Mathematical Sciences in the FY 2004 Budget

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Highlights

- Federal support for the mathematical sciences is slated to grow from an estimated $340.35 million in fiscal year (FY) 2003 to an estimated $365.97 million in FY 2004, an increase of 7.7%.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would receive a 13.1% increase, for a total of $201.87 million in FY 2004 compared to an estimated $178.45 million in FY 2003.
- The Applied and Computational Mathematics program of the Defense Advanced Research Projects Agency (DARPA), a Department of Defense (DOD) agency, would grow by 15.3%. Other major DOD mathematical science programs are not growing.

Introduction

Three federal agencies supply the majority of support for mathematical sciences research through seven dedicated programs in the National Science Foundation (NSF), the Department of Defense (DOD), and the Department of Energy (DOE). 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 and DOE support research in the mathematical sciences that contributes to the research and development missions of these agencies. Research supported through these programs is primarily carried out in academic institutions.

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 (ARO); the Mathematical, Computer, and Information Sciences Division within

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the Office of Naval Research (ONR); the Applied and Computational Mathematics Program within the Defense Advanced Research Projects Agency (DARPA); and the Mathematical Sciences Program within the National Security Agency (NSA). The DOE funds mathematics through its Applied Mathematics program within the DOE Mathematical, Computational, and Computer Sciences Research program.

The National Institutes of Health (NIH) also funds mathematical sciences research. Funds are administered through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB) for research in the mathematical sciences that support their missions.

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).

Trends in Federal Support for the Mathematical Sciences

FY 2004 aggregate spending for mathematical research and related activities is estimated to be $342.87 million, a potential increase of 7.7% over FY 2003 estimated spending. Most of this increase is a result of the 13.1% increase proposed by the NSF. Except for DARPA, DOD agencies have had very little increase in funding levels over the last several years, and after adjusting for inflation these programs have decreased in real terms. The DOE projects no increase for FY 2004 over FY 2003.

The NSF is continuing to shoulder a significant portion of the federal support for research in the mathematical sciences, especially in academia, where the NSF provides 68% of the support. The mathematical sciences budget within the NSF is growing at a much faster rate than the mathematical sciences budgets at other agencies. In fact, budgets for the mathematical sciences in the DOD and DOE are barely increasing, if at all. At the same time that growth in the DOD and DOE budgets is stagnating, the fundamental contributions of the

mathematical sciences to advances in science and technology continue to increase.

National Science Foundation

For FY 2004 the mathematical sciences continue to be an NSF-wide priority area. The foundation has requested $89.09 million to carry out the priority area activities in FY 2004, with $67.39 million of this amount in the DMS and the remaining $21.7 million provided throughout the rest of the foundation. The NSF first requested that the mathematical sciences be designated as a priority area in FY 2002.

The DMS is slated to receive a budget of $201.87 million in FY 2004. This would be a $23.42 million increase over the $178.45 million (approximate, based on FY 2003 appropriations language) the division is to receive for FY 2003.

The goal of the mathematical sciences priority area is to advance frontiers in three interlinked areas. For FY 2004 the NSF plans to invest in the following mathematical sciences activities: fundamental mathematics and statistical sciences, interdisciplinary research connecting the mathematical sciences with science and engineering, and mathematical sciences education.

Fundamental mathematical and statistical sciences research includes themes such as dynamical systems and partial differential equations, geometry and topology, stochasticity, number theory, algebraic and quantum structures, the mathematics of computation, Bayesian estimation, and multiscale and multiresolution analysis. Support for research in these areas will be provided through focused research groups and individual investigator grants, as well as through institute and post-doctoral training activities.

Three broad interdisciplinary themes have been identified for initial emphasis in the mathematical sciences priority area: mathematical and statistical challenges posed by large data sets, managing and modeling uncertainty, and modeling complex non-linear systems. Research in these areas will be supported through interdisciplinary focused research groups, interdisciplinary centers, interdisciplinary cross-training programs, and partnership activities with other agencies.

The mathematical sciences education activity will foster closer connections between research and education. Support for undergraduate and graduate education and postdoctoral training, coupled with curriculum reform, is a major part of the mathematical sciences education activity.

Air Force Office of Scientific Research (AFOSR)

The Directorate of Mathematics and Space Sciences provides funds for research and related activities in the mathematical sciences in support of the Air Force mission. Current program emphases include cooperative control, quantum computing, and Maxwell's equations. The AFOSR program includes dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, electromagnetics, and signals communication and surveillance. The AFOSR budget shows a decrease under the administration's budget proposal.

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 ARO budget shows a modest increase over FY 2003.

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 four program areas: Integrated Sensing and Processing; Molecular Observation, Spectroscopy and Imaging Using Cantilevers; Optimal Portable Applications Libraries; Quantum Information Science and Technology; and Virtual Electromagnetic and Testrange. The FY 2004 budget for the mathematical sciences would increase by 15.3% over FY 2003.

Department of Energy

Mathematics is funded through the Applied Mathematics program of the Mathematical, Information, and Computational Sciences Division (MICS) of DOE. Research is conducted on the underlying mathematical understanding of physical, chemical, and biological systems and on advanced numerical algorithms that enable effective description and prediction of such systems on terascale computing systems. Research in applied mathematics supported by MICS underpins computational science throughout the DOE. For FY 2003 and FY 2004 the budget of the Applied Mathematics program includes $5 million each year for two "thrust" areas: Genomes to Life (computational biology) and Nanoscience. The Genomes to Life activity is a partnership with the Office of Biological and Environmental Research; the nanoscience activity is a partnership with the Office of Basic Energy Sciences. The Applied Mathematics Programs budget would not increase in 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 NIGMS is supporting a biomathematics initiative in cooperation with the NSF. Mathematical sciences areas of interest are those that support the missions of NIGMS and NIBIB. These mission areas include population biology, system biology, macromolecular structures, and bioinformatics for NIGMS; and computational science, model development, and bioinformatics for 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.

National Security Agency (NSA)
The NSA has a small grants program that supports fundamental research in the mathematical areas of algebra, number theory, discrete mathematics, and probability and statistics. Other funds are available to support Historically Black Colleges and Universities, Research Experiences for Undergraduates, and a sabbatical leave program for university faculty. As the world's largest employer of mathematicians and constrained to hire only U.S. citizens, the NSA has a special interest in encouraging more U.S. citizens to study mathematics.

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; sequencing and scheduling; and construction of complex system software. The Mathematical, Computer, and Information Sciences Division's budget would be level in FY 2004.

Note: Information gathered from agency documents and from agency program officers.

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

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Request	Change 2003–2004 Amount	Change 2003–2004 Percent
National Science Foundation					
DMS	$151.53	$178.45*	$201.87	$23.42	13.1%
Department of Defense					
AFOSR	$ 32.70	$ 32.50	$ 30.20	$ -2.30	-7.1%
ARO	9.30	9.70	10.20	0.50	5.2
DARPA	16.30	19.60	22.60	3.00	15.3
NSA	2.30	3.00	3.00	0.00	0.0
ONR	12.20	11.00	11.00	0.00	0.0
Total DOD	$ 72.80	$ 75.80	$ 77.00	$ 1.20	1.6%
Department of Energy					
Applied Mathematics	$ 23.00	$ 29.00	$ 29.00	$ 0.00	0.0%
National Institutes of Health					
NIGMS	$ 35.00**	$ 35.00**	$ 35.00**	$ 0.00	0.0%
NIBIB	17.40**	22.10**	23.10**	1.00	4.5%
Total NIH	$ 52.40	$ 57.10	$ 58.10	$ 1.00	1.8%
Total All Agencies	$299.73	$340.35	$365.97	$24.62	7.5%

*This figure is estimated based on language in the FY 2003 Omnibus Appropriations Bill.

**Rough estimate based on conversation with program manager.

[1]Budget information comes from agency documents and conversations with program managers. DOD FY 2003 and FY 2004 numbers are estimates.