Report of the 2010 Committee of Visitors
Division of Mathematical Sciences
National Science Foundation

26-28 April 2010

Submitted on behalf of the Committee by
C. David Levermore, Chair

to

H. Edward Seidel,
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1. Charge, Organization, and Procedures

The 2010 Committee of Visitors (COV) for the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) was charged by Edward Seidel, Acting Assistant Director for Mathematical and Physical Sciences (MPS), to address and report on:

- the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions;
- the quality and significance of the results of the Division's programmatic investments;
- the relationship between award decisions, program goals, and Foundation-wide programs and strategic goals;
- the Division's balance, priorities, and future directions;
- the Division's response to the prior COV report of 2007; and
- any other issues that the COV feels are relevant to the review.

Following NSF guidelines, the COV consisted of a diverse group of members representing different work environments (research-intensive public and private universities, primarily undergraduate colleges and universities, private industry, other Federal government agencies or laboratories, and non-U.S. institutions), gender, ethnicity, and geographical location. A list of the COV members and their affiliations is given in Appendix A.

Before the meeting, members were supplied by means of public and password-protected websites with some of the data needed to perform our audit functions. These data included the COV report from 2007 and the DMS responses; DMS annual reports for 2007, 2008, and 2009; detailed information about the distribution of awards in DMS and its programs.

The COV met on 26-28 April 2010 at the Crystal City Doubletree Hotel in Arlington, Virginia. The unusual date and location was due to the record snowfall in February that forced the cancelation of the originally planned COV meeting at the NSF. The meeting began with welcomes by Edward Seidel, MPS Acting Assistant Director, and David Levermore, COV Chair. Morris Aizenman, MPS Senior Science Associate, then informed the COV about the NSF's conflict of interest policy, emphasizing the special nature of the COV.

Peter March, DMS Director, presented an overview of the DMS to the full committee and answered questions. The Committee then divided into three subcommittees, each of which met separately to examine proposals from a subset of the DMS disciplinary programs as well as proposals from the Institutes, Interdisciplinary, Infrastructure, and Workforce (I/I/I/W) programs. The table below summarizes the programs reviewed by each group; lists of the COV members assigned to each group appear in Appendix B. The chairs of these subcommittees were Mary Ellen Bock, Mikhail Kapranov, and Juan Meza respectively. The COV Chair, David Levermore, moved from group to group during the meeting.

At the beginning of the initial subcommittee meetings, relevant DMS program officers presented overviews of their programs and answered questions. After training in accessing the electronic jackets (e-jackets), subcommittee members began their audit function by carrying out a detailed review of a selection of proposals. (The selection process is described at the start of Section 4.)

Group	Disciplinary Programs	I/I/I/W Programs
A	Analysis Probability Statistics	Workforce
B	Applied Mathematics Algebra, Number Theory, and Combinatorics Foundations Mathematical Biology	Interdisciplinary Infrastructure
C	Computational Mathematics Topology and Geometric Analysis	Institutes

Subcommittees were encouraged to, and did, request additional data as well as further meetings with program officers. Peter March, Deborah Lockhart (DMS Deputy Division Director), and DMS program officers were available for consultation throughout the entire COV meeting. To summarize the audit results associated with its charge, the COV was asked to use the NSF COV template. The COV's answers to the questions in the template are contained in Section 4. The COV was also asked to answer a list of six "additional questions" posed by DMS and MPS. The COV's responses to these questions are given in Section 5.

On the second morning the full COV met with the DMS administrative staff to get their perspective. On the final day, the full COV met with Edward Seidel, Peter March, Deborah Lockhart, and Patricia Page (DMS Program Support Manager) to present and discuss the expected highlights of our report.

Acknowledgment. The COV is very grateful to Peter March, Deborah Lockhart, and the DMS program officers for their hospitality and helpfulness during the COV meeting. Their candor in discussing complicated and potentially controversial issues was extremely valuable, as was the provision of additional information that we requested on short notice. The COV is also very grateful to DMS administrative staff for both their valuable input and their prompt and friendly assistance.

2. Major Findings, Recommendations, and Concerns

The COV was impressed with the excellence of the DMS. Its awards supported work of the highest quality. Its portfolio of disciplinary and interdisciplinary research, institutes, workforce programs, and infrastructure projects is well balanced and healthy. The largest single component of this portfolio consists of individual investigator awards in disciplinary programs. It also includes interdisciplinary research programs run in partnership with other divisions within the NSF, and with other agencies. The DMS has played a leading role in the development and implementation of these programs. All DMS programs received many worthy proposals that did not get funded, even with the benefit of the ARRA funds in 2009. The COV also found that the panel review process has generally functioned extremely well. The COV commends the way the DMS handled the ARRA funds, and applauds the extra effort this demanded from all involved. Finally, the COV feels that the leadership of the DMS provided by Peter March and Deborah Lockhart has been impressive and inspires confidence. Their engagement with the community has been especially commendable.

This section gives our major findings, recommendations, and concerns. It includes consensus views and views held by significant fractions of the COV. It does not attempt to include every individual view. Our findings, recommendations, and concerns related to specific disciplinary programs are presented in Section 3. Our responses to the template and additional questions are given in Sections 4 and 5 respectively.

2.1. Proposal Review Process

The fidelity of its proposal review process is critical to the NSF. Panels, sometimes supplemented by mail reviews, largely handle the review process for the DMS. Mail reviews were used exclusively whenever there were not enough proposals in an area to justify a panel. Site visits play an important role in the final selection of large awards.

The COV judged that the DMS review process has generally worked extremely well. It was felt that the heavy reliance on panels was justified for several reasons. First, it allows the DMS to respond to proposers faster than a mail-based review process. Second, panel summaries generally gave proposers valuable cohesive feedback. Third, in instances where comparisons could be made, it was felt that panels did a better job than when only mail reviews were used. This might be because the interaction between reviewers on a panel leads to a better understanding of what is being proposed. It might also be because the dynamics of panels works against unreasonable reviews, even ones by mail.

The 2007 COV had found that there was considerable confusion regarding the interpretation of the "broader impacts" criterion, and had recommended that the DMS take steps to remedy this confusion. The DMS responded by drafting a "Dear Colleague" letter explaining the criterion. This letter was posted on the DMS website and was used as a basis for giving better guidance to reviewers. As a consequence, we found that there has been an improvement in the understanding of this criterion by reviewers. However, widespread misunderstanding persists among proposers.

Since the 2007 COV report, there has been an increased emphasis on the "potentially transformative" component of the "intellectual merit" criterion. The COV found that there is considerable confusion about what this means. We received different interpretations from different program officers. In addition, the committee saw different interpretations by both reviewers and proposers during our review.

The COV therefore recommends that the DMS take further steps towards clarifying its review criteria. We recommend that the "Dear Colleague" letter addressing "Broader Impacts" be updated, and that one addressing "Intellectual Merit" be created. The idea is that these should serve to inform everyone involved in a timely fashion. For example, the letters should be included in the package for mail reviewers and should be discussed with review panels when they convene. Additionally, we recommend that links to these letters and a clear advisory that they should be read should be placed on every solicitation webpage and where project descriptions are submitted.

The COV encourages the DMS to experiment further with having reviewers score each of the two criteria separately. Such dual scoring could provide good feedback to both proposers and the DMS regarding how reviewers are evaluating and balancing the two criteria. The COV members held a diversity of views about what might work best. Some on the Committee even suggested having reviewers give three scores, one for each criterion and one overall score. Some on the Committee who were in favor of two scores thought that three scores was a bad idea. Most of the Committee felt that separate scoring is a good idea for large proposals and the Institutes in particular. However, many on the Committee felt that separate scores should be approached carefully for small proposals. There is concern that changes in scoring might adversely affect the dynamics of a panel, or add to the program officer's workload. Many on the Committee urged caution against using the scores alone as a basis for funding decisions, as there are many factors, such as diversity and potentially transformative impact, which a program officer should weigh in coming to a final decision. However, because of their potential benefits, these ideas should be tried on small scales to better understand the tradeoffs.

The COV found that on the whole the DMS handled "conflict of interest" situations well. However, there were instances that were disruptive because some panelists had a serious conflict of interest and did not reveal the extent of their conflict until late in the review process. When these conflicts were discovered, the DMS took immediate and appropriate steps to address the situation. However, we recommend that steps be taken to avoid such events. One problem is that the NSF "conflict of interest" form requires interpretation. Panelists can in good faith be confused about the nature of their conflict. The NSF might consider modifying its form to include a short checklist to be filled out above the signature line that lists common conflicts that would lead to disqualification from a panel. Such a step would avert problems before panels convene. Of course, the DMS cannot modify this NSF form on its own. However, the DMS might consider reviewing such a list during the conflict of interest briefing to panels. Such a step would catch problems before panels begin their deliberations.

The COV believes that the NSF guidelines regarding "conflict of interest" have major gaps. For example, they do not mention domestic partners. We suggest that these guidelines be updated.

2.2. ARRA

The COV found that the DMS was able to use the ARRA funding effectively across all areas. We were particularly impressed by the ability of the Math Institutes to work jointly to respond to short-term postdoctoral funding opportunities in 2009. The Institutes were able to create 45 new jobs within 6 weeks of availability of ARRA funds, through a uniform application process that was used by all five Directors of the major Institutes. There was also clear evidence that due to the new funding, there was a significant increase in participation from new investigators and women in some programs at the DMS.

The COV would also like to applaud the exceptional performance at every level of the DMS under the extreme workload and time constraints necessary to disburse these new funds. It was clear that extraordinary measures were undertaken by everyone at the DMS to not only complete the normal workload, but all of the new funding awards within the very limited time frame required by the new funds.

The ARRA funds allowed the DMS to increase the number of NSF graduate fellowships awarded in the Mathematical Sciences in 2009. The original list of 20 awardees for graduate fellowships selected by the NSF Division of Education and Human Resources (EHR) included one female and no minorities. When the DMS augmented this list by 42 awardees, the diversity of the list was increased significantly.

The 2009 ARRA stimulus funds allowed a dramatic increase in the number of postdocs supported in the mathematical sciences, but there was no significant increase in female or minority support over 2008 observed for awardees that identified their gender and/or minority status in the MSPRF data.

One effect of the 2009 ARRA funding designated for new researchers was an increase in their proportion among the DMS's pool of funded researchers. This led to a corresponding increase of diversity in this pool (both in gender and minority categories) since the new researcher applicants tend to be more diverse.

2.3. Disciplinary Programs

Individual investigator awards funded by its disciplinary programs constitute the single biggest component of the DMS budget. Our findings, recommendations, and concerns that apply broadly to these programs are presented here. Those that apply to specific programs can be found in Section 3.

The COV found that proposals funded by the DMS disciplinary programs were generally of the highest quality. One measure of this is the recognition given their PIs. Ten out of the 20 plenary speakers at the twenty sixth International Congress of Mathematics in 2010 and eight out of the 32 plenary speakers at the sixth International Congress on Industrial and Applied Mathematics in 2007 were funded by DMS. Because these meetings are held only every four years, these addresses represent high recognition of these speakers by their peers worldwide. One DMS PI,

Bradley Efron, was awarded the National Medal of Science in May 2007. The COV found many other measures of the quality of the work funded by the DMS. These are also presented in Sections 3 and 4.

The COV found that the DMS received many high quality proposals that it was unable to fund. This was true even in 2009 when funding rates were higher due to the ARRA funds.

The COV believes that the funding of core DMS programs should not have been flat over the last three years. As the DMS portfolio in applied and interdisciplinary programs has grown due to the increased importance of mathematics in other fields, so too should its portfolio in core programs. A strong core is required to help develop new mathematics to meet the challenges brought by these applications. In doing so, the core will be enriched and evolve. The long-term health of the mathematical sciences depends on the vitality of this interaction. As the evidence presented in Section 3 shows, the core programs are now remarkably strong. However, they must maintain the same pace of growth as the mathematical sciences grows to remain healthy.

The COV felt that the DMS disciplinary programs should do a better job of reviewing those interdisciplinary proposals that they handle. Here we are referring to those proposals that fall outside of the interdisciplinary programs that have their own panels. These are not just applied proposals. For example, such a proposal might span analysis and number theory. Such a proposal is typically sent to two panels that consider it in an order that is determined more by logistics than science, and with little interaction. One great lesson of the recent experience with interdisciplinary panels is that the interaction of the reviewers with different perspectives is essential to effectively evaluating such proposals. The COV therefore encourages DMS to explore ways to introduce more interaction into the process by which such interdisciplinary proposals are evaluated. For example, reviewers from the first panel might be teleconferenced into the second panel, or small panels might be convened virtually to consider small numbers of interdisciplinary proposals. More ideas are given in Section 4.

The COV found that some progress has been made regarding the numbers of female PIs over the past three years. However the same cannot be said regarding underrepresented minorities. Needless to say, the DMS must continue its efforts to improve the situation across all the mathematical disciplines.

2.4. Interdisciplinary Programs

The COV found that the portfolio of solicited interdisciplinary programs is one of the many success stories of the DMS. These programs represent targeted initiatives developed by the NSF in response to the evolving needs of science and industry. They typically involve collaboration between DMS and another division of the NSF or another federal funding agency (e.g., National Institutes of Health or Department of Defense), on a topic of great scientific interest or strategic national priority. These programs include:

- Cyber-Enabled Discovery and Innovation program (CDI)
- Collaboration in Mathematical Geosciences (CMG)

- Mathematical and Statistical Research for Threat Detection (DTRA)
- CHE-DMR-DMS Solar Initiative (SOLAR)
- Foundations of Data and Visual Analytics (FODAVA)
- Accelerating Discovery in Science and Engineering through Petascale Simulation and Analysis (PetaApps)
- The joint initiative between DMS and NIGMS (National Institute of General Medical Sciences)

These programs serve a truly important role, as they bring together researchers with different backgrounds to work on problems that otherwise would fall through the cracks in the traditional subdivision by disciplines and programs. The outcome of the research included highly prominent breakthroughs. To give just one example, Doron Levy's work on optimizing Leukemia treatment, funded through the DMS-NIGMS initiative, was featured in the national media and was presented in a testimony before Congress.

One characteristic feature that distinguishes the management of these programs is the use of mixed panels, which include people with backgrounds in both areas of collaboration. Bringing such people together in one conversation, as opposed to having two separate specialized panels, allows a truly efficient review of the proposals.

The funding of focused interdisciplinary programs is typically shared between divisions or between agencies, and this cross-program and cross-agency funding is crucial for the success of the programs. In the examples we saw, bringing mathematics into the scientific equation provides impressive payoff. The expense of including the mathematical component is relatively minor by the standards of other disciplines, but the cross-fertilization achieved by doing this is worth many times more.

The COV was impressed by the success of the Interdisciplinary Program portfolio and recommends expanding it with an eye on emerging new applications.

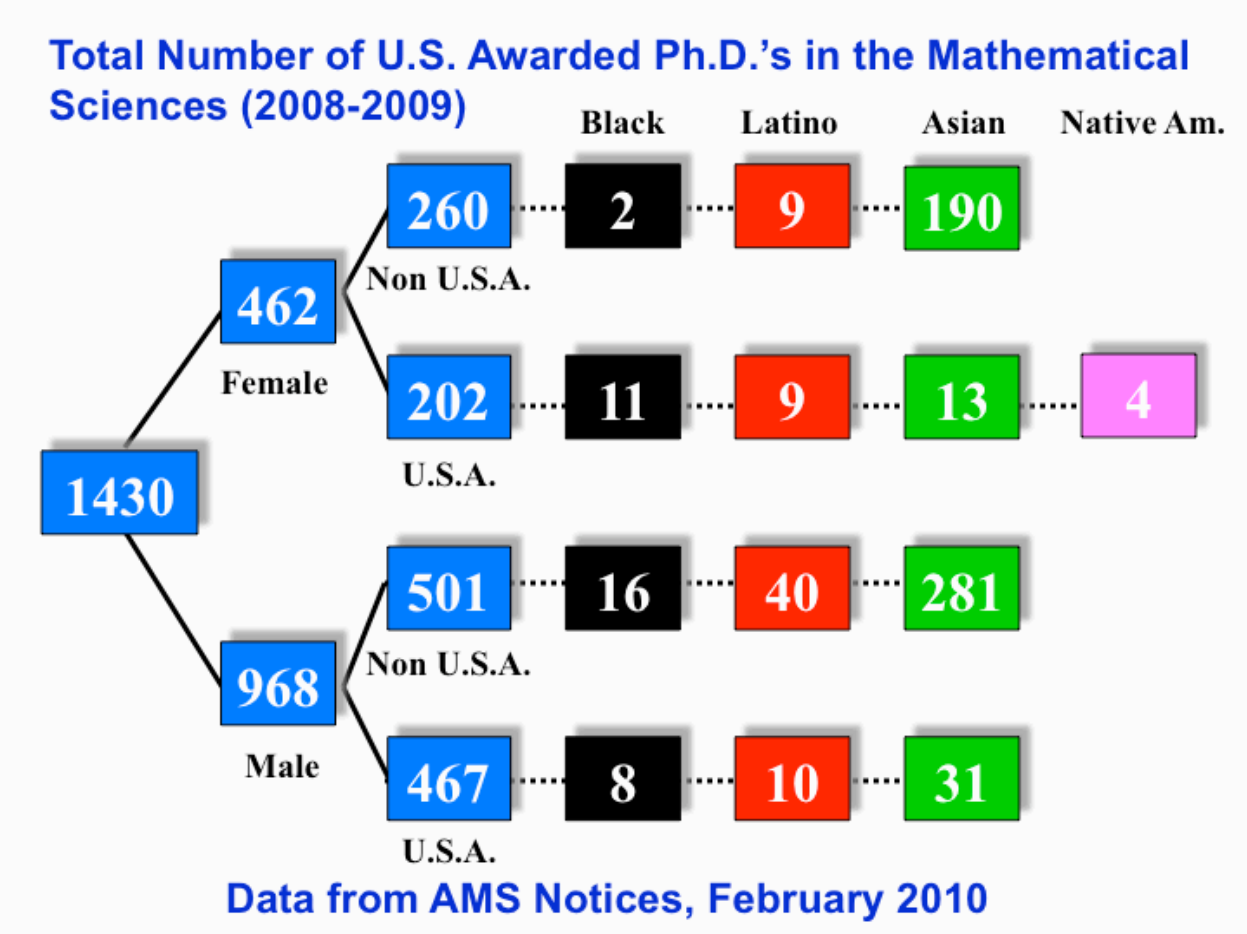
2.5. Workforce

The COV applauds the fact that a rich tapestry of workforce programs have evolved to meet the needs of the mathematical sciences community. For instance, the successful program Vertical Integration of Graduate Research and Education (VIGRE) has led to the Research Training Groups (RTG) and Mentoring through Critical Transition Points (MCTP) programs. We see great potential in the new "unsolicited proposals" program because applicants can more freely tailor a workforce proposal to the needs of their individual institutions and because it may generate new programs from its own successes. To help realize this potential, the "unsolicited proposals" program should be more visible on the DMS website.

The DMS investment in workforce programs has traditionally been about 15% of its budget but the effect of ARRA increased both the percentage and the amount in 2009 through a large increase in the number of graduate fellowship and postdoctoral awards.

While the 2009 ARRA stimulus funds clearly increased the number of MSPRF postdoctoral awards in the mathematical sciences on the order of 35% over 2008, there was essentially no increase in the number of female or minorities over 2008 and their proportions among the awardees fell. However DMS augmented a list of 20 NSF graduate fellowship awardees selected by EHS that included a single female and no minorities with an additional 42 awards that added 13 self-identified females and 2 self-identified minorities to the list.

The significant DMS investment in workforce programs means that assessment is essential! The experience with the assessment of the VIGRE program and the ongoing assessment of the mathematical institutes give valuable insight on how to approach it. One key component of assessment is the analysis of pipeline data such as found in the graph below.



The graph was provided by William A. Massey and based on William A. Massey, Derrick Raphael, and Erica N. Walker, "A Survey of CAARMS12 Participants", American Mathematical Society Contemporary Mathematics Series, CONM 467 (2008). It was updated with data from Polly Phipps, James W. Maxwell, and Colleen Rose, "2009 Annual Survey of the Mathematical Sciences (First Report)", Notices of the American Mathematical Society **57**, February 2010, Table 6: Gender, Race/Ethnicity, and Citizenship of 2008-09 New Doctoral Recipients (page 255). (http://www.ams.org/notices/201002/rtx100200250p.pdf)

2.6. Institutes

The COV found that the DMS has a very strong portfolio of ten Institutes with a well-balanced set of activities. In particular, the quality of the research at all of the Institutes was excellent, with many examples of new research fostered through their programs. While there was a wider spectrum of quality of the educational components, this component was still quite good.

The COV noted that the structure of the Institutes enables them to quickly respond to emerging research and educational opportunities. The approaches that the Institutes used to achieve their individual research and education goals varied widely. Some Institutes mainly used long programs, some use only short programs while others used a mixture. The COV found that the variety in approaches was good and that it should be encouraged as the community itself has many different needs and requirements.

The COV also enthusiastically supports the DMS response to the 2007 COV request for an assessment. In that report the COV recommended, "an analysis of the complete portfolio of institute activities be undertaken as soon as possible". As a result, DMS commissioned a study that is being coordinated by a newly hired AAAS fellow, Katherine Socha. This assessment report, which is based on a logic model, will be a key element to guide planning and prioritization development for the Institutes as a whole. The COV was impressed with the results so far and the project plans. We look forward to the results of this study to help answer this important question.

The one area that the COV found that needed some attention was in the dissemination and reporting of the outcomes of the various programs at the Institutes. There was a wide disparity between Institutes in terms of how well information pertaining to the research programs was available. Some Institutes have fairly complete and well-documented web pages with clear indicators of outcomes resulting from their programs. Other Institutes have only basic information regarding their programs. As this part of the DMS program accounts for nearly 10% of the overall DMS portfolio and the Institutes are such a visible component of the mathematics program, the COV recommends that the Institutes be directed to improve this aspect of their programs.

In general, across all institutes, there are positive trends for women, but some issues remain with respect to underrepresented minorities. In terms of program organizers and advisory boards, some institutes are doing well, but others still have some work to do. At the advisory board level, where appointments can be made, women are well represented. We suggest keeping specific stats on women and underrepresented minorities who serve as workshop organizers. We suggest that the Institutes pay particular care in the selection of all of their board members to assure that the boards are truly representative of the communities served by the Institutes. MSRI did an excellent job in expanding opportunities for women in mathematics, drawing people from a wide range of backgrounds and institutions to its programs, and providing a wide spectrum of programs, which educate and inform the public about mathematical research.

2.7. Infrastructure

The Infrastructure programs of the DMS fall into two types:

1. Research infrastructure programs which include travel and conference grants, as well as grants allowing academics to gain experience in different areas.
2. Equipment grants that enable researchers to work on problems with experimental or advanced computational components.

Travel and conference grants are important for promoting community, diversity and international presence. They include, in particular, grants to the American Mathematical Society for travel to the 2010 International Congress of Mathematicians (in Hyderabad, India), grants to the Mathematical Association of America and Society of Industrial and Applied Mathematicians enabling junior academics to attend national meetings, as well as grants to organizations such as Association of Women in Mathematics, and Society for the Advancement of Chicano and Native Americans in the Sciences, which promote diversity in academia. They currently involve quite minor dollar expenditures but the difference these investments make for the community and the profession cannot be overestimated. This is certainly a direction deserving attention and continued support. Funds for annual conferences and winter/summer schools provide regional diversity and balance of research activity across the US.

The Interdisciplinary Grants in Mathematical Sciences (IGMS) program allows mathematicians to spend time working in different departments or in industry, thereby acquiring new experience and interdisciplinary connections. It has led to remarkable progress. One can mention, for example, the highly regarded work of Keith Promislow on fuel cells funded by IGMS.

Equipment grants, in the specific context of mathematics, are very important for applications such as cryptography, fluid dynamics and biomathematics. Often such grants enable crucial collaborations between different areas. We recognize that the needs for equipment change over time and recommend continued support for this program in the current interdisciplinary environment.

2.8 Staff

The COV believes that the DMS is understaffed both in program officers and in administrative staff. The DMS seems to manage a higher number of proposals and panels than many NSF divisions of its size. For example, in 2009 it managed 2731 proposals and 79 panels with about 25 program officers and an administrative staff of six, while we suspect based on awards that those numbers are much lower for other NSF divisions that have staffs of similar or larger size. The COV could not make such comparisons exactly because it was not given access to the corresponding numbers for other divisions. This staff shortage was keenly felt during the response to the ARRA funding in 2009.

The COV feels that DMS program officers play an important role in insuring the high quality of awards through their management of the review process and their outreach to the community.

The ability of the DMS to be as effective as it is with so few of them is amazing. One concern is that this heavy workload might make the continued recruitment of well-qualified program officers more difficult. The COV did not have the opportunity to meet with the program officers as a group to discuss this heavy workload and other crosscutting issues, but we recommend such a meeting be set up for future COVs.

The COV was pleased to have the opportunity to meet with the DMS administrative staff. Because this has not been a feature of previous COVs we take this opportunity to address issues specific to the administrative staff.

The COV saw that the administrative staff is especially affected by this heavy workload. Because of its small size, it is heavily impacted by absences due to illness or vacation. There is insufficient time for career development. While their dedication was illustrated by the extraordinary effort they delivered to help award the ARRA funds, it is clear that morale will suffer if paths to advancement are not clear. This is especially true because technology is rapidly changing the NSF work environment. The staff should therefore have access to training that can help them adapt to this environment. Moreover, this training should be followed by opportunities to practice what has been learned. Such opportunities have been lacking due to the heavy workload.

The COV heard evidence that the rationale for decisions that affected their workload were not always communicated to the administrative staff by some program officers. Everyone works harder when they understand the payoff for doing so. Communicating these payoffs is therefore important.

2.9. COV

Because examining the documentation of awards plays such a central role in the DMS evaluation process by the COV, it is imperative to make it more transparent to future COVs how to interrogate the award database. In particular, panels play a central role in the review process, but the COV found that it was difficult to mine the database to see how well they functioned. Often a DMS officer responded to the request of a subcommittee to provide the help needed. However this process was not the best use of time by either the subcommittee or the program officer during the COV meeting. Moreover, it also meant that some subcommittees figured out how to make some helpful queries while others did not. In the interest of making the COV meeting more efficient and effective, the DMS should think of ways to improve this aspect of the COV process.

One suggestion would be to convene a small group of former COV subcommittee chairs, and members to examine the current database and suggest short sets of instructions for database queries that might be helpful to a COV. These sets of instructions can then be provided to a COV, thereby reducing the need to call in a program officer to generate helpful queries.

Another suggestion is to have the COV subcommittee chairs and the chair arrive a half day early to familiarize themselves with the systems so that they can more easily guide their groups.

Furthermore, if it were easier to access the data in a more panel-centric way, the subcommittees could do their jobs more effectively. For instance, it would help if the COV could be provided access to all jackets associated with one or two panels from each disciplinary program, giving each group a columnar list of applicants (and links to all the jackets) reviewed by a panel along with separate columns designating the panel rating of each applicant and the ultimate decision by program officers about funding the applicant.

Finally, the COV felt that the meeting with the administrative staff was a good innovation and recommends that it be continued and complemented by a meeting with just the program officers. We feel that these meetings would help future COVs identify and address crosscutting issues such as workload, communication, management, conflict of interest problems, and evaluative criteria. The second morning of the COV meeting is a good time for these meetings, as it gives the COV members both time to develop a perspective about issues that might arise, and time to develop their recommendations.

3. A More Detailed Look at Disciplinary Programs

Here we take a brief look at each DMS disciplinary program. We give more detail regarding some of the highlights, prizes, and awards that we used to judge the quality of the DMS investment. Further information can be found in Section 4.

3.1. Algebra, Number Theory, and Combinatorics

Recent years brought several fundamental breakthroughs in classical problems of algebra, algebraic geometry and number theory. These areas underwent rapid growth and influx of much new talent. Of the ten DMS-funded plenary speakers at the 2010 ICM, three are funded by the ANTC program: Ngo, Parimala, and Reshetikhin. One can mention the proof of the Sato-Tate conjecture in number theory that came out of the work of Richard Taylor (DMS-0600716) who was awarded the 2007 Shaw Prize (jointly with Robert Langlands). Taylor has done fundamental work in number theory and contributed to the proof of "Fermat's Last Theorem." In representation theory, R. Bezrukavnikov (DMS-0625234) and I. Mirkovic (DMS-0901768) proved the conjectures of Lusztig. Recent work of Bao Chau Ngo (DMS-1000356) on the Langlands program is widely viewed as extremely important, especially his proof of the Fundamental Lemma. In algebraic geometry, Christopher Hacon (DMS-0757897) and James McKernan were awarded the 2009 Frank Nelson Cole Prize in Algebra for their groundbreaking contributions to birational geometry in dimensions greater than three. Robert Griess (DMS-0600854) was awarded the 2010 Leroy P. Steele Prize for Seminal Research.

3.2. Analysis

An extremely strong portfolio of research was found in the analysis program. It led to the establishment of the universal behavior of eigenvalue spacings of a random matrix by Terry Tao (DMS-0851061) and Van Vu. Furthermore, Tadeusz Iwaniec (DMS- 0800416), Jani Onninen, and Leonid Kovalev (DMS-0700549) settled the 1962 conjecture of Johannes Nitsche on harmonic mappings between annuli. Also, Charles Fefferman (DMS-0901040) has demonstrated that, computationally, finding the best m-times continuously differentiable function over an n-dimensional space to approximate a set of values at N points in that space can be done with a constant (depending on m and n) times a bound of order N logN. The extremely high quality of the research supported by the analysis program is signaled by the large number of prizes given to its researchers, including the Bocher Memorial Prize to Charles Fefferman and Carlos Kenig (DMS-0456583), the NSF Waterman Award to Terry Tao, the Leroy P. Steele Prize for Lifetime Achievement to Luis Caffarelli (DMS-0701016), the Moore Prize to Sorin Popa (DMS-0605456) and the 2010 Conant Prize to Bryna Kra (DMS-0900873).

3.3. Applied Mathematics

Applied Mathematics is a healthy, diverse, and evolving discipline. The corresponding program of the DMS supports a portfolio of projects spanning connections to biology, physics,

engineering, and social sciences. Techniques from fluid dynamics and dynamical systems are finding broader ranges of applications. Remarkable highlights include the recent work of George Haller (2008, funded by DMS-0404845 in the past) who solved a century-old problem in fluid dynamics. Michael Brenner (DMS-0907985) helped to unravel the concept of entropy as it relates to how atoms and molecules assemble themselves. In 2008 Elizabeth Chen (DMS-0500555) set a world record for the densest packing of 3-space with tetrahedra. In 2009 this record was broken by Salvatore Torquato (DMS-0804431) and his students. However, in 2010 even this new record was superseded by Elizabeth Chen (DMS-0801029) and her collaborators. This research has far-ranging applications from improved data storage to fundamental properties of atoms. The research of Graeme Milton (DMS-0707978) led to a new cloaking method that advances the technology for making an object invisible. In addition, in recent years new directions in applied mathematics became increasingly important such as applications of harmonic analysis to analyzing large clouds of data.

3.4. Computational Mathematics

Computational Mathematics covers a broad range of vibrant activities that address many of our national priorities. In 2009, the program took the lead in connecting scientists at universities with researchers at the DOD national labs and the Defense Threat Reduction Agency (DTRA), and successfully launched a new program to develop the next generation of mathematical and statistical algorithms for the detection of chemical and biological threats. Another good example of the strong research within this program was the discovery of the Bregman family of fast algorithms for l_1 minimization by Stanley Osher (DTRA/DMS-0914561, DMS-0835863, DMS-0714807), Wotao Yin (Career DMS-0748839) and coworkers. Applications of Bregman algorithms include compressed sensing, low rank matrix completion, image restoration, blind motion de-blurring, blind speech extraction, and music noise reduction. We list some awards to PIs in our response to question A.1.12.

While there is good evidence of a strong research portfolio, it was unclear, whether this program has reached the full potential possible given the vitality of this field. The COV encourages DMS to actively cultivate new growth opportunities in the computational mathematics area, such as fundamental algorithms for new computer architectures and links to computational statistics to name just two. This program showed an increase in the percentage of awards going to new investigators as well as the percentage of proposals awarded to women. However, the percentage of proposals awarded to minorities is still extremely low and the COV encourages DMS to maintain its efforts in this area.

3.5. Foundations

The area of Foundations of Mathematics remains very active, and new applications to classical areas are being found. For instance, the work of Christian Rosendal (DMS-0901405) answers classical questions about structure of Banach spaces in analysis. Hugh Woodin (DMS-0856201) is a plenary ICM-2010 speaker.

3.6. Mathematical Biology

Mathematical Biology continues to be a strong program. It has expanded its portfolio to include applications of mathematical areas such as topology and network theory, in addition to more standard approaches based on differential equations and statistics. Potentially transformative projects funded in 2009 include the research of David Chopp on modeling and simulation of microbial fuel cells (DMS-0921015) and C. Wolgemuth (DMS-0920279) on collective dynamics of cells in tissues. In addition, the joint NSF/NIGMS program complements the Mathematical Biology program.

3.7. Probability

Research funded by the probability program led to significant contributions to the analysis of large random structures, such as random matrices, random graphs, stochastic networks, spin glasses, and percolation clusters. Work on the theory of random matrices by Bryan Rider (DMS-0645756) led to the Rollo Davidson Prize and work of Richard Kenyon (DMS-0805493) on conformally invariant structures led to the Loeve Prize. The Abel prize honored S.R.S. Varadhan (DMS-0904701) for creating a unified theory of large deviations. Interactions with researchers in biology, genetics and statistical mechanics were highlights of the research. Support for interdisciplinary work was effectively provided through the AMC-SS panel (across disciplines) for proposals with stochastic modeling.

3.8. Statistics

The addition of an excellent program officer who is permanent will bring the benefits of history and "institutional memory" to the statistics program and its outstanding cadre of rotators. The program's strong support of research about the statistical analysis of complex, high dimensional and massive data has resonated with the statistics community's embrace of these important national problems. The work of Iain Johnstone (DMS-0906812) in exploring phase transitions for the proportion of "important" variables out of the many available in high dimensional data problems will continue to improve our understanding of the definition of "sparsity" in models. The potential for interaction with computational mathematics on these problems is worth exploring. Honors to outstanding researchers supported by this program included the presentation of the Guy Silver Medal from the Royal Statistical Society to Iain Johnstone. Bradley Efron (DMS-0804324) was awarded the National Medal of Science in May 2007 for his exceptional work in Statistics. Efron is best known for the bootstrap resampling technique, one of the first computer-intensive statistical methods, which has had a major impact in virtually every area of statistical application.

3.9. Topology and Geometric Analysis

The COV found that this program has an outstanding track record with many impressive research highlights. This was evidenced by several major awards to DMS funded PIs including the 2007 Veblen Prize in Geometry to Peter Kronheimer, Tomasz Mrowka, Peter Oszvath, and Zoltan Szabo; the 2008 Clay Research Award and the 2009 Shaw Prize to Clifford Taubes; and the 2010 Wolf Prize to Shing-Tung Yau and Dennis Sullivan. In this particular review period, it was also encouraging to see progress towards broadening participation as noted by a significant number of female CAREER awardees including DeMarco and Harvey.

4. Responses to Template Questions

This section contains the responses of the three subcommittees defined in Appendix B to the template questions provided by the NSF.

The jackets reviewed by the COV were chosen in three stages. First, for the disciplinary, interdisciplinary, infrastructure, and workforce programs, an administrative staff member made a random selection of approximately equal numbers of awards and declinations from the three fiscal years under review. All the current institute jackets were made available to group C. The DMS program officers then added jackets that were "interesting" and/or that presented a "balanced" picture of the program, reflecting "borderline" or difficult cases, high-impact awards, mixes of junior and senior investigators, and so on. Finally, during the COV the subcommittees requested additional jackets.

For the reader's convenience, we include a list of frequently used acronyms.

CAREER: Faculty Early Career Development Program

CDI: Cyber-enabled Discovery and Innovation

CMG: Collaboration in Mathematical Geosciences

EMSW21: Enhancing the Mathematical Sciences Workforce of the 21st Century

FRG: Focused Research Group

IGMS: Interdisciplinary Grants in Mathematical Sciences

MCTP: Mentoring through Critical Transition Points

MSPRF: Mathematical Sciences Postdoctoral Research Fellowship

REU: Research Experiences for Undergraduates

RTG: Research Training Group

RUI: Research in Undergraduate Institutions

VIGRE: Vertical Integration of Graduate Research and Education

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

A.1 Questions about the quality and effectiveness of the program's use of merit review process. Provide comments in the space below the question**.** Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	
1. Are the review methods (for example, panel, ad hoc, site visits) appropriate? Comments: **Group A**: Panel review is a major improvement over mail review. The committee feels the system works well and should continue. **Group B**: Panel reviews are more effective and fair because of the evolving interactive assessment. However, for programs that are very broad, mail reviews may be needed to provide additional expertise to review technical aspects. Including mail reviewers on a conference call could help preserve the interactive process. Grouping into "thirds" (top 3rd, middle 3rd etc.) is very effective in ranking proposals. Currently, proposals of an interdisciplinary nature submitted to "disciplinary" programs, such as Mathematical Biology or Applied Math, are reviewed by disparate panels and ranked alongside those reviewed by a single panel. So that they can be reviewed positively by one and negatively by the other. Alternative mechanisms for review should be explored. For example, the experience with Interdisciplinary Programs shows the value of mixed panels to evaluate such proposals. Increasing the mix on panel membership would be helpful. The use of additional mail reviews with remote conferencing might help. Also, one can convene an ad hoc virtual panel with appropriate expertise to evaluate a small number of orphaned interdisciplinary proposals. **Group C**: We reviewed panel-only reviews (equalization meeting). Generally the process is effective, though we suggest more reviewers per panels, about 6-8 proposals per reviewer. The current workload seems too high leading to many of the reviews being extremely brief. A smaller workload per reviewer would allow for more constructive feedback to be provided to the PIs. The process of having reviewers physically in the same room is good and should be maintained. It would be useful if reviewers acknowledged the strength and confidence in their rating, and expertise in the field. This would allow panels and POs to more	Yes

properly weight different reviews of the same proposal. External written reviews submitted to panels were often not very useful, because they lack comparative information. The NSF might consider asking external reviewers to compare and/or rank several proposals, as the panels do. At times the summaries do not convey a faithful consolidation of individual opinions. While this is natural given the discussions that happen during a panel, when it does happens there is a strong need for an indication why there is a discrepancy.	
2. Are both merit review criteria addressed in individual reviews? In panel summaries? In Program Officer review analyses? Comments: **Group A**: In individual reviews? Yes, in most. In panel summaries? Yes, panels did an outstanding job. In Program Officer review analyses? Yes, they did an excellent job. **Group B**: There is a need for better understanding of the Broader Impact criterion by applicants as well as panelists. The GPRA data shows that 96% addressed both criteria in 2009 but the interpretation of BI seems to vary. It may be helpful to introduce a quantitative score of the BI component of proposals. **Group C**: Yes to both review criteria. Program Officer review analyses are generally very thorough and complete the process. However the panel summaries are often weak and in need of improvement. There is a concern with how Broader Impact is addressed. It was a concern when the only Broader Impact a panel cites for a proposal involves the PIs status as a member of an under-represented group. We refer here only to the broader impact criterion: (a) for individual reviews this is rarely addressed in a meaningful way, (b) for the majority of panel summaries it is addressed, and (c) it is always addressed by the PO comments. The intellectual impact is always addressed well. We suggest that reviewers could be provided with a template to help them model their response to the broader impact criterion.	Yes

3. Do the individual reviewers provide substantive comments to explain their assessment of the proposals? Comments: **Group A**: Yes, to a varying degree. Reviewer comments summarized strengths and weaknesses, and in declinations specifically spelled out the latter. **Group B**: By and large this is true and often there are many insightful comments. At the same time it is clear that there are reviewers who give only cursory remarks. The practice of the panel members self-assessing their expertise relative to the proposals prior to the panel, seems very effective and should be applied in all disciplinary programs. It may be good to preserve this information in the record. **Group C**: The reviews could be more substantive if the workload on panelists was reduced. More detail on how specific questions should be addressed could be provided to panelists such as: What is meant by merit? Innovative? Risk? Perhaps more specific questions/guidance to the reviewers would be useful. Also a need to define common criteria for E/VG/G/F/P ratings. We observed great variation among reviewers in the use of grading criteria. In the best case, the reviews provide expert appraisals of the research projects. Often however, they simply briefly summarize the contents of the proposal and offer a neutral opinion. See (1): it's important for a review to convey how much weight their opinion should carry. If a reviewer gives a ranking of "Good", the review should explain why the proposal was not ranked more strongly.	Yes
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Comments: **Group A**: Brief but thoughtful reasons are provided. The PI will have the sense of the panel from the summaries. **Group B**: For declined proposals some quantitative information on the % of funded proposals is helpful, when provided. **Group C**: Many panel summaries are good, with some in need of improvement. In many cases, the panel summary is one of the weak points of the overall review – too brief and merely repetitive with the review comments.	Yes

See (1): sometimes there is an unexplained loss of enthusiasm between the individual reports and the summary. A more thorough panel summary, that reflected information that arose during the panel discussions, could be an invaluable resource to PIs.	
5. Does the documentation in the jacket provide the rationale for the award/decline decision? (Note: Documentation in jacket usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), program officer review analysis, and staff diary notes.) Comments: **Group A**: The program officers provide useful and detailed analysis. The diary notes and review analysis provide extremely useful information. **Group B**: It is rather hard to follow the paper trail. For instance, hard to connect the panel notes with actual decision, which is not on the same web page. Requires manual search of a large database. It would be better if the diary notes were complemented by a clear trail leading from the panel ranking to the final decision. For instance, there could be an annotated list of panels and panel rankings. In addition, it would be useful to include information on which proposal received a final decision after the panel meeting and which proposals were placed in some other process (e.g., additional reviews, equalization). Another helpful item would be to easily find in which cases the ordering of the panel was reversed and what was the rationale. It is not easy to find or guess such rationale in individual cases. **Group C**: Very good documentation – auditable process. The jacket appears to be rather detailed and complete.	Yes

6. Does the documentation to PI provide the rationale for the award/decline decision? (Note: Documentation to PI usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written or telephoned with diary note in jacket) of the basis for a declination.) Comments: **Group A**: The program officer explanations are sufficiently thorough. The feedback process seems to be working well. **Group B**: Meaning of "resubmission encouraged" may not be clear to the PI. As it is, there is no mechanism to treat resubmissions in any special way. It may be wise to not use this expression but give a more clear indication of the ranking of the proposal in the batch. As before, some % estimate of funded proposals would be helpful. **Group C**: Explanation and other documentation were found to be very good within the computational math area. Within the Topology and Geometric Analysis area we found that it was in general good, but not always. In addition, it is not clear how a PI can request further information regarding a decision when the information to which they have access does not appear to be consistent. This can be an issue if a PI feels a funding decision is inappropriate.	Yes
7. Is the time to decision appropriate? Note: Time to Decision --- NSF Annual Performance Goal: For 70 percent of proposals, inform applicants about funding decisions within six months of proposal receipt or deadline or target date, whichever is later. The date of Division Director concurrence is used in determining the time to decision. Once the Division Director concurs, applicants may be informed that their proposals have been declined or recommended for funding. The NSF-wide goal of 70 percent recognizes that the time to decision is appropriately greater than six months for some programs or some individual proposals. Comments: **Group A**: Improvement is apparent. Staff did an amazing job considering the impact of the ARRA volume and timing in 2009.	Yes

Group B: In 2007-8 this ambitious goal has been met. 2009 seems to have been an exception because of the arrival of the ARRA money late in season. This represented a 50% surge in the whole activity with no additional staff. The NSF should be commended for this service under these exceptional circumstances.

Group C: Others years were better than FY09 (ARRA-funding). Overall acceptable. Clearly there were delays in 2009 because of the stimulus package (ARRA). There is some concern that long delays (greater than 9 months) may cause a declined PI to miss a review cycle. Overall though this time to decisions seemed appropriate.

Additional comments on the quality and effectiveness of the program's use of merit review process:

Group A: The process works well. The committee commends the work of the panels, program officers and staff. Proposals in fields that crossed over two areas were reviewed in both areas, which resulted in effective decisions.

Group B: In spite of all the logistical difficulties, it works remarkably well. The panel review system provides a much needed interactive procedure. We would like to suggest exploring additional locations to hold panel meetings. Institutes already funded by the NSF might help provide logistics. Also, the idea of virtual panels deserves more exploration.

Group C: Overall positive merit review is handled well. Broader Impact and Panel Summaries are in need of improvement – but this is not particular to Computational Math or DMS. Although there are minor problems, overall the process is surprisingly effective. Participants on panels found the experience valuable and informative.

A.2 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	
1. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: **Group A**: The panel process seems to be working well with a good mixture of expert reviewers, with a broad knowledge of the field, in each panel. Where appropriate, multiple panels are convened for a given program, for example, separate panels in probability and in finance, when numbers warrant. **Group B**: Virtually all the time, with some occasional anomalies here and there. Mostly very good selection. **Group C**: Reviewers had the right background/expertise. Their comments give evidence of the technical depth of the reviewers. Makeup of panels is generally very good. Perhaps teleconferencing or expanded use of reviews by mail (in which reviewers would be sent many proposals) would bring more participants who are unable to easily serve on panels into the process.	Yes
2. Did the program use reviewers balanced with respect to characteristics such as geography, type of institution, and underrepresented groups? Comments: **Group A**: We commend the program officers for assembling diverse panels. **Group B**: The % of reviewers from underrepresented groups has gone up from 24% in 2002 to 36% in 2009 per GRPA Performance Indicator. Geographic data statistics is cumbersome to judge. Low acceptance rate for panelists complicates the assessment. **Group C**: It is important for younger researchers to be involved in the review process. If possible, this type of data should be recorded and tracked.	

3. Did the program recognize and resolve conflicts of interest when appropriate? Comments: **Group A**: Jacket summaries include careful and precise descriptions of the procedures followed in resolving conflicts of interest. **Group B**: We feel that the NSF is very effective in handling the COI issues. In a few cases it did happen that such issues were recognized only after the conflicting report is released to the panel. The effect of incidents like this on the outcome is hard to gauge, so it is in the interest of the proposers to exercise diligence in filling the COI form. **Group C**: The minutes give careful notes on declared conflicts of interest. The review process in fact sometimes suffers, because expert reviewers cannot participate due to a mild `conflict of interest'. If anything the current conflict of interest policy is overly strict.	Yes

Additional comments on reviewer selection:

Note: Demographic data is self-reported, with only about 25% of reviewers reporting this information.

Group A: Examples of common sources of conflict of interest (e.g., a panelist's spouse or domestic partner applying to that panel) could be supplied to potential panelists early on, as a way of identifying such conflicts prior to convening a panel. A checklist for possible conflicts of interest could be included. We recognize that reviewer selection is difficult. The program officers have been effective.

Group B: The response rate for serving on the panels seems to have increased from (the very low, in our opinion) 25% in 2007. It would be good to educate the community about the importance of this service. Impressive quality nevertheless. Giving more of an advance notice would ensure a higher response rate.

Group C:

A.3 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	
1. Overall quality of the research and/or education projects supported by the program. Comments: **Group A**: Overall quality of funded projects was excellent. **Group B**: Excellent. Very high quality. Many breakthroughs. **Group C**: High quality of the funded research, although there were some minor concerns within the computational math area. The quality of supported research is extraordinary, and much more could be supported without loss of excellence. A wide range of educational benefits, to both graduate students and undergraduates also results from funding in this area.	
2. Does the program portfolio promote the integration of research and education? Comments: **Group A**: Yes, especially through workforce programs. VIGRE was effective and this is continued through the Research Training Group (RTG) and the Mentoring through Critical Transition Points (MCTP) programs. **Group B**: Infrastructure programs include funding for conferences with special emphasis on graduate student support. Very important. **Group C**: Funding of conferences, graduate students and other workforce programs is integrated into research funding in a productive and beneficial way. Both research and education benefit.	Yes

3. Are awards appropriate in size and duration for the scope of the projects? Comments: **Group A**: In the past the size of awards and their durations did not seem to be adequate for the projects and their impact on the competitiveness of the nation. This improved in 2009 due to ARRA. Our committee hopes that funding will continue to increase to meet the goal of doubling the NSF budget that began in 2008. **Group B**: Some subcommittee members feel that more 5yr individual awards would be a wise investment. Others felt the current balance is appropriate. However, for Interdisciplinary Projects 5 yr awards are already standard for a good reason, and the subcommittee members were in agreement about that. **Group C**: Modest size and typical 3-year duration is appropriate for the scope of the proposed projects. There are some concerns that funding of graduate Ph. D. students is uneven, and that some productive PIs should be granted more funding for students. Funding for projects in mathematical research should also be comparable to support for theoretical physics. There is some concern that in a few areas postdocs are funded on individual grants, leading to imbalances between fields. This can lead to misunderstandings in PIs' departments concerning what the DMS funds and what their corresponding postdoc funding policies are.	Yes
4. Does the program portfolio have an appropriate balance of: • Innovative/potentially transformative projects? Comments: **Group A**: Yes. Potentially transformative research has always been encouraged, and there are many examples of great success. We are confident this will continue. **Group B**: It would be good to encourage proposals that include more innovative components. It may be a good idea to quantify the transformative potential of the proposals as a part of the Intellectual Merit criterion. **Group C**: Definition and examples of what these terms mean are in need of clarification and documentation. A Dear Colleague Letter could be helpful. The period under review features many revolutionary mathematical developments, which are well recognized and supported through the NSF. As just one example, the FRG of Colding-Gabai-Minicozzi aims to capitalize on the huge recent advanced regarding Ricci flow to solve central problems in 3-dimensional topology, such as the virtually Haken conjecture.	Yes

5. Does the program portfolio have an appropriate balance of: • Inter- and Multi- disciplinary projects? Comments: **Group A**: There is significant interdisciplinary work in analysis, probability, and statistics. Improving interaction between statistics and computational mathematics could present further opportunities for the analysis of high-dimensional and massive data. **Group B**: We would like to see more solicitation for such proposals. What has been successful so far is the targeted ID solicitations such as CMG, NIGMS, MSPA-MCS. Individual disciplinary programs do not have resources to support ID research on a wider scale. It may be wise to have special funds available for such "fractional funding". **Group C**: NSF-DTRA, FRG, CMG. Program has strong co-funding arrangements with other NSF programs. It was unclear what defines disciplinary versus multi-disciplinary for computational math? The Topology and Geometric Analysis portfolio of funded projects contains many solid examples of work crossing disciplines within mathematics and within science. At the same time, there is some concern that funding for essential core mathematics may suffer in competition with the push for interdisciplinary initiatives.	

6. Does the program portfolio have an appropriate balance considering, for example, award size, single and multiple investigator awards, or other characteristics as appropriate for the program? Comments: **Group A**: Yes, but there remains much room for improvement regarding award size. **Group B**: Advantages and disadvantages of submitting joint proposals are not made clear. More guidance to potential proposers would be desirable. **Group C**: Number of large awards (e.g. FRG) seems about right. Combination of single-investigator and collaborative research projects is appropriate. It is clear that there is plenty of unfunded excellence, and that even small grants to these unsupported individuals would have a large impact on their careers and research programs.	Yes

7. Does the program portfolio have an appropriate balance of: • Awards to new investigators? NOTE: A new investigator is an investigator who has not been a PI on a previously funded NSF grant. Comments: **Group A**: A significant and needed improvement was seen in 2009. This remains a concern of the committee. We encourage DMS to increase the size of MSPRF while insuring the diversity of awardees. **Group B**: Good the way it is. No need to go further. **Group C**: Data shows increase in percentage of awards going to new investigators from 2007 to 2009. This is a positive trend. Especially with ARRA it has been possible to bring many new investigators under NSF support. Other programs such as CAREER have also benefited young researchers.	Yes
8. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments: **Group A**: **Group B**: **Group C**: This is difficult to ascertain from the data that the committee was given, at least in the time frame that we had.	Yes
9. Does the program portfolio have an appropriate balance of: • Institutional types? Comments: **Group A**: Yes, but some concern was expressed about the low number of RUI proposals submitted and funded. Improved solicitation may help. **Group B**: Although a large % of RUI proposals is funded, there seems to be a shortage of high quality proposals for RUI.	Yes

Group C: The entire spectrum of institutions is represented, including private, state, 4-year colleges, and 1st and 2nd tier universities.	
10. Does the program portfolio have an appropriate balance: ▲ Across disciplines and sub disciplines of the activity? Comments: **Group A**: **Group B**: Over time, some sub-disciplines grow/decline in importance and therefore the level of competition in the area changes. It would be good to have a mechanism to address this issue. We are not aware of a mechanism of equalizing between the programs. **Group C**: Not obvious how to define disciplines versus multi-disciplinary research for Computational Math. Program seems to have a good balance of different kinds of research and different applications. Some potentially transformative projects are not well funded simply because they do not fit clearly into an existing NSF category.	
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: **Group A**: While the overall participation of underrepresented groups is low, the programs are working effectively in some areas, such as in the success rate of applicants. Some areas are doing better than others, such as the analysis program's success rates. For women, there has been an improvement in statistics and probability programs, especially in 2009. However, no significant improvement in the success rate was observed in 2009 for minority applicants in statistics. The panel hopes that continued emphasis will be placed on funding postdocs from underrepresented groups, since this will help in the future to address the especially low numbers of these groups among senior faculty. **Group B**: Some progress with participation of women, less so with other underrepresented groups.	

Group C: Percentage of proposals awarded to women is reasonable and increased from 2007 to 2009. Percentage of proposals awarded to minorities is extremely low. Proposal award rates are acceptable, but work on soliciting more proposals from underrepresented groups is needed (i.e. increase the pool of proposals and not just the award rate). The NSF is clearly making great efforts in this difficult area, but more could be done to encourage high-quality proposals from underrepresented groups.	
12. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports. Comments: **Group A**: Absolutely. Here are some examples: Developments in compressive sensing by Richard Baraniuk and Kevin Kelly at Rice University were selected by Technology Review in October 2007 as one of ten significant emerging technologies for the year. The work of the University of Maryland mathematician Doron Levy paves the way for new therapies for curing myelogenous leukemia (CML). The Probability Program is to be commended for being a part of the topic area AMC-SS. AMC-SS exists to consider the interdisciplinary research of stochastic systems as a division-wide focused topic area. This is in response to the surge of research activities within the mathematical sciences community on analysis, modeling, and computation of inherently stochastic systems. The Statistics Program's support for doctoral graduate students in the field helps to meet the growing national demand for the high level expertise of those who can use, analyze and make sense of the explosion of digital data. For Today's Graduate, Just One Word: Statistics 08/05/09 New York Times Technology By Steve Lohr http://www.nytimes.com/2009/08/06/technology/06stats.html?em Scientific American Reuters - June 19, 2008 Approach enlists immune system to fight leukemia	Yes

Leukemia patients may be able to avoid developing resistance to the drug Gl...
By Julie Steenhuysen
CHICAGO (Reuters) - Leukemia patients may be able to avoid developing resistance to the drug Gleevec through ahttp://www-users.math.umd.edu/~dlevy/press/45.pdf
mathematical formula that predicts when they should receive an immune-boosting vaccine, researchers said on Thursday.

This info comes from http://www-users.math.umd.edu/~dlevy/press/45.pdf

Medical New Today

Mathematical Modeling May Help Leukemia Therapy
Editor's Choice
Main Category: Blood / Hematology
Also Included In: Cancer / Oncology
Article Date: 27 Jun 2008 - 0:00 PDT
email to a friend printer friendly view / write opinions rate article
A study published in the open-access journal PLoS Computational Biology demonstrates how
sophisticated mathematical modeling has encouraged the development of an optimally-timed vaccine for
chronic myelogenous leukemia (CML)

Researchers Doron Levy (University of Maryland), Peter P. Lee (Stanford University),and Peter S. Kim (École Supérieure d'Électricité,Gif-sur-Yvette, France) collected data over four years from CML patients who were receiving therapy with the drug imatinib. They then developed a mathematical model that uses a patient's natural anti-leukemia response when treated with imatinib to improve leukemia treatment. More information can be found on the website: http://www-users.math.umd.edu/~dlevy/press/4.pdf

Group B: Yes, see Part B for examples.

Group C: The Committee feels that the computational math program is extremely relevant, but that relevance is not well articulated to the broader community. A minor example of this is in the mission statement on the Computational Math homepage, which could highlight this relevance much more clearly (current mission statement “The prominence of computation in the research is a hallmark of the program” is interpreted as vague/weak).

On the other hand, the ADT (joint DMS and DTRA) program is a success story of how computational research can be used to create new and transformative algorithms for threat reduction and detection of chemical and biological materials to aid in decision making and public safety. The computational math program also has a strong component in signal and image analysis to address the challenges in the

digital age. Some notable accomplishments include the work of Candes and Tao (NSF Waterman Award, 2006), who proved that a large but low rank matrix can be recovered from a few randomly selected entries with high probability by minimizing the L1 norm of the vector consisting of singular values. The problem is also known as the Netflix problem for predicting customer rankings of on-line movies. Other applications include structure from motion (inferring scene geometry from video where incomplete data may be due to occlusion or tracking failure). In 2008-2009, Candes and coworkers developed singular value thresholding (SVT) method for computing large matrix completion problems. Low rank and sparsity are used to keep data storage low. The SVT method can be formulated as a linearized Bregman iteration.

Another good example is the work of Ingrid Daubechies (CMG-0530865, DMS-0914892) who developed the L1 regularized wavelet coefficients method for tomographic inversion with applications in geophysics, and image processing for artist identification. Ingrid Daubechies is the recipient of 2007 ICIAM Pioneer Prize.

Andrea Bertozzi (DMS-DTRA, 0914856, AAAS fellow 2010) and coworkers developed boundary tracking algorithm for segmentation of high dimensional data such as hyper-spectral images or tracking object in many frames of videos. Applications include atomic force microscopy (AFM) imaging, control of AFM tip for real time data collection, as part of her CDI project joint with Lawrence Berkeley National Lab (CDI-0940417).

Ronald Devore (DMS-DTRA, 0915231) established the connection of compressed sensing and best k-term approximation, found deterministic construction of compressed sensing matrices, developed iteratively reweighted least squares minimization for sparse recovery (joint with Daubechies and others), and fast point cloud surface reconstruction algorithms. He received the 2007 SPIE Wavelet Pioneer Award.

Weinan E (DMS-0914336) developed sublinear scaling subspace iteration algorithms for electronic structure analysis and density functional theory. He received the 2009 SIAM Kleinman Prize.

Mathematics forms the foundation of the entire national scientific enterprise. The NSF does an outstanding job of recognizing the importance and impact of basic research in the area of Topology and Geometric Analysis.

13. Additional comments on the quality of the projects or the balance of the portfolio:

Group A: The Committee found that the projects are of very high quality. The proposals funded from the ARRA were as good as those funded through regular appropriations. This group encourages multiple panel reviewing, when appropriate, leading to better quality inter- and multi-disciplinary projects. It was suggested to pursue the enhancement of innovative and potentially transformative projects through the creation of ad-hoc panels or reviewing mechanisms such us AMC-SS that may identify new ideas that may have been overlooked at the classical program panels.

Group B: The overall quality of the projects is extremely high. Unfortunately, many excellent proposals remain unfunded.

Group C: We are very concerned with the large number of excellent research proposals that were rejected for funding. Even in the context of ARRA funding, it is clear that there is a need more support. It also seems likely that the pool of high-level proposals would be even larger if more were accepted. Finally, increased support for mathematics would bolster, on a national level, the recognition of the central importance of mathematics and science in the 21st century.

A.4 Management of the program under review. Please comment on:

1. Management of the program.

Comments:

Group A: We were very impressed with the professionalism of the program officers, whose reports gave concise but informative descriptions of the review process and the substantive issues that arose during reviews.

In the last COV report, the need for a permanent statistics officer was noted. We're happy to see that has been done.

Group B: It is important that the program officers have discretion to take into account factors other than the panel rankings.

Group C: Both programs selected panelists across a wide spectrum of experts including universities, National Labs, DOD, and DOE. This helps maintains a healthy state-of-the-art research direction with both the theoretical and practical significance. In addition, the management of the Institutes was exceptional as evidenced by dealing both thoughtfully and thoroughly with several thorny issues arising over the review period.

2. Responsiveness of the program to emerging research and education opportunities.

Comments:

Group A: The speedy actions of DMS with respect to ARRA funding gave evidence of DMS's responsiveness to this issue. Initiating a special postdoctoral program through the mathematics research institutes was a creative and effective way of creating employment for postdocs, enhancing their research expertise and ultimately improving the quality of the nation's future academic faculty.

Group B: Focused Interdisciplinary programs provide timely response to new opportunities. At the same time, changes in the relations of the existing disciplines are harder to respond to on organizational level. Still, program officers respond to such changes in a timely fashion.

Group C: The Computational Mathematics program responded to one emerging research area by launching the ADT program. It also reacted quickly and effectively to ARRA opportunities, funding many excellent proposals in a timely manner.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments:

Group A: Program managers were sensitive to the evolution of fields, and incorporated this into planning for future years. The panel noted the flexibility of the program officers in the face of changing circumstances.

Group B: The equalization within a program is a part of this process. Another instance of this process is cost sharing between different programs or Directorates. We appreciate that the programming priorities and allocations do evolve to reflect the quality and distribution of proposals.

Group C: Some areas within the Computational Mathematics program have a well-developed vision of computational issues related to national priorities. The program officers were involved in planning joint brainstorming workshops with DOD to attract funding opportunities for university researchers and integrating advanced mathematics with defense applications.

4. Responsiveness of program to previous COV comments and recommendations.

Comments:

Group A: The DMS has been highly responsive to previous COV recommendations, when those recommendations involved internal DMS policies, or analysis and collection of internal DMS data. Where collection of external data was suggested, DMS has sometimes been unable to comply (e.g., the demographics of mathematics PhDs), but when possible has brought in external assistance (e.g., assessing the impact of the institute program)

Group B: The DMS did a thorough job of clarifying the meaning of the Broader Impact requirement for the community, which was a major recommendation of the 2007 COV. We commend their continuing effort in this direction. Also, careful consideration is being given to junior investigators, as recommended in 2007. The participation of women and underrepresented minorities has been broadened. The use of panels became more common, per recommendations.

Group C: The DMS was highly responsive to the previous COV comments. The new study that was commissioned to investigate the broader Mathematics Institute portfolio is well thought out and has a great chance of successfully completing its goals. The COV was impressed with the results so far and the project plans. We look forward to the results of this study to help answer this important question.

5. Additional comments on program management:

Group A: Here is one idea that may be specific to the field of probability. A major subset of the applied probability community works in the field of operations research. NSF proposals in operations research may not be sent to DMS. This could skew the count on the number of under-represented minorities doing research in probability. To remedy this, one should keep track of two numbers. The first number is already being complied, the number of under-represented minority proposal applicants and awardees in probability. The second number would be to compile the number of applicants in applied probability inside and outside of DMS. This would be similar to the spirit of AMC-SS.

Group B: The DMS staff (including program officers) are to be applauded for exceptional job of handling the increased workload related to the ARRA funds, without the benefit of any additional resources.

Group C: The Computational Mathematics program prompted its researchers to transform mathematics education with new teaching methods based on information processing in the digital age.

PART B. RESULTS OF NSF INVESTMENTS

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The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award "highlights" as well as information about the program and its award portfolio as it relates to the three outcome goals of Discovery, Learning, and Research Infrastructure. The COV is not asked to review accomplishments under Stewardship, as that goal is represented by several annual performance goals and measures that are monitored by internal working groups that report to NSF senior management.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 <u>OUTCOME GOAL for Discovery: "</u>*Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering."*

Comments:

Group A: Below are examples of excellent research on important topics funded by the DMS.

Random Matrices
Random Matrices and Applications, Jinho Baik, University of Michigan Ann Arbor, (DMS-0457335)
Asymptotics of Determinants of Perturbations of Convolution Operators, Estelle Basor, California Polytechnic State University Foundation, (DMS-0500892)
Spectral Problems and Inverse Spectral Problems, Percy Deift, University of Pennsylvania, (DMS-0003268)

Poincare Conjecture Update
Topology of Manifolds and Algebraic Varieties, John Morgan, Columbia University, (DMS-0706815)
Geometrical Differential Equations and Applications, Gang Tian, Princeton University, (DMS-0703985)

Recent Progress on Quantum Unique Ergodicity
Topics in the Analytic Theory of L-Functions, Kannan Soundararajan, Stanford University, (DMS-0739562)
Rigidity, Entropy and Arithmetic in Homogeneous Dynamics, Elon Lindenstrauss, Princeton University, (DMS-0800345)

Progress in Positive Curvature
Parabolic Problems in Conformal Geometry, Simon Brendle, Stanford University, (DMS-0605223)
Differential Geometry and Partial Differential Equations, Richard Schoen, Stanford University, (DMS-0604960)
Workshop on Global Riemannian Geometry, Frederick Wilhelm, University of California-Riverside, (DMS-0813659)

Patterns in Tiles -- Penrose Tiling
Subfactors and Planar Algebras, Dietmar Bisch, Vanderbilt University, (DMS-0653717)

High Dimensional Data
High Dimensional Data: New Phenomena and Theory in Modeling and Approximation, Iain Johnstone, Stanford University, (DMS-0906812).
Inference in High Dimension: Statistics, Computation and Information Theory **,** Bin Yu University of California, Berkeley (DMS-0907632*)*
Monte Carlo and reconfigurable Computing in Bayesian Inference **,** Wing Wong Stanford University, (DMS-0906044).

Group B: Truly outstanding results have been achieved by DMS supported researchers. The Division can be justifiably proud of the world-class research coming out of the support.

ANTC highlights; C, Hacon (Utah, DMS-0757897) and J. McKernan (MIT, DMS-0701101): work on birational classification of algebraic varieties: major breakthrough in algebraic geometry. R.Parimala (Emory, DMS-0653382): plenary ICM-2010 speaker

M. Kisin (Harvard, DMS-0701123) and M. Emerton (Northwestern, DMS-0701315): advances on the p-adic Langlands program and the Fontaine-Mazur conjecture. T. Gee (DMS-0841491) and R.Taylor (Harvard, DMS-0600716): proof of the Sato-Tate conjecture and its Hilbert modular form analogue.

Foundations highlights: C. Rosendal (UIUC DMS-0901405): work on Banach spaces addresses classical problem of analysis. J. Steel (UC Berkeley, DMS-0855692): advances in inner model theory. W.H. Woodin (UC Berkeley, DMS-0856201): plenary ICM-2010 speaker.

Mathematical Biology highlights: D. Levy (Maryland, DMS/NIGMS 0758374): fundamental work on math modeling of Leukemia treatment.

Applied Math highlights: Haller (MIT, DMS-0404845): century old problem in fluid dynamics solved. Vanden-Ejiden (NYU, DMS-0708140) Transition pathways and rare events in dynamical systems. K. Promislow (Michigan State, IGMS-0929189): Modeling of hydrogen fuel cells.

Group C: The megaprogram Topology and Geometric Analysis has funded research leading to a great many fundamental advances in the review period. Highlights include Taubes' solution to the Weinstein conjecture (recognized by the Clay Research Award and NSA Award in Mathematics in 2008 and the Shaw Prize in 2009), the solution to long-standing Kervaire conjecture by Hill, Hopkins and Ravenel, and the determination of the smallest volume hyperbolic 3-manifold by Gabai and Meyerhoff.

In addition to such specific breakthroughs, there have been notable advances in the whole approach to problems in low-dimensional geometry and topology, born out of interactions with symplectic geometry, visible in the work of Kronheimer-Mrowka and Oszvath-Szabo recognized by the Veblen Prize in 2007.

As an example of NSF support for work by younger mathematicians, Maryam Mirzakhani (in collaboration with Eskin, Lindenstrauss and others) continues to make notable advances at the boundary of ergodic theory and the theory of Riemann surfaces.

The COV happily notes that 4 out of 10 CAREER awards in Geometry and Topology during the 2007-2009 time frame were awarded to women.

The Computational Mathematics program supports a broad range of projects that are developing cutting edge numerical algorithms. For example, new mathematical tools are being developed to advance state-of-the-art signal processing capabilities in the digital age, thus enabling new cross-fertilization in multidisciplinary areas and potentially transformative research results. Other examples of the new computational mathematics developed in the program have many other important application areas, such as computational fluid mechanics, medical imaging, modeling of tiny grains in polycrystalline materials and computational geometry. At the same time, there are clear opportunities for new growth in the program (e.g. fundamental algorithms for new computer architectures, links to statistics) that should be considered.

Osher (UCLA, DTRA/ DMS-0914561, DMS-0835863, DMS-0714807), Yin (Career DMS-0748839): discovery and development of fast Bregman iterations for computing L1 minimization with applications to compressed sensing, blind signal and image recovery. Candes and Tao (NSF Waterman, 2006) proved exact low rank matrix completion with high probability from few random entries, and related singular value thresholding algorithm by Candes and coworkers. Daubechies (DMS-0504924, DMS-0530865, DMS-0914892), Devore (DTRA, 0915231) for their work on iteratively re-weighted least squares minimization for sparse recovery, L1 methods on wavelet domain, and fast point cloud surface reconstruction algorithms; Bertozzi (DMS-DTRA, 0914856) for her work on boundary tracking algorithms of segmentation of high dimensional data. Weinan E (DMS-0914336) developed sublinear and linear scaling subspace iteration algorithms for electronic structure analysis.

The computational mathematics program brought up a new generation of excellent young researchers: Selim Esedoglu (U Michigan, DMS-0748333, DMS-0713767), Lexing Ying (U Texas Austin, DMS-0846501), Wotao Yin (Rice U, DMS-0748839), all Career award recipients and Sloan fellows, to name just a few.

B.2 OUTCOME GOAL for Learning: "*Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.*"

Comments:

Group A: A few examples from among the many highlights of DMS suffice to illustrate the effectiveness of DMS in reaching the learning outcome goal:

Len Stefanski, Professor of Statistics at NC State University (NCSU) has developed a clever, entertaining and effective way to impress upon students the importance of regression, while also teaching good statistical practice. He engineered a method of embedding "hidden" messages or images in large complex data sets that are revealed only via careful and sophisticated application of statistical regression methods. The image appears at the final stage of analysis when students look at so-called residual plots --- graphical displays that provide visual clues as to whether a data analyst's regression modeling is deficient in any way. (DMS-0504283)

The EDGE Program, jointly funded with the Andrew W. Mellon Foundation, is designed to strengthen the ability of women and minority students to successfully complete graduate programs in the mathematical sciences. The summer program consists of two core courses in analysis and algebra/linear algebra, in addition to mini-courses in vital areas of mathematical research, short-term visitors from academia and industry, guest lectures, graduate student mentors, and problem sessions. In addition, a follow-up mentoring program and support network was established with the participants' respective graduate programs. Participants in the program were women who were graduating seniors who have applied to graduate programs in the mathematical sciences, recent recipients of undergraduate degrees who are now entering graduate programs, or first-year graduate students. (DMS-0209478)

Moebius transformations move points of the Euclidean plane around by a sequence of translations, rescalings, rotations, and inversions in circles. They are defined by formulas that are simple (in complex arithmetic) but have effects that are hard for many users to visualize, especially the effects of an inversion. *Moebius Transformations Revealed* is a short video by Douglas Arnold and Jonathan Rogness that depicts the beauty of Moebius transformations and shows how moving to a higher dimension reveals their essential unity. It was one of the winners in the NSF 2007 Science and Visualization. The video, which was first released on YouTube in June 2007, has been watched there by more than a million viewers and classified as a "Top Favorite of All Time" in the Film & Animation category. The video is available in a variety of formats at http://www.ima.umn.edu/~arnold/moebius/index.html. (DMS-0713568)

Undergraduate students Julianne Kulevich and Christopher Smith, advised by Professor Gareth Roberts of the Mathematics and Computer Science Department at the College of the Holy Cross, presented their research project to members of the U.S. Congress and other

distinguished visitors at the U.S. Capitol on April 30, 2008. Their presentation was part of the annual *Posters on the Hill* event sponsored by the Council on Undergraduate Research. Each year, sixty student posters, selected competitively from entries in all fields of science and social science, are displayed at the U.S. Capitol during a late afternoon reception. The program also features visits by students and their faculty mentors to their Representatives' and Senators' offices. Ms. Kulevich and Mr. Smith presented their original work on "Using Algebraic Geometry in the Circular, Restricted Four-Body Problem." This work forms a piece of ongoing efforts to solve the n-body problem, the problem of finding, given the initial positions, masses, and velocities of n bodies, their subsequent motions as determined by classical mechanics, that is, Newton's laws of motion and Newton's law of gravity. Despite its apparently straightforward nature, the n-body problem of mathematical physics has been open since the 19th century. (DMS-0708741)

The NSF provided partial support for a conference "Knotting Mathematics and Art: Conference in Low-Dimensional Topology and Mathematical Art" (PI Masahiko Saito, University of South Florida), which took place in Tampa, Florida on November 1-4, 2007 and had about 100 participants. The Advanced Mathematical Institute of the Osaka City University co-sponsored the conference, and over 25 Japanese mathematicians attended. Before the conference, undergraduate mathematics majors, members of the Math Club at the university, participated in a pre-conference workshop where they assembled a huge polyhedral sculpture of over 1000 pieces (it was a 120 cell, a projection in 3-space of a regular 4-dimensional polyhedron), which was exhibited in the main lobby of the Museum of Science and Industry. There were three accompanying art exhibitions, two at the galleries on the university campus, and one at the Museum of Science and Industry. (DMS-0726492)

Shelly Harvey from Rice University is a recipient of a CAREER award from the DMS. For the educational component of her project she proposed to establish a two-week summer mathematics program for high-school girls. The goal of the program is to introduce high-level abstract mathematics to the girls. The first such workshop took place on June 16-27, 2008 on the Rice University campus. Harvey received over 75 applications from 13 different high schools and accepted 20 of those students. The teaching staff consisted of Harvey, a postdoctoral assistant and two graduate students, all female. The core of the program was a two-week course in knot theory, a branch of pure mathematics closely related to Harvey's research program. In addition, there were several individual modules on other parts of mathematics, including group theory, cryptography, countable and uncountable sets, probability, logic and proofs. Nearly all of these topics are not covered in a high school mathematics syllabus. Several connections were built between knot theory and the material developed in the modules. The participants also investigated some open problems. Harvey's intention was to introduce the students to the concept of research in mathematics and demonstrate that, unlike the homework that they do in their typical math classes, not all mathematics problems are already solved. (DMS-0726492)

The Workforce Program was particularly successful in its efforts in expanding the scientific literacy of the country. Let us cite a couple of examples.

Carlos Castillo Chavez of Arizona State University (DMS-0739195) has engaged in several outreach activities to encourage Hispanic American and Native American undergraduate students to enter PhD programs, especially ones in mathematical or computational biology. He has run summer institutes, and received the 2007 AAAS Mentor Award for his work.

Regarding individual accomplishments, UNC graduate student Joyce Lin has theoretically and experimentally demonstrated a notable counterintuitive phenomenon in fluid dynamics. In essence, "slow and steady wins the race": it is possible for a partial decrease in fluid density to retard the overall progress of a particle falling through the fluid. In view of density variations in atmospheric, oceanic, and other natural systems, this fundamental result has potential implications for understanding of a wide range of important processes, such as sedimentation, distribution of pollutants and biomass, and adaptation of marine organisms to their environment. The work has been accepted for publication in Physics of Fluids Letters, and was done in collaboration with RTG (DMS-0502266) PIs Roberto Camassa and Richard McLaughlin. Lin is currently working on her doctorate and is part of the VIGRE program at the University of Utah. (DMS-0602219)

Group B:

- Pavel Etingof (MIT, DMS-0504847) & Victor Ostrik (Oregon, DMS-0602263), both high level research mathematicians, were engaged in mentoring of high school students, who won prestigious awards:
- Intel Talent search 2009 grant won by E. Larson (Eugene OR) .
- Travis Schedler won 1997 Fifth Westinghouse Prize, while under direction of Etingof, and he is now himself a DMS-funded PI (DMS-0900233). This is an example of clear documentable success.
- Math Problems in Industry Workshop at U. Delaware (DMS-0753064), Rensselaer PolyTech
- (DMS-0753071), Worcester PolyTech (DMS-0753050):
- Park City Math Institute: annual integrated 3 week summer program with NSF support involving undergraduate and graduate students, high school teachers, postdocs and academic faculty (including extremely high profile researchers). Prime example of a fundamental education initiative that reaches out to the broader community.
- A yearly conference, supported by NSF, promoting the interaction of Math and industry. Industry contributes to expenses.
- SACNAS conferences (DMS-0938070): enhance the opportunities of minority students who wish to pursue advanced degrees in science.

Group C: The program has made outstanding contributions to this goal. As a few prime examples: through the NSF CAREER program, noted topologist Shelly Harvey has established a summer mathematics program for high-school students. Frank Morgan, an expert in minimal surfaces, has done a remarkable job of involving undergraduates in serious mathematical research. At the graduate level, Benson Farb (University of Chicago) has done an outstanding job of mentoring Ph. D. students and postdocs, many of whom have gone on to become leaders in their own right.

Computational Mathematics programs are also having significant broader impact. For example, Pasquali, Guidoboni, Glowinski (DMS-0811160) involves efforts to involve underrepresented minorities by participating in the activities of the Rice Alliance for Graduate Education and the Professoriate (AGEP) program.

Andrea Bertozzi led a training program in applied differential equations and scientific computing for undergraduate students (REU program supported by DMS-0601395) at UCLA. The training covered a broad range of topics: thin film flows, fluid mixing, statistical modeling of gang violence in Los Angeles, crime hotspots detection, simulation of movement of burglars, image processing, robotic path planning and visibility with limited sensor data among others, with students publishing research papers in the SIAM undergraduate journal. This program is a role model for REU activities in computational mathematics.

The Math Institutes are also to be commended for their support of conferences like SACNAS, CAARMS, and Blackwell-Tapia, all of which serve the underrepresented minority communities.

B.3 OUTCOME GOAL for Research Infrastructure: "Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools."

Comments:

Group A: The infrastructure of the mathematics research institutes has had a profound and sustained impact on research productivity in the mathematical sciences.

Group B: Applied programs such as MRI (includes DMS participation) and SCREMS

ICM travel grants: very important for maintaining global presence.

EDGE grant: Collaboration between Bryn Mawr and Spelman designed to strengthen the ability of women and minority students to successfully complete graduate programs.

IGMS grants send mathematicians to work in different environments: important for development of new expertise and ID connections.

Summer UG programs at MSRI-UP: funded by NSF. Some alumni already got NSF Graduate Fellowships.

Math Research Communities: initiative geared at early career mathematicians, holding week-long conferences. DMS-0751449.

Group C: Not applicable

PART C. OTHER TOPICS

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

Group A:

- There is a need to improve solicitation for and improve panel understanding of RUI.

- Steps to improve gender and minority representation are always important.

Group B:

- The budgets of ANTC and Foundations programs seem not to keep with the increased quality of proposals and to leave much unfunded excellence. It is particularly difficult to fund proposals involving applications of algebra.

- The reviewing of Math Bio proposals remains a challenge despite obvious importance of the discipline.

Group C:

- While the panel system is, in general, an excellent system for evaluating proposals, there is some concern for proposals that fall between the expertise of various panels. While this does not seem to be a systemic problem and the COV has no specific recommendations here, we hope this issue will be carefully considered when it arises.

- It would be beneficial to PIs, especially young PIs, to have the review process spelled out in a clearer fashion. For example, an explanation of the panel review process would make the review process more transparent, help the PI write a better proposal and inspire greater confidence among potential PIs.

C.2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

Group A, B, C:

- Concern about budgets for core programs was expressed!

C.3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance:

Group A:

- See previously noted concern regarding conflict of interest.

Group B:

- The DMS appears to not have enough program officers and administrative staff support. In particular, the ARRA funds presented additional burden. Also, training staff for new technologies is an important issue.

- Setting aside appropriate time for this training is essential and very difficult given the current workload.

Group C:

- Staff!!! Details to be provided by others.

C.4. Please provide comments on any other issues the COV feels are relevant.

Group A:

- Further clarification of the meaning of the terms “broader impact” and “potentially transformative research” and their importance should be provided and better disseminated.

Group B:

Group C:

- The COV feels the upper level leadership of the DMS provided by Peter March and Deborah Lockhart is impressive and inspires confidence. The engagement in the community is impressive and should be commended.

C.5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

Group A:

- Presenting the data in a panel-centric method would help the COV review process.

Group B:

- Better presentation of the data, more panel-centric would be very helpful.

Group C:

- The COV would benefit from a better initial summary of the panels that were held in a given area, panel rankings in that area and decisions in a given year. This is important top-level information that is difficult of obtain under the current system.

- Better access to aggregate data by subject area would make the COV's job much simpler. For example, overall funding rates, rates for young PIs, women, and underrepresented groups would be helpful; as would geographic data and data on institution type.

- A list of frequently asked questions for the COV, especially on various ways to access information in the e-jacket system, would be a great help to future COVs.

- It is good to try to have reasonable overlap between each COV (at least one person per subcommittee).

5. Responses to Additional Questions

This section contains the responses of each subcommittee to the additional questions provided by the DMS.

Question 1. Please comment on the response by the Division of Mathematical Sciences (DMS) to the previous Committee of Visitors report.

Group A: See Section 4.A.4, #4

Group B: Good and timely response, good follow through. Substantial progress has been made in educating panelists about broader impact criteria. Additional effort is needed to educate potential proposers.

Group C: The DMS's response to the previous COV report was good and thorough, but the DMS needs to continue to work on community understanding of broader impacts and how it figures into proposal evaluations. The Dear Colleague Letter that Peter March wrote in response to the last COV concerning broader impacts was helpful but should be revised to reflect the evolving understanding of the issue and needs to be more widely distributed, especially to PIs as they prepare their proposals.
The evaluation of data on the scope and effectiveness of Mathematical Institutes that the previous COV recommended has begun. The DMS is developing a careful and systematic way to collect this information. It is essential that this effort continue.

Question 2. The DMS received $98 million of the American Recovery and Reinvestment Act (ARRA) funds in FY 2009 and was given guidance to accomplish the following:

a. **create jobs;**
b. **support new investigators, including CAREER**
c. **support high risk/high impact and research supporting the priorities of the Administration, for example, climate and energy**

Please comment on the extent to which the DMS used ARRA funds effectively.

Group A: We believe staff used the funds very effectively, especially in its decision to support post-docs. See Section 4.A.4, question 2.

Group B: With the ARRA funds, DMS was highly successful in both creating jobs and supporting new investigators.

Group C: Many jobs were created using ARRA. In particular, expansion of the MSPRFs offered and the postdoctoral positions offered though the mathematical institutes was very effective. Funding more projects without issuing a second call for proposals was an excellent choice. Even given the extra funding there was still unfunded excellence. The data shows that there was a higher level of support for new investigators. Precisely the percentage of new PIs that were funded in Computational Mathematics increased from 24 and 28% in the previous two years to 33%, other areas saw similar increases.

The DMS was very effective in using the ARRA money. They managed to quickly and responsibly handle this exceptional event.

Question 3. Please comment on the size, scope, and effectiveness of the portfolio of national mathematical science institutes.

Group A:

Group B:

Group C: See Section 4.A on the Institutes.

Question 4. Please comment on the size, scope, and effectiveness of the DMS Workforce portfolio.

Group A: The workforce portfolio is valuable in training and integrating research, and will improve the demographics of the profession. We hope for increased funding levels especially for NSF postdocs program, MSPRF, in the future. Postdoctoral experiences enhance the competitiveness of the nation's research and improve the quality of the nation's future academic faculty. The effective use of ARRA funding shows that additional funding would be well used. We like the flexibility provided by the "unsolicited proposals" program. The Research Training Group (RTG) and Mentoring through Critical Transition Points (MCTP) programs are valuable evolutions of VIGRE. Such programs enhance the STEM workforce and the nation's competitiveness in math and science.

Group B:

Group C:

Question 5. Does the portfolio of research supported by the DMS provide appropriate collaborative opportunities between the mathematical sciences and other fields, both within the NSF and with other federal funding agencies?

Group A:

Group B: Yes. In particular, Focused Interdisciplinary Programs portfolio is one of the true success stories of the DMS. Their experience, especially with use of mixed panels, ought to be used in other areas.

Group C: The level of collaboration is appropriate and the DMS should continue to take advantage of such opportunities; however, it is important, moving forward, to be mindful not to neglect the DMS support for research in core mathematics.

Mathematical Institutes have played an important role in fostering collaborative projects.

SIGNATURE BLOCK:

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For the 2010 Committee of Visitors, Division of Mathematical Sciences
C. David Levermore, Chair

Appendix A.

Members of the 2010 DMS Committee of Visitors

Last name	First name	Institution
Avramov	Luchezar	University of Nebraska, Lincoln
Bernoff	Andrew	Harvey Mudd College
Bock	Mary Ellen	Purdue University
Boston	Nigel	University of Wisconsin, Madison
Cohn	Henry	Microsoft Research New England
Corlette	Kevin	University of Chicago
Etnyre	John	Georgia Institute of Technology
Fauci	Lisa	Tulane University
Fomin	Sergey	University of Michigan, Ann Arbor
Gamba	Irene	University of Texas at Austin
Gray	Genetha	Sandia National Laboratories-Livermore
Gutierrez	Cristian	Temple University
Kapranov	Mikhail	Yale University
Kosygina	Elena	Baruch College-CUNY
Kuperberg	Krystyna	Auburn University
Landwehr	James	Avaya Labs Research
Lee	Steven	Lawrence Livermore National Laboratory & DOE
Levermore	David	University of Maryland, College Park
Massey	William	Princeton University
McMullen	Curtis	Harvard University
Meza	Juan	Lawrence Berkeley National Laboratory
Milton	Graeme	University of Utah
Randoloph	Timothy	Fred Hutchinson Cancer Research Center
Renardy	Yuriko	Virginia Polytechnic Institute and State University
Salisbury	Thomas	York University
Savitt	David	University of Arizona
Schonbek	Maria	University of California, Santa Cruz
Sogge	Christopher	Johns Hopkins University
Wasserstein	Ronald	American Statistical Association
Willcox	Karen	Massachusetts Institute of Technology
Woodin	W. Hugh	University of California, Berkeley
Xin	Jack	University of California, Irvine

Appendix B.

DMS 2010 Committee of Visitors Subcommittee Assignments

Committee Chair: C. David Levermore

Subcommittee A

Analysis
Probability
Statistics
Workforce

Subcommittee A Chair: Mary Ellen Bock

Last name	First name
Bock	Mary Ellen
Gamba	Irene
Gutierrez	Cristian
Kosygina	Elena
Landwehr	James
Massey	William
Salisbury	Thomas
Schonbek	Maria
Sogge	Christopher
Wasserstein	Ronald

Subcommittee B

Algebra, Number Theory, and Combinatorics
Applied Mathematics
Foundations
Mathematical Biology
Infrastructure
Focused Interdisciplinary Programs

Subcommittee B Chair: Mikhail Kapranov

Last name	First name
Avramov	Luchezar
Bernoff	Andrew
Boston	Nigel
Fauci	Lisa
Fomin	Sergey
Kapranov	Mikhail
Milton	Graeme
Randolph	Timothy
Renardy	Yuriko
Savitt	David
Woodin	W. Hugh

Subcommittee C

Computational Mathematics
Topology and Geometric Analysis
Mathematical Sciences Research Institutes

Subcommittee C Chair: Juan Meza

Last name	First name
Cohn	Henry
Corlette	Kevin
Etnyre	John
Gray	Genetha
Kuperberg	Krystyna
Lee	Steven
McMullen	Curtis
Meza	Juan
Willcox	Karen
Xin	Jack

Appendix C: Conflict of Interest Report

The Division of Mathematical Sciences held its triennial Committee of Visitors (COV) on April 26-28, 2010. The COV was composed of 32 members from the scientific community chosen for their scientific expertise and awareness of developments in their respective fields of the mathematical sciences, as well as a sense of issues, perspective, and balance across the mathematical sciences. The 32 COV members composed a diverse committee with respect to geographic, institutional, gender, ethnicity, age, private sector, and scientific representation. The following table describes the main features of the COV with respect to these issues:

Category	Number
Member of MPS Advisory Committee	1
Academic Institutional Type	
Research	22
Comprehensive	0
4-Year	2
Public	14
Private	8
Industry	2
Government Laboratory	3
Government Agency	1
Non-profit Organization	1
Professional Society	1
Outside of U.S.	1
Location	
Northeast	8
East	4
Southeast	3
Midwest	6
Southwest	2
West Coast	8
International	1
Female	9
Minority	7
No DMS Proposal in Past Five Years	11

The COV was briefed on issues of Conflict of Interest for the purpose of one of the COV's statutory responsibilities, namely the reading of proposals, reviews, and recommendations, and commenting on the handling of actions and the appropriateness of recommendations. Each COV member completed an NSF Conflicts of Interest form. Known conflicts, such as those involving the home institutions of COV members, were entered into the eCOV system prior to the start of the meeting. Other conflicts were entered as they became known over the course of the meeting. Entering these conflicts prevented COV members from electronically accessing proposals with which they were conflicted. None of the COV members was involved in the review of a program in which he or she had a pending proposal. The DMS COI officer was available at all times during the COV meeting to answer questions and resolve issues regarding conflicts of interest.

Appendix D: Agenda

Division of Mathematical Sciences Committee of Visitors
April 26 -28, 2010

Monday, April 26

8:00 am	Continental Breakfast (Commonwealth Room)
	Opening Sessions in Commonwealth Room:
8:30 am	Welcome and Charge to the Committee Dr. H. Edward Seidel Acting Assistant Director, Directorate for Mathematical and Physical Sciences
8:45 am	Welcome Dr. C. David Levermore Chair, DMS Committee of Visitors
9:00 am	Conflict of Interest Briefing Dr. Morris Aizenman Senior Science Associate, MPS
9:15 am	Overview of Division of Mathematical Sciences Dr. Peter March Division Director, DMS
10:00 am	Coffee break in Breakout Rooms Subcommittee A Madison Room Subcommittee B Monroe Room Subcommittee C Van Buren Room
10:20 am	Overview of Disciplinary Programs (in Breakout Rooms) Various Program Officers
10:40 am	How to Read an Award/Declination Jacket Various Program Officers
11:00 am	Begin Review of Disciplinary Programs
12:00 noon	Working Lunch
3:00 pm	Coffee Break
3:30 pm	Continue Program Review
6:00 pm (approx)	Dinner in groups (locations to be announced)

Tuesday, April 27

8:00 am	Continental Breakfast (Commonwealth Room)
8:15 am	Committee of the Whole (Commonwealth Room)
8:45 am -9:15 am	Meeting with DMS Administrative Staff
9:30 am	Move to Breakout Rooms Subcommittee A Madison Room Subcommittee B Monroe Room Subcommittee C Van Buren Room
9:40 am	Overview of Institutes/Interdisciplinary/Infrastructure/Workforce Programs (in Breakout Rooms) Various Program Officers
10:00 am	Begin Review of Institutes/Interdisciplinary/Workforce Programs
12:00 noon	Working Lunch
1:30 pm	Discussion of Procedure and Timing (Committee of the Whole, Commonwealth Room)
2:00 pm	Discussion and Drafting of Subcommittee Reports Subcommittee A Madison Room Subcommittee B Monroe Room Subcommittee C Van Buren Room
5:30 pm	Reception
Post-reception	Working Dinner (on your own)

Wednesday, April 28

8:00 am	Continental Breakfast (Commonwealth Room)
8:30 am	Presentation of Draft Reports by Subcommittee Chairs (Commonwealth Room)
9:15 am	Continue Discussion and Drafting of subcommittee Reports Subcommittee A Madison Room Subcommittee B Monroe Room Subcommittee C Van Buren Room
10:00 am	Continue Discussion of Subcommittee Reports and Overall Report (Committee of the Whole, Commonwealth Room)
11:30 am	Briefing of Dr. H. Edward Seidel, Acting AD/MPS, by Committee of Visitors (Commonwealth Room)
12:30 pm	Working Lunch, Further Discussion with DMS Staff, Revisions to Report
3:00 pm	Adjourn