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Mathematical Sciences in the FY 2009 Budget

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HIGHLIGHTS

- Federal support for the mathematical sciences is slated to grow from an estimated $477 million in FY 2008 to an estimated $528 million in FY 2009, an increase of 10.7 percent.

- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would increase by 16.0 percent to $245.70 million.

- The aggregate funding for the mathematical sciences in the Department of Defense (DOD) agencies Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Defense Advanced Research Projects Agency (DARPA), National Security Agency (NSA), and Office of Naval Research (ONR) would increase by 9.5 percent.

- Aggregate funding for the mathematical sciences in the Department of Energy (DOE) would increase by 9.4 percent to $95.3 million.

INTRODUCTION

Research in the mathematical sciences is funded primarily 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). As in previous years, the majority of federal support for the mathematical sciences in FY 2009 would come from NSF, contributing approximately 46.5 percent of the federal total. DOD accounts for around 19.7 percent of the total, with NIH supplying 15.7 percent, and DOE around 18.0 percent. NSF currently accounts for nearly 70 percent of the federal support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. DOD, DOE, and NIH support research

in the mathematical sciences that contributes to the missions of these agencies.

The DOD supports mathematical sciences research and related activities in several programs: the Directorates of Mathematics, Information, and Life Sciences and Physics and Electronics, within the AFOSR; the Mathematical and Information Sciences Division within the ARO; the Mathematics, Computers, and Information Sciences Research Division within the ONR; the Defense Sciences Program and the Microsystems Technology Office within DARPA; and the Mathematical Sciences Program within the NSA.

The DOE funds mathematics through its Applied Mathematics and Scientific Discovery through Advanced Computing (SciDAC) programs within the DOE Office of Advanced Scientific Computing Research. 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).

TRENDS IN FEDERAL SUPPORT FOR THE MATHEMATICAL SCIENCES

The FY 2009 estimated aggregate spending for mathematical sciences research and related activities would be $528.10 million, a potential increase of 10.7 percent over FY 2008 estimated spending (see Table 1). The NSF Division of Mathematical Sciences budget would increase by 16.0 percent in FY 2009, while the DOD agencies would increase by 9.5 percent for FY 2009. AFOSR would increase its mathematical sciences spending by 24.2 percent while the ARO mathematics budget decreases by 2.5 percent. The mathematical sciences budgets of the remaining DOD agencies would not grow in FY 2009. The DOE mathematical sciences budget increases by 9.4 percent while NIH funding is flat.

The mathematical sciences make major contributions to the country's intellectual capacity and are enabling technologies, which provide the tools, insight, and capability needed for innovation and technological progress. Many disciplines depend on discoveries in the mathematical sciences to open up new frontiers and advance discovery. Even so, many mathematical scientists who are performing excellent research and who submit grant proposals deemed of very high quality, are consistently either not funded or are under funded. According to the *Science and*

Engineering Indicators, 2008 Edition, in FY 2006 only 34.6 percent of full-time mathematics faculty having doctoral degrees received federal research support. This is much lower than most other fields of science.

Table 1: Federal Funding for the Mathematical Sciences (millions of dollars) #

	FY 07 Actual	FY 08 Estimate	FY 09 Request	Change 08-09 Amount	Change 08-09 Percent
National Science Foundation					
DMS	205.74	211.79	245.70	33.91	16.0%
Department of Defense					
AFOSR	34.9	38.4	47.7	9.3	24.2%
ARO	14.0	12.0	11.7	-0.3	-2.5%
DARPA*	18.0	27.0	27.0	0.0	0.0%
NSA	4.0	4.0	4.0	0.0	0.0%
ONR *	13.6	13.6	13.6	0.0	0.0%
Total DOD	84.5	95.0	104.0	9.0	9.5%
Department of Energy					
Applied Mathematics	32.8	36.9	43.2	6.3	17.1%
SciDAC **	41.7	50.2	52.1	1.9	3.8%
Total DOE	74.5	87.1	95.3	8.2	9.4%
National Institutes of Health					
NIGMS*	45.0	45.0	45.0	0.0	0.0%
NIBIB*	38.1	38.1	38.4	0.0	0.0%
Total NIH	83.1	83.1	83.1	0.0	0.0%
Total All Agencies	447.84	476.99	528.10	51.11	10.7%

Budget information is derived from agency documents and conversations with agency program managers and representatives.
* Estimates
** Scientific Discovery through Advanced Computing (SciDAC)

National Science Foundation (NSF): The Division of Mathematical Sciences (DMS)[1] is housed in the NSF Directorate of the Mathematical and Physical Sciences (MPS). This directorate also contains the Divisions of Astronomical Sciences, Chemistry, Materials Research,

[1] http://www.nsf.gov/div/index.jsp?div=DMS

Physics, and Multidisciplinary Activities. The DMS supports advances in the intellectual frontiers of the mathematical sciences and enables the advance of knowledge in other scientific and engineering fields.

The DMS has essentially two modes of support: research and education grants, and institutes. Grants include individual-investigator awards; awards for multidisciplinary groups of researchers; and educational and training awards aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. The DMS provides core support for five mathematical sciences research institutes, as well as major support for three other institutes. These institutes, funded on a competitive basis, serve to develop new ideas and directions in the mathematical sciences, as well as to promote interaction with other disciplines.

In FY 2009, approximately 61 percent of the DMS budget will be available for new research awards, with the remainder going to continuing commitments from previous years. The DMS FY 2009 priorities are fundamental mathematical and statistical science, including activities that strengthen the core of the discipline and enable effective partnering with other science and engineering disciplines; and interdisciplinary research and education, including key components of the American Competitiveness Initiative (ACI) where the mathematical sciences play a critical role in discovery for competitiveness and innovation. These ACI components are the NSF-wide initiatives of Cyber-enabled Discovery and Innovation (CDI), Science Beyond Moore's Law, and Adaptive Systems Technologies; and MPS initiatives in Quantum Information Sciences, MPS-Life Sciences Interface, and ACI Fellows.

The ACI Fellows program aims to improve the freshman and sophomore experience in mathematics through involvement in interdisciplinary, discovery-based activities. The program hopes to help increase the number of undergraduate mathematics, science, and engineering majors. The goal of the MPS-Life Sciences Interface is to promote the emergence of biology as a quantitative science and encourage bio-technological innovation. Adaptive Systems Technologies will focus on innovation in areas such as robotics, sensor systems, specialized materials, and assistive devices. Quantum Information Sciences (QIS) involves research on quantum computing and communications, including the understanding and implementation of algorithms for QIS.

The DMS is slated to receive a budget of $245.70 million in FY 2009, an increase of $33.91 million or 16.0 percent over the FY 2008 budget estimate. The $33.91 million is broken down as follows: $20.81 million increase for core programs; $5.20 million increase for Cyber-enabled Discovery and Innovation (CDI); $1.75 million for Science Beyond Moore's Law; $2.0 million for Quantum Information Sciences; $1.0 million for MPS-Life Sciences Interface; $0.50 million for Adaptive Systems Technologies; $2.0 million for ACI Fellows; and a $2.0 million increase for early careers investigators.

Air Force Office of Scientific Research (AFOSR): Funding for the mathematical sciences at AFOSR is found in the Directorate of Mathematics, Information, and Life Sciences and the Directorate of Physics and Electronics. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, electromagnetics, and sensing, surveillance, and navigation.[2] The AFOSR FY 2009 budget for the mathematical sciences would increase by 24.2 percent over FY 2008.

Army Research Office (ARO): The Mathematics Program, housed in the Mathematical and Information Sciences Division,[3] manages the following programs: modeling of complex systems; computational mathematics; discrete mathematics and computer science; probability and statistics and stochastic analysis; and cooperative systems. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and large-scale systems which are of critical interest to the Army. The areas of application include communication networks, image analysis, visualization and synthetic environments, pattern recognition, test and evaluation of new systems, sensor networks, network science, robotics, and autonomous systems. The division also works closely with the Computer and Information Sciences Division of ARO to develop mathematical theory for systems control, information processing, information assurance, network design, and data fusion. The ARO budget for the mathematical

[2] For additional information on the focus areas within each these portfolios, please refer to the Broad Area Announcement 2008-1 which can be viewed on the AFOSR public website at http://www.afosr.af.mil

[3] http://www.arl.army.mil/main/main/default.cfm?Action=29&Page=194

sciences would decrease by 2.5 percent from FY 2008.

Defense Advanced Research Projects Agency (DARPA): The Defense Sciences Office (DSO) and the Microsystems Technology Office (MTO) inside DARPA both have mathematics programs cutting across mathematics and its applications. Current program areas include: Analog-to-Information, Cognitively Augmented Design for Quantum Technology, Discovery and Exploitation of Structure in Algorithms, Femtosecond Adaptive Spectroscopy Techniques for Remote Agent Detection, Focus Areas in Theoretical Mathematics, Fundamental Laws of Biology, Mathematical Time Reversal, Multiple Optical Non-redundant Aperture Generalized Sensors, Non-Linear Mathematics for Mixed Signal Microsystems, Predicting Real Optimized Materials, Protein Design Processes, Robust Uncertainty Management, Sensor Topology and Minimal Planning, Space-Time Adaptive Processing, and Topological Data Analysis. DARPA has also announced an open BAA on 23 Mathematical Challenges.[4] Aggregate funding for the mathematical sciences is unchanged from FY 2008.

Department of Energy (DOE): Mathematics at DOE is funded through the Office of Advanced Scientific Computing Research (ASCR),[5] one of six interdisciplinary research offices within DOE's Office of Science. Research supported by ASCR underpins computational science throughout DOE. ASCR funding for the mathematical sciences is found primarily in the Applied Mathematics program and the Scientific Discovery through Advanced Computing (SciDAC) program. The Applied Mathematics program supports research on the mathematical methods and numerical algorithms that enable the effective description, understanding, and prediction of complex physical, biological, and engineered systems. Subjects of current interest include numerical methods for the parallel solution of systems of partial differential equations, large-scale linear and nonlinear systems, and large-scale parameter-estimation problems; analytical and numerical techniques for modeling complex physical and biological phenomena, such as fluid turbulence and microbial populations; analytical and numerical methods for bridging a broad range of temporal and spatial scales; and optimization, control, and risk analysis of complex systems such as

[4] Further details can be found at
http://www.darpa.mil/dso/personnel/mann.htm and
http://www.darpa.mil/MTO/personnel/healy_d.html
[5] http://www.science.doe.gov/ascr/

computer networks and electrical power grids. The FY 2009 Applied Mathematics program budget will support a new joint Applied Mathematics-Computer Science Institute to focus on the challenges of computing at extreme scales that blur the boundaries between these disciplines; a new effort in the mathematics of extremely large datasets to address the most fundamental issues in finding the key features, understanding the relationships among those features, and extracting scientific insights from them; and increases in key areas of long-term research most relevant to meeting the challenges of computing at extreme scales and risk assessment in complex systems. In FY 2009, the SciDAC program will support 17 Science Application Partnerships, nine Centers for Enabling Technologies, and four SciDAC Institutes that were competitively selected in FY 2006. Applied mathematics plays a fundamental role throughout the Science Application Partnerships and is the principal focus of three Centers for Enabling Technology and one SciDAC Institute. Aggregate funding for the mathematical sciences would increase by 9.4 percent over FY 2008.

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). Mathematical sciences areas of interest are those that support the missions of NIGMS and NIBIB. Currently, NIGMS is supporting a biomathematics initiative at around $12 million per year in cooperation with NSF, and NIBIB is participating in a joint initiative with NSF and other NIH institutes, "Collaborative Research in Computational Neuroscience." The aggregate budget for the mathematical sciences in NIBIB and NIGMS is unchanged from FY 2008.

National Security Agency (NSA): The Mathematical Sciences Program of the NSA administers a Grants Program that supports fundamental research in the areas of algebra, number theory, discrete mathematics, probability, and statistics. The Grants Program also accepts proposals for conferences and workshops in these research areas. In addition to grants, the Mathematical Sciences Program supports an in-house faculty Sabbatical 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). NSA is the largest employer of mathematicians in the United States. As such, it has a vested interest in maintaining a healthy academic

mathematics community in the United States.[6] The NSA mathematics budget would remain unchanged from FY 2008.

Office of Naval Research (ONR): The ONR Mathematics, Computers, and Information Research 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 multi-phase, multi-material, multi-physics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and image analysis and understanding; 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.[7] The Mathematical, Computer, and Information Sciences Division's budget would remain unchanged from FY 2008.

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

[6] For more information, see the website http://www.nsa.gov/msp/index.cfm
[7] For more information see the website,
http://www.onr.navy.mil/sci_tech/31/311/default.asp