Mathematical Sciences in the FY 2000 Budget

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Overview

Mathematical research studies the logical structures and processes that all scientists rely on to make sense of the world, from chaos to cryptography, from medical imaging to movie graphics, and from large data set algorithms to the calculus of infinitesimals. That is why mathematics is often at the center of multidisciplinary initiatives large and small. Compared with laboratory scientists, for example, mathematicians can also accomplish much with grants of relatively modest size involving a small number of experts and students working on special-seeming problems with relatively little equipment. When awarding such grants, detailed priorities and targets set in advance are less crucial than when decisions must be made between large and mutually exclusive projects. Indeed, curiosity-driven, investigator-initiated, and peer-reviewed funding mechanisms work especially well in this field, where the applications of research to areas both within mathematics as well as in other disciplines, whether immediate or after many years, tend to be solid, surprising, and significant.

The role of the United States as world leader in mathematical research should be maintained by the president's budget request and throughout the federal budgeting process. Most research on mathematics takes place at institutions of higher education and in government laboratories. Mathematicians also do valuable work throughout the economy, yet few private firms can afford to invest much in research whose payoffs, while great in total, may be distributed too widely in space and time to be adequately rewarded by the market. Government also has a role in drawing the attention of researchers to new fields and opportunities faster than might happen without federal involvement.

Three federal agencies supply the vast majority of funding for mathematical research in the United States: the National Science Foundation (NSF), the Department of Defense (DoD), and the Department of Energy (DoE). NSF provides more than half of all federal support for the mathematical sciences and is able to focus more on basic research than other mission agencies. Programs located in the Army, Navy, Air Force, and Defense Advanced Research Project Agency (DARPA) at DoD together account for about a third of federal support for the mathematical sciences. DoE's Mathematical, Information, and Computational Sciences (MICS) program makes up most of the rest of the dedicated spending on mathematics.

Other federal agencies, such as the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), the National Institute for Standards and Technology (NIST), the Department of Transportation (DoT), and the Environmental Protection Agency (EPA), are also involved with mathematics in many ways. For example, mathematical research at NIST focuses on "analytical and computational methods for solving scientific problems of interest to American industry," and NIH has begun facilitating grants that include support for mathematicians and other fundamental researchers. Because spending related to mathematical research at these agencies is generally integrated into other categories of work rather than budgeted as dedicated programmatic funds for mathematics, the scale of their support is difficult to estimate in advance. This report, therefore, focuses on explicit expenditure plans at NSF, DoD, and DoE.

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Highlights

- The Division of Mathematical Sciences (DMS) at the National Science Foundation is requesting $105.3 million, an increase of $4.4 million (4.4%) over FY 1999.
- Basic research accounts at the Department of Defense would remain flat overall, receiving $1.113 billion, an increase of only 0.5% above the FY 1999 level of $1.108 billion.
- The Department of Energy's Mathematical, Information, and Computational Sciences (MICS) program would increase by $45.8 million (33%) above the $138.8 million provided in FY 1999. The MICS request includes $52.0 million in new funding for the Strategic Simulation Initiative, DoE's portion of the administration's FY 2000 information technology initiative (IT^2).
- In terms of incremental as opposed to core funding, the centerpiece of the president's FY 2000 research budget request is a $366 million initiative for information technology, known as IT^2. Of the six participating agencies, the three largest shares go to NSF ($146 million), DoD ($100 million), and DoE ($70 million). Mathematical research is critical to achieving the goals of this initiative. However, the mechanisms for involving disciplines other than computer science are not yet clear.

FY 2000 R&D Funding Requests, by Agency

The table at the end of this report shows the FY 2000 budget request for mathematical research programs at NSF, DoE, and DoD. Below are brief descriptions of each of these programs and the funding levels requested by the president.

National Science Foundation

NSF's Division of Mathematical Sciences (DMS) supports a wide range of projects aimed at developing and exploring the properties and applications of mathematical structures. In FY 2000, DMS would receive $105.3 million in total, an increase of $4.4 million (4.4%) over FY 1999. Research sponsored by DMS is conducted in areas including analysis, geometry, topology, foundations, algebra, number theory, applied mathematics, statistics, probability, biomathematics, and computational mathematics, as well as various multidisciplinary areas. Funding for DMS research projects would remain relatively flat, increasing $1.4 million (1.9%) to $73.3 million. Through its many programs, DMS also plays a key role in ensuring both the vitality of the discipline itself and its availability as a resource for progress in science, technology, and industry. DMS Infrastructure Support, responsible for postdoctoral research fellowships, graduate education, research conferences, workshops, and shared research equipment, would increase $3.0 million (10.3%) to $32.0 million. The Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE) program funds innovative educational programs "in which research and education are integrated, and in which undergraduates, graduate students, postdoctoral fellows, and faculty are mutually supportive." Begun in FY 1998 with only eight awards, VIGRE expanded from $4.5 million in FY 1998 to nearly $19.0 million in FY 1999, including some funding carried over from the previous year, and would receive $16.0 million in FY 2000.

Department of Energy

The Mathematical, Information, and Computational Sciences (MICS) Division investigates the mathematical underpinnings of challenges that range from supercomputing to the human genome project, and from chemical structures to mechanical engineering. The Applied Mathematics Program, for example, funds research in the mathematics of physical systems, optimization and mathematical programming, dynamic systems theory and chaos, geometric and symbolic computation, as well as numerical analysis and scientific computation. In FY 2000, the MICS program would receive $184.6 million, up $45.8 million (33%) from the $138.8 million provided in FY 1999. Of this total, MICS would be asked to dedicate $52.0 million for the Strategic Simulation Initiative, DoE's portion of the administration's information technology for the twenty-first century program (IT^2). MICS also would provide $14.6 million for the Next Generation Internet initiative, the same amount appropriated in FY 1999. Additionally, the FY 2000 budget also requests $1.9 million for new science education activities to support college faculty and student research participation at DoE laboratories.

Department of Defense

Defense Advanced Research Projects Agency (DARPA): The Applied and Computational Mathematics program seeks to combine new mathematical techniques with high-performance computing hardware technology "to revolutionize the DoD's modeling and simulation capability" to improve over "previous methods such as engineering trial and error." Supported research focuses on developing new mathematical algorithms, such as those based on wavelets and partial differential equation techniques for image processing and data compression, as well as on control strategies for advanced materials processing. Because of the limited release of program-level budget request data by DoD, the FY 2000 request for this program is unknown.

National Security Agency (NSA): By its own account, NSA is one of the largest employers of mathematicians in the U.S. and perhaps the world. Since 1987 the NSA Mathematical Sciences Program has funded critical mathematical research in the areas of algebra, number theory, discrete mathematics, probability, statistics, and cryptology. Using these techniques, mathematicians at NSA contribute di-

rectly to the two missions of the agency: while some "help design cipher systems that will protect the integrity of U.S. information systems, others search for weaknesses in adversaries' codes." For security reasons, the NSA does not disclose the exact amounts it will spend, but the agency does state that it will continue to "vigorously" support mathematics research proposals.

Air Force Office of Scientific Research (AFOSR): AFOSR's Mathematics and Computer Sciences Division is located within the Directorate of Mathematics and Space Sciences, which is responsible for basic research in mathematical, computer, and space sciences. Many critical research activities are multidisciplinary and involve support from the other scientific directorates within AFOSR. For example, the control theory and mathematical modeling research supported by this directorate complements many structural, fluid mechanics, and propulsion research programs run by the Directorate of Aerospace and Materials Sciences. Mathematical research supported by the Air Force spans a range of fields in mathematics, including, for example: optimization and discrete mathematics, including linear and nonlinear programming; computational geometry; physical mathematics and applied analysis, including nonlinear optics, the mathematics of materials, inverse problems, and theoretical fluid dynamics; signal processing, probability, and statistics, drawing on wavelet methods and reliability analysis; and computational mathematics using novel parallel computing, reliable numerical methods, and spectral techniques. The FY 2000 budget request for Mathematics and Computer Sciences is $32.9 million, a decrease of $1.5 million, or 4.4%.

Army Research Office (ARO): Mathematical sciences play a key role in the analysis and modeling issues that arise in military science, engineering, and operations. For example, ARO explains that some promising approaches to computer vision for automatic target recognition (ATR) require research in a wide range of mathematical areas including constructive geometry, numerical methods for stochastic differential equations, Bayesian statistics, tree-structured methods in statistics, probabilistic algorithms, and distributed parallel computation. The ARO's Mathematics and Computer Science Division therefore attempts systematically to advance fundamental knowledge that relates to the Army's needs, supporting extramural basic research in applied analysis and physical mathematics, computational mathematics, stochastic analysis, applied probability and statistics, systems and control, software and knowledge-based systems, and discrete mathematics and computer science. In particular, ARO supports several centers and institutes that fall under the University Research Initiative (URI). Because of the limited release of program-level budget request data by DoD, the FY 2000 request for this program is unknown.

Office of Naval Research (ONR): The Mathematical, Computer, and Information Sciences Division, part of the ONR's Information, Surveillance, and Electronics Department, supports "fundamental investigations into mathematical foundations for models, computability, and processes." This includes research in the mathematical areas of applied analysis, discrete mathematics, numerical analysis, operations research, visualization, and probability and statistics in support of the naval mission. Applications range from enhancing surveillance techniques to improving human-computer interaction. Because of the limited release of program-level budget request data by DoD, the FY 2000 request for this program is unknown.

Federal Support for the Mathematical Sciences
FY 1998–FY 2000 (in millions of dollars)

Agency	FY 1998 Actual	FY 1999 Estimate	FY 2000 Request	FY 1999–2000 Percent
National Science Foundation				
DMS	$ 93.6	$100.9	$105.3	4.4%
Department of Defense				
AFOSR	$ 30.5	$ 34.4	$ 32.9	−4.4%
ARO	12.0	12.0	*	*
ONR	7.7	7.0	*	*
DARPA	22.5	19.5	*	*
Department of Energy				
MICS	$124.0	$138.8	$184.6	33.0%

*Unknown at time of publication.