

# Mathematical Sciences in the FY 2003 Budget

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## Highlights

- Federal support for the mathematical sciences is slated to grow from an estimated \$282.9 million in FY 2002 to an estimated \$326.204 million in FY 2003, an increase of 15.3 percent.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would receive a 20.1 percent increase for a total of \$181.87 million in FY 2003 compared to \$151.48 million in FY 2002.
- The mathematics program at the Defense Advanced Research Projects Agency (DARPA), a Department of Defense (DOD) agency, would grow by 33.2 percent. Other major DOD mathematics programs would decline after factoring in inflation.
- The Department of Energy's (DOE) applied mathematics program FY 2003 budget would increase by 13.2 percent over FY 2002.

## Introduction

The National Science Foundation (NSF), the Department of Defense (DOD), and the Department of Energy (DOE) together supply the majority of federal support for mathematical sciences research. The NSF accounts for approximately 70 percent of the academic research support for 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.

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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 and Computer Sciences Division within the Army Research Office (ARO); 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 (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.

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

## Trends in Federal Support for the Mathematical Sciences

The FY 2003 estimated aggregate spending for mathematical research and related activities is \$326.2 million, a potential increase of 15.3 percent over FY 2002 estimated spending. Most of this increase is a result of the 20.1 percent increase proposed for the Division of Mathematical Sciences at the NSF. The DOD agencies have had very little increase in funding levels the last several years, and after adjusting for inflation most DOD programs have decreased in real terms. The increase at DOE for FY 2003 is a healthy 13.2 percent increase over the FY 2002 level.

The NSF is shouldering a significant portion of federally supported academic research in the mathematical sciences, approximately 70 percent. Just a few years ago the NSF portion was in the 50 percent range. This change has come about because of significant increases in the NSF budget while the

budgets of the other agencies have decreased or stayed constant. Recently the contributions that the mathematical sciences make to advances in science and technology have gained more recognition. Hopefully this will result in adequate funding for mathematical sciences research in the future.

#### **National Science Foundation**

For FY 2003 NSF has proposed the mathematical sciences as a Foundation-wide priority area and has requested \$60.09 million to carry out the priority area activities. The NSF first requested that the mathematical sciences be designated as a priority area in FY 2002 and added \$30 million for the priority area to the Division of Mathematical Sciences (DMS) budget. The FY 2003 budget request adds another \$30.09 million across the Foundation for a total of \$60.09 million for this priority area. The amount of money requested within DMS for the mathematical sciences priority area is \$47.39 million, while the remaining \$12.7 million of the \$60.09 million total is spread throughout the rest of the NSF.

According to the FY 2003 budget request, the DMS would receive an increase of \$30.39 million for a total of \$181.87 million compared to the FY 2002 level of \$151.48 million. Of the \$30.39 million increase, \$17.39 million is for activities supporting the goals of the NSF-wide mathematical sciences priority area. The remaining \$13 million of the increase is for DMS investments beyond the priority area.

Three goals emerge from the designation of the mathematical sciences as a priority area: fundamental research in the mathematical and statistical sciences, integration of mathematics and statistics research across the full range of science and engineering, and mathematical sciences education. Scientific areas of special interest addressing the second goal are management of large data sets, modeling of uncertainty, and modeling and prediction of complex nonlinear systems.

Mathematics is central to advances in science and technology, so the agency plans to place emphasis on building partnerships with other disciplines. This would be done by establishing collaborations through other NSF divisions and directorates and through other federal agencies. Collaborative projects receive support through the mathematical sciences and from the participating NSF divisions or agencies. Several collaborative efforts began in FY 2002 and include partnerships with the NSF Directorates of Computer and Information Sciences and Engineering (CISE) and Geosciences (GEO), with the National Institute of General Medical Sciences (NIGMS) of the NIH, and with DARPA.

The DMS has several established programs that will facilitate the implementation of the goals of the mathematical sciences priority area. Targeted educational activities can be carried out through the

Vertical Integration of Research and Education (VIGRE) program, the Research Experiences for Undergraduates (REU) program, and by supplements to existing grants. The Focused Research Group (FRG) program would be used to facilitate interdisciplinary interactions as well as to continue to enhance mathematical research through the support of groups of mathematicians working on a problem or on a set of problems.

In FY 2003 the DMS would fund up to seven mathematical sciences institutes. Currently three institutes are supported. Up to four additional institutes will be awarded seed money in FY 2002 with full funding slated to begin in FY 2003. There are no plans to have an institute solicitation in FY 2003; the three current institutes will be reviewed when their current five-year awards expire and can receive, upon satisfactory review, a second five-year award.

The DMS would use some of the additional funds to increase size and duration of grants. The average size of DMS grants is among the smallest in the NSF, and the National Science Board has supported increased grant size and duration in order to support research adequately based on the needs of the science and engineering enterprise.

#### **Air Force Office of Scientific Research (AFOSR)**

The Directorate of Mathematics and Space Sciences of AFOSR 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 and Computer Sciences Division of ARO continues to be application driven. Specific areas of interest are modeling and simulation of the environment, discrete mathematics, computational mathematics, stochastic analysis, and mathematics related to materials science. Mathematics, which contributes to the advancement of the cognitive sciences and to the biological sciences, is a new interest. The ARO mathematical sciences budget has not increased in two years.

#### **Defense Advanced Research Projects Agency (DARPA)**

For FY 2003 the Applied and Computational Mathematics Program at DARPA plans to emphasize the areas of computational geometry and topology, particularly as applied to representation and analysis of geospatial data; modeling and control of quantum systems; applied and computational

harmonic analysis, especially in connection with waveform design for active sensing and with representation of gravitational data; optimization of integrated sensing and processing systems; and numerical analysis, particularly applied to electromagnetic scattering problems. The FY 2003 budget for the mathematical sciences would increase by 33.2 percent over FY 2002.

**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. The NSA is the world's largest employer of mathematicians. Because it is 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 scientific objective of ONR's Mathematical, Computer, and Information Sciences Division 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 division's budget has experienced very little growth in recent years.

**Department of Energy**

Mathematics is funded through the Applied Mathematics program of the Mathematical, Information, and Computational Sciences Division of DOE. Research is conducted on the underlying mathematical understanding and numerical algorithms to enable effective description and prediction of physical systems. The president's proposed FY 2003 budget includes an increased level of funding for the Computational Sciences Graduate Fellowship program and funding for developing the mathematical understanding and techniques needed for a partnership with the DOE Biological and Environmental Research Program. This research would offer ways to solve environmental challenges related to DOE's missions, including toxic waste cleanup, new clean energy sources, and global climate stabilization through carbon sequestration. The FY 2003 budget for the Applied Mathematics program would grow by 13.2 percent over FY 2002.

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

**Federal Funding for the Mathematical Sciences (millions of dollars) \***

	FY 2001 Actual	FY 2002 Estimate	FY 2003 Request	Change 2002-2003 Amount	Change 2002-2003 Percent
National Science Foundation					
DMS	\$121.441	\$151.48	\$181.87	\$30.39	20.1%
Department of Defense**					
AFOSR	32.7	32.6	32.5	-0.1	-0.3%
ARO	26.4	26.4	26.4	0.0	0.0%
DARPA	16.3	25.0	33.3	8.3	33.2%
NSA	1.7	2.25	2.5	0.25	11.0%
ONR	12.5	13.2	13.4	0.2	1.5%
Total DOD	89.6	99.45	108.1	8.65	8.7%
Department of Energy					
Applied Mathematics	27.11	32.0	36.234	4.234	13.2%
Total All Agencies	238.151	282.93	326.204	43.274	15.3%

\*Budget information comes from agency documents and conversations with program managers.

\*\*Budgets are estimates for FY 2002 and FY 2003; DARPA amount assumes approval of Geosciences initiative.