematical sciences contribute to advances in biomedical research. This trend of contributing to research in the biomedical sciences—and to the biological sciences in general, for that matter—will be sustained in the future.

The mathematical sciences are making major contributions to the country's intellectual capacity, and the need for the mathematical sciences in scientific discovery and technological innovation is accelerating. Yet many mathematical scientists who perform excellent research and submit grant proposals deemed of very high quality are either not funded or are underfunded. According to the *Science and Engineering Indicators*, 2002 Edition, only 28.3 percent of full-time academic mathematicians receive federal research support. This is much lower than most other fields of science.

National Science Foundation (NSF)

For FY 2005 the mathematical sciences would continue to be an NSF-wide priority area. The foundation has budgeted $89.11 million to carry out the priority area activities in FY 2005, with $67.39 million of this amount coming from the DMS and the remaining $21.72 million coming from throughout the foundation. The NSF-wide allocation depends on cooperative funding opportunities with other NSF directorates and requires matching funds from the DMS. The mathematical sciences were first designated an NSF priority area in FY 2002, and currently this designation is planned to go through FY 2007. In FY 2006 the priority area is projected to receive approximately $90 million, and in FY 2007 approximately $92 million.

The DMS is slated to receive a budget of $202.25 million in FY 2005, only a 0.9 percent or $1.84 million increase over the FY 2004 level. This low increase is quite surprising given that the mathematical sciences are a priority area and given that advances in science and engineering rely more than ever on the mathematical sciences.

The FY 2005 increase in the DMS would:

- Maintain the investment in focused mathematical sciences research teams, interdisciplinary training groups, and other collaborative mechanisms related to advancing science and engineering.
- Enhance the national institutes in the mathematical sciences that address the growing interface with other disciplines and the mathematical and statistical problems whose solutions will contribute to both fundamental knowledge and national needs. In FY 2005 support for mathematical sciences research institutes would increase by $1.5 million over FY2004, rising from a total of $15.1 million to a total of $16.6 million.
- Enhance research training activities in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. This would be achieved by a redistribution of funds from other targeted investments in people.

Air Force Office of Scientific Research (AFOSR)

The Directorate of Mathematics and Space Sciences provides funds for research in the mathematical sciences in support of the Air Force mission. Current program emphases include cooperative control, quantum computing, and Maxwell's equations. Beginning perhaps as early as FY 2005, a new initiative in nanoscience is anticipated. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, systems and software, electromagnetics, and signals communication and surveillance. The AFOSR budget would increase slightly over FY 2004.

Army Research Office (ARO)

The Mathematical Sciences Division is divided into the following programs: applied analysis, computational mathematics, discrete mathematics and computer science, probability and statistics and stochastic analysis, and mathematical modeling and simulation. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and systems that are of critical interest to the army. The areas of application include ad hoc and wireless networks, image and scene analysis, and the testing and evaluation of new systems. The FY 2005 budget would increase by 5.3 percent over FY 2004.

Defense Advanced Research Projects Agency (DARPA)

DARPA's Applied and Computational Mathematics program activities are structured around two interrelated central themes: development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data and mathematical modeling to enable virtual design. These themes are addressed through the six program areas: Integrated Sensing and Processing,

Table 1. Federal Funding for the Mathematical Sciences (millions of dollars)[1]

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change 2004–05 Amount	Change 2004–05 Percent
National Science Foundation					
DMS	$178.79	$200.41*	$202.25	$1.84	0.9%
Department of Defense					
AFOSR	$ 32.5	$ 30.0	$ 30.9	$0.9	3.0%
ARO	9.9	9.5	10.0	0.5	5.3
DARPA	16.3	21.5	23.0	1.5	7.0
NSA	3.0	3.0	3.5	0.5	16.7
ONR	10.5	12.5	12.4	0.1	-0.8
Total DOD	$ 72.2	$ 76.5	$ 79.8	$ 3.3	4.3%
Department of Energy					
Applied Mathematics	$ 21.3	$ 22.6	$ 29.3	$ 6.7	29.6%
National Institutes of Health					
NIGMS	$ 35.0**	$ 35.0**	$ 35.0**	$ 0.0	0.0%
NIBIB	27.0**	27.9**	28.1**	0.2	0.7
Total NIH	$ 62.0	$ 62.9	$ 63.1	$ 0.2	0.3%
Total All Agencies	$334.29	$362.41	$374.45	$12.04	3.3%

**This figure is estimated based on language in the FY 2004 Omnibus Appropriations Bill.*

***Estimates based on conversation with program manager. The NIGMS FY 2005 number is the author's best guess based on a conversation with an NIGMS representative last year.*

[1]Budget information comes from agency documents and conversations with agency program managers and representatives. DOD FY 2004 and FY 2005 numbers are estimates.

Time-Reversal Methods, Predicting Real Optimized Materials, Quantum Information Science and Technology, Geospatial Representation and Analysis, and Virtual Electromagnetic and Testrange. Additionally, DARPA has core mathematics activities supporting work in geometric Langlands and stochastic partial differential equations. The FY 2005 budget for the mathematical sciences would increase by 7.0 percent over FY 2004.

Department of Energy (DOE)

Mathematics is funded through the Applied Mathematics program of the Mathematical, Information, and Computational Sciences Division (MICS) of the DOE. Research is conducted on the underlying mathematical understanding of physical, chemical, and biological systems and advanced numerical algorithms that enable effective description and prediction of such systems on terascale computing systems. Research in applied mathematics supported by the MICS underpins computational science throughout the DOE. The FY 2005 budget for the Applied Mathematics Program continues the Computational Sciences Fellowship program at its current level of $3.5 million. The FY 2005 budget also includes $8.5 million for the new Atomic to Macroscopic Mathematics (AMM) research effort to provide the research support in applied mathematics needed for understanding complex physical processes that occur on a wide range of interacting length- and time-scales. Current state-of-the-art theory and modeling of complex physical systems require that the physical phenomena being modeled either occur at a single scale or widely separated scales with little or no interaction. The AMM effort will support university researchers, partnerships between universities and national laboratories, and multidisciplinary research teams at national laboratories. The Applied Mathematics Program FY 2005 budget would increase by $6.7 million over FY 2004.

National Institutes of Health (NIH)

The NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB). Currently the NIGMS is supporting a biomathematics initiative in cooperation with the National Science Foundation. Mathematical sciences areas of interest are those that support the missions of the NIGMS and the NIBIB. These mission areas include population biology, system biology, macromolecular structures, and bioinformatics for the NIGMS; and computational science, model development, and bioinformatics for the NIBIB. Computational science includes development and application of theoretical methods, mathematical

modeling, and computational simulation techniques in the study of biological systems. Bioinformatics includes research, development, and applications of informatics tools and approaches for expanding the use of biological, medical, behavioral, or health data, including those to acquire, store, organize, archive, analyze, or visualize data. The FY 2005 NIH budget supporting the mathematical sciences would grow slightly over FY 2004.

National Security Agency (NSA)

The NSA has a small grant program that supports fundamental research in the mathematical areas of algebra, number theory, discrete mathematics, probability, and statistics. The grant program also accepts proposals for miscellaneous conferences and workshops in these research areas. Additional funding is available to support Historically Black Colleges and Universities, Research Experiences for Undergraduates, and a faculty sabbatical leave program. The program administrators are especially interested in funding initiatives that encourage the participation of underrepresented groups in mathematics (such as women, African Americans, and other minorities). The NSA is the world's largest employer of mathematicians and is constrained to hire only U.S. citizens. As a result, the NSA has a special interest in encouraging more U.S. citizens to study mathematics. The FY 2005 NSA budget would increase by 16.7 percent over FY 2004.

Office of Naval Research (ONR)

The ONR Mathematical, Computer, and Information Sciences Division's scientific objective is to establish rigorous mathematical foundations and analytical and computational methods that enhance understanding of complex phenomena and enable prediction and control for naval applications in the future. Basic research in the mathematical sciences is focused on analysis and computation for multiphase, multimaterial, multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and imaging processing; modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; and formal methods for verifiably correct software construction. The Mathematical, Computer, and Information Sciences Division's budget would decrease in FY 2005.

Note: Information gathered from agency documents and from agency representatives.