THE DIVISION OF

CIVIL, MECHANICAL AND MANUFACTURING INNOVATION

DIRECTORATE FOR ENGINEERING

NATIONAL SCIENCE FOUNDATION

DIVISION PLAN: A PLAN FOR RESOURCE ALLOCATION 2008

NSF 08-33

TABLE OF CONTENTS

EXECUTIVE SUMMARY

> *A good scientist is a person with original ideas. A good engineer is a person who makes a design that works with as few original ideas as possible -Freeman Dyson.*

The Division of Civil, Mechanical and Manufacturing Innovation (CMMI) was formed on October 1, 2006, by the merger of the Division of Civil and Mechanical Systems (CMS) and the Division of Design and Manufacturing Innovation (DMI). As CMMI matures, it will seek to take advantage of the synergy between its current activities, and it will strive to allocate its resources in ways that better serve the overall research community. This plan identifies opportunities that CMMI has to advance the goals of the National Science Foundation (NSF) and the Directorate for Engineering (ENG) and to lead its research communities to higher levels of performance. The plan provides guidelines for decision making in the management of CMMI's resources.

CMMI has been organized into three clusters: Materials Transformation and Mechanics, Innovation Sciences and Decision Engineering, and Engineering Infrastructure Systems. These clusters group programs roughly by areas of expertise in their research communities. One goal of this clustering is to encourage interaction among program directors to foster further synergy among programs.

Each CMMI program presents a unique opportunity to enable frontier and transformative research. One goal of the division is to encourage research projects that exploit the division's resources and provide the greatest possible payoff to engineering and to society. To encourage such research, CMMI will:

- Promote the development and health of the research community through the funding of the best proposals, emphasizing transformative research
- Enable easy communication to alert the community to special opportunities
- Foster the emergence of new areas of research through the use of funding mechanisms such as Small Grant for Exploratory Research (SGER) awards and awards to small groups
- Promote the support of students through mechanisms such as Research Experiences for Undergraduates (REU) supplements
- Engage a diverse set of reviewers to obtain unbiased and high-quality reviews
- Encourage collaborations across disciplinary and geographical boundaries
- Ensure transparency through standardization across the division and adoption of best practices
- Enable the research community to contribute to the evolution of the division through workshops and assessments aimed at setting research agendas
- Keep mortgages low to enable flexibility in year-to-year funding priorities

CMMI will also conduct a self-evaluation through indicators such as:
- Number of workshops conducted
- Outreach activities conducted

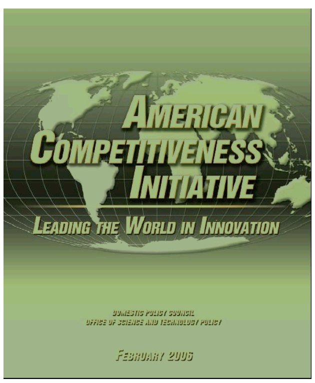
- REU/Research Experiences for Teachers (RET) and other supplemental awards
- Proposal dwell times
- Major honors and awards received by grantees
- External assessments, including by the National Academy of Engineering (NAE), World Technology Evaluation Center (WTEC) and the Committee of Visitors (COV)

INTRODUCTION

> *"Genius is the summed production of the many with the names of the few attached for easy recall." Edward O. Wilson*

The 20th century was a time of invention and innovation from the airplane to the space shuttle, from the calculator to the PC, from the electric motor to the nuclear submarine, from anesthesia to micro-surgery, from the telephone to global communication, from one-off manufacturing to mass production.

It was truly the century of the engineer. Entirely new engineering disciplines emerged aeronautical engineering, aerospace engineering, nuclear engineering, computer engineering, bioengineering and classical disciplines flourished. The number of mechanical engineers in the United States grew from about 10,000 at the opening of the century to about a quarter of a million by the close of the century. Industrial engineering was born.



The challenge for the 21st century is to continue and advance the importance and recognition of engineering to society. This is a challenge of research in which academe plays an important role. NSF will be at the forefront of this challenge. While on the one hand we face a period of limited resources, on the other hand we face an imperative to contribute to the larger welfare of society.

CMMI enables a globally competitive and sustainable future for the nation by supporting fundamental research that advances the frontiers of knowledge. CMMI focuses research support on areas relating to designing, building and securing critical infrastructure and manufacturing and enterprise systems. CMMI also invests in engineering education by supporting research that leads to new engineering pedagogy and activities that engage engineering students.

Such support is in line with the goals of the president's 2006 *American Competitiveness Initiative* (ACI), which states that, "Sustained scientific advancement and innovation … are key to maintaining [the nation's] competitive edge." CMMI addresses the ACI challenge with this plan, which sets forth guidelines for the application of its limited resources.

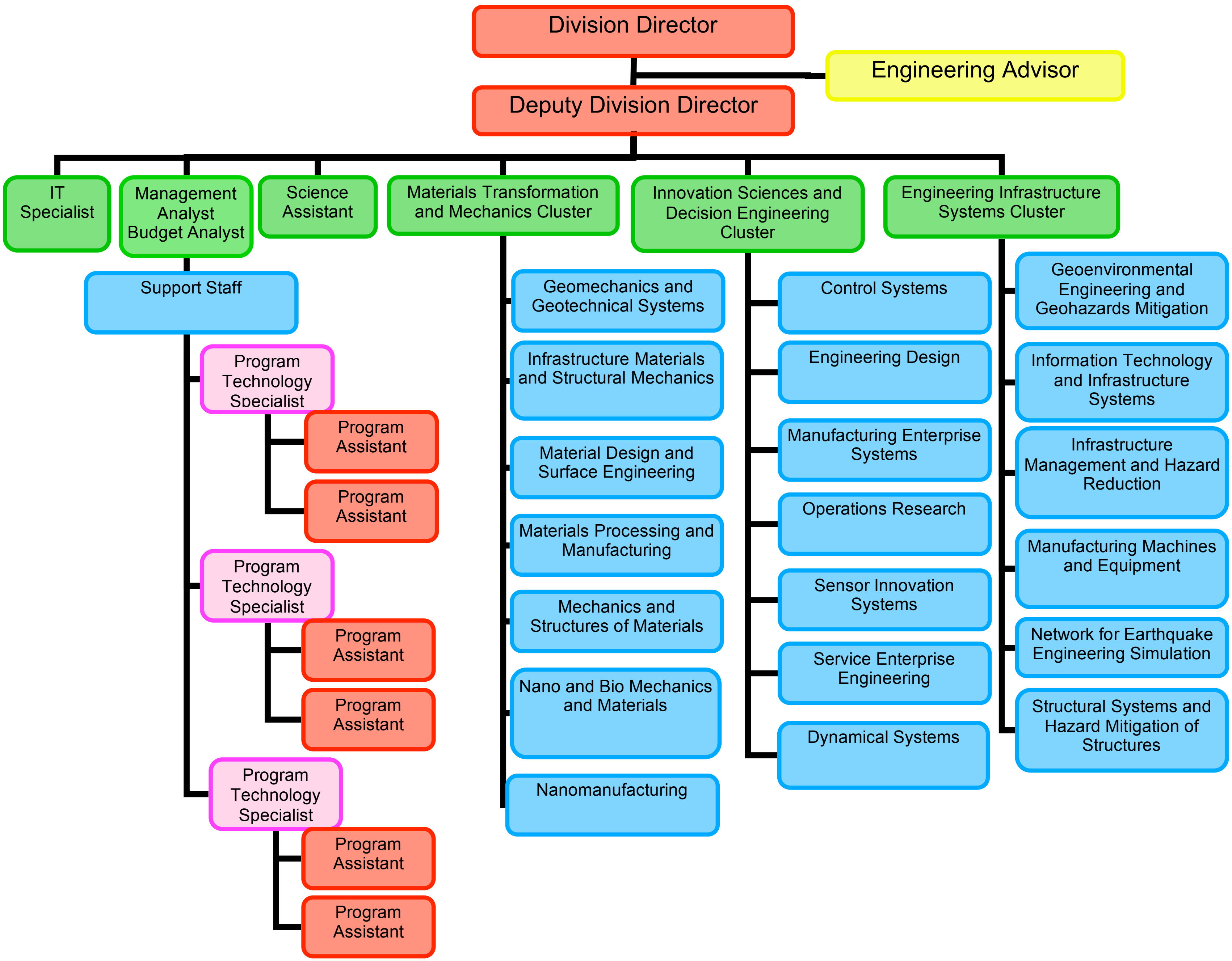
A new division

The division was formed Oct. 1, 2006, by the merger of the Division of Civil and Mechanical Systems (CMS) and the Division of Design and Manufacturing Innovation (DMI). The merger brought together the programs and staff of the two former divisions with no change in programs or staff.

Together, the divisions had 20 research programs, which were brought into CMMI to form three program clusters: Engineering Infrastructure Systems, Innovation Sciences and Decision Engineering, and Materials Transformation and Mechanics. The current organization of the division is shown on the next page.

CMS and DMI conducted strategic planning before the merger. Thus, this plan combines and builds on the plans of the independent divisions. It also draws upon the results of the most recent Committee of Visitors reports and the advice of numerous external workshops and reviews.

CMMI Organizational Chart

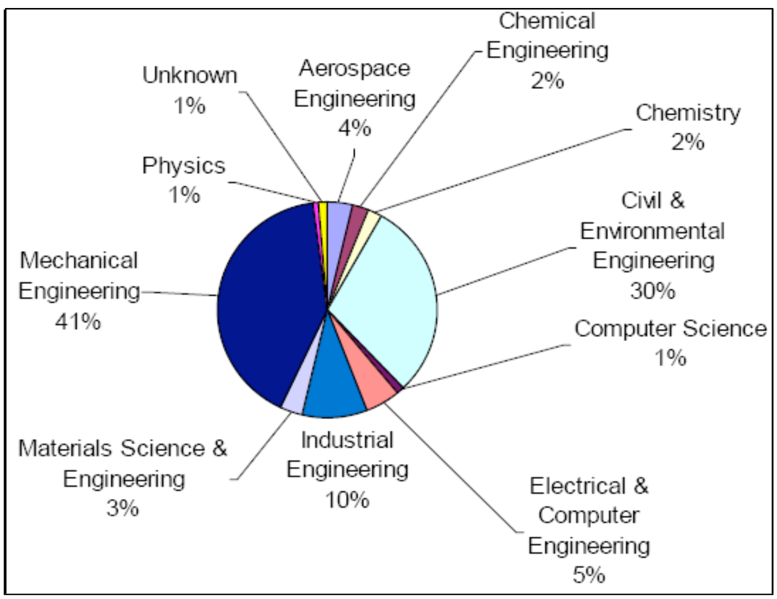


THE CMMI RESEARCH COMMUNITY

I do not think there is any thrill that can go through the human heart like that felt by the inventor as he sees some creation of the brain unfolding to success... Such emotions make a man forget food, sleep, friends, love, everything." Nikola Tesla

An analysis of proposals submitted and funded in fiscal year 2006 shows that CMMI serves a diverse research community with a focus in civil, mechanical and industrial engineering—that focus includes a wide range of additional disciplines. While well over 90 percent of the division's funding goes to the three core disciplines noted, the division entertains proposals submitted by researchers from such diverse disciplines as materials science, management science, mathematics, sociology, anthropology, architecture, urban planning, nuclear engineering, medicine and bioengineering.

In fiscal year 2006, about 43 percent of the funds distributed by the CMMI predecessor divisions were to professors in civil engineering departments. Comprising this civil engineering community are two major subdisciplines: structural engineering and environmental engineering.



The disciplinary distributions of proposals submitted to CMMI in fiscal year 2006

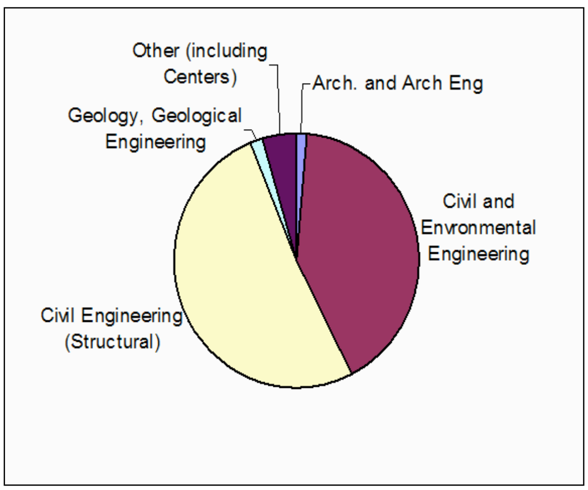
The mechanical engineering community supported by the division includes mainly those subdisciplines that relate to solid mechanics, sensing and control, engineering design, manufacturing, and emerging areas such as nanomanufacturing.

The division supports research in all traditional areas of industrial engineering and has recently added the emerging service sector, including healthcare engineering. The division has broadened the communities it serves by supporting research on hazards and hazard mitigation, particularly through its response to disasters including Hurricane Katrina and the Great Sumatra-Andaman Earthquake and Tsunami of 2004.

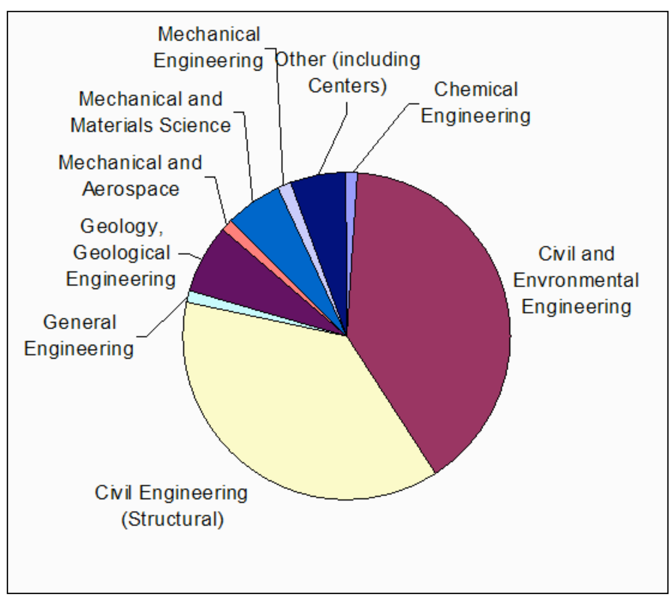
Diversity of CMMI programs

Examination of the disciplines supported by program provides additional insight. Programs that focus more on the established and traditional areas of the core disciplines tend to serve communities that are also more focused, whereas programs that focus on emerging areas, such as nanomanufacturing, tend to serve more diverse communities. New disciplines typically emerge from the union of heretofore-disparate disciplines. However expected this trend is, the challenge it offers CMMI is still large. Vitality in the division gained through the support of emerging technologies has widened the scope of the communities seeking its support.

The graphs presented here derive from an examination of proposals submitted to and awards made by the research programs of the CMMI forerunner divisions. Classification of disciplines is based on departmental declarations made by principal investigators on the cover page of the proposals.

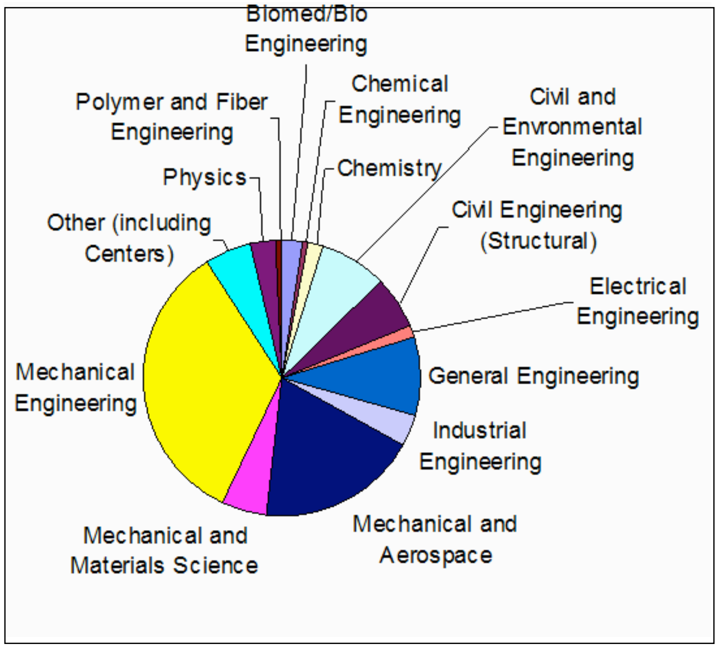


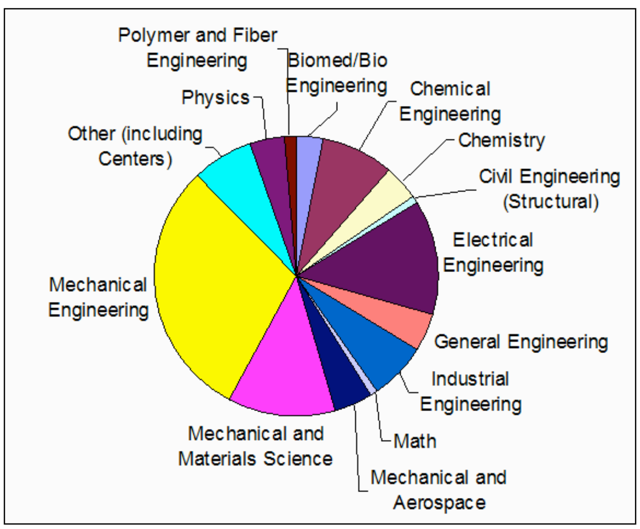
The disciplinary distribution of proposals submitted to the Network for Earthquake Engineering Simulation (NEES) research program in fiscal year 2006



The disciplinary distribution of proposals submitted to the Geomechanics and Geotechnical Systems Program in FY 2006

The disciplinary distribution of proposals submitted to the Nanomanufacturing program in fiscal year 2006





The disciplinary distribution of proposals submitted to the Mechanics and Structures of Materials Program in FY 2006

DEFINING THE GOALS

"May the fact that I cannot understand 19/20 of your Electromagnetic Theory prevent me from congratulating you on the completion of Vol. II?" Editor, Oliver Heaviside's book on electromagnetic theory.

Goals

The goals of NSF include *discovery, learning, research infrastructure and stewardship*. CMMI operates within these goals and assumes leadership and responsibility for their pursuit in the disciplinary areas of civil and mechanical infrastructure, materials transformation and mechanics, manufacturing, engineering design, dynamical systems and control, the service sector and industrial engineering. These NSF-wide goals translate into the following division objectives:

Objectives

In support of discovery:

1. *Encourage and enable innovative and high-quality research*. CMMI will conduct at least seven annual workshops for setting its research agenda. At least 2 percent of the division's discretionary research budget will be awarded through SGER proposals.

2. *Foster the emergence of new areas of research in fields relevant to the division.* CMMI will conduct an annual workshop to identify the most promising areas for advancement, and will choose an emphasis area for promotion of innovation. Three percent of the division's budget will be used to encourage research in the selected area.

3. *Enable and encourage research collaborations across disciplinary and geographical boundaries*. CMMI will continue to collaborate in ENG and NSF-wide initiatives. In addition, CMMI will conduct an annual workshop to identify discoveries and innovations emerging from its programs that will benefit most from small-group research, and will allocate three percent of its discretionary research budget to small-group research aimed at these discoveries.

In support of learning:

4. *Promote the support of students and encourage them to pursue advanced engineering educational opportunities*. CMMI will support REU and RET supplements, and will encourage the participation of women and minority students in particular by allowing REU supplements for two students per grant when at least one is a woman or minority. CMMI's objective is to have a representation of woman and minority REU students that is at least 50 percent

higher than their typical representations in undergraduate education typically.

5. *Reach out to and engage potential students and faculty across the entire diversity of the nation's society*. CMMI will conduct at least five outreach activities each year, with at least two of these activities consisting of workshops on developing proposals and research. Emphasis will be to reach women and minority groups as well as states participating in the Experimental Program to Stimulate Competitive Research (EPSCoR) program.

6. *Mentor young faculty members*. CMMI will seek to establish proposal review panels in which 20 percent are young faculty members. At least one biannual workshop will be aimed at mentoring minority faculty members. CMMI program directors will interact daily with various principal investigators (PIs) and prospective PIs, and the division will continue train its support staff to assure that callers can be referred to the appropriate program director for advice.

In support of research infrastructure:

7. *Maintain and further develop the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) research*. CMMI supports the NEES network of facilities, enabling large-scale earthquake research. It will adhere to the NSF objectives for the operations of large-scale research infrastructure, keeping operating time lost due to unscheduled downtime to less than 10 percent of the total scheduled operating time for 90 percent of operational facilities.

8. *Support the establishment of extreme-event databases*. CMMI will enable data to be collected soon after extreme events, such as tsunamis, hurricanes and earthquakes for future scientific and engineering purposes. Such information is ephemeral and quick action is required to capture it. CMMI will provide funds through rapid allocation processes for collecting data on all important extreme events. CMMI will also continue to support continuous data collection to prepare for and assess risk and threat vulnerability in the face of such events.

9. *Major Research Instrumentation*. CMMI will continue to support provisioning research instrumentation to its PIs through funding from the MRI program. CMMI will inform its communities about the MRI program as a part of normal outreach activities.

In support of Stewardship:

10. *Promote the development of the academic research community*. Through its grantees conference, CMMI will encourage collaboration and development of research programs. The division looks to have at least 5 percent of proposals submitted to involve collaborations among many institutions.

11. *Engage a diverse group of reviewers who have specific expertise in the areas of the proposals they review and can provide high-quality proposal reviews*.

CMMI will maintain a level of diversity in proposal review panels and in other review processes equivalent to the gender and ethnic mix of experts in each respective research and education community. CMMI's goal is that no more than 70 percent of panelists will be used more than once each year, and that no one panelist will be used more than three times in a year.

12. *Conduct the division's affairs—particularly the merit review process, including decisions to grant or decline awards—in a manner that is unbiased, free of conflicts-of-interest, timely and transparent*. CMMI will develop and post on an internal Web site a set of best practices covering much of the proposal review and award process. CMMI will meet the Government Performance Results Act (GPRA) goals for proposal processing, and all conflicts will be handled appropriately.

13. *Enable easy communication with the outside community to alert the community about special opportunities, make NSF goals and procedures clear, and enable PIs to consult with program directors about research ideas, potential proposal opportunities, and results of the merit review process*. CMMI will conduct a grantees conference every 18 months to give grantees the opportunity to display their research, make connections with other grantees, and hear about CMMI's plans and initiatives for the forthcoming period.

14. *Recruit respected experts to serve as program directors*. CMMI will seek to obtain all new program directors who have a minimum of 10 years experience beyond the Ph.D. degree, equivalent to a tenured professor.

Values

Shared values of the CMMI personnel, consistent with those of ENG and NSF, include:

- Devotion to quality, both of internal operations and for the broader external community
- Promotion of personal growth and opportunity
- Respect for each other and the division's grantees and broader research community
- Honesty and openness in the work environment and all professional matters
- Responsibility to their position and the external community
- Protection of confidentiality when appropriate

These values enable division staff members to work together and discuss matters openly. Opinions of all division members are respected and heard, and decisions are made based on freely provided information. Disclosure of information is <u>never</u>

discouraged or punished.

Priorities: Achieving a Funding Balance

The seed corn in CMMI supported research lies in the innovate prowess of individual investigators. The bulk of innovation comes from individual investigator awards. However, the important and necessary research that develops nuggets of innovation into usable technologies often comes from the efforts of small, medium and, as the technology emerges, large groups. Thus, CMMI believes that its core programs and emphasis on individual investigator awards must be protected. This policy is not intended to de-emphasize group research, but rather to emphasize the need for balance between individual investigators and groups. The past several years have seen increased emphasis on group research. Emphasis should be on achieving the appropriate balance to ensure, if for no other reason, that groups will in the future have new technologies to address. These premises set CMMI's priorities given increases or decreases in its overall budget.

If CMMI's discretionary budget were to double, therefore, our priority would be first to strengthen the core programs to encourage innovation through individual investigator awards. Based on experience, the division can double the core budget, to enable more opportunities for research without jeopardizing the quality of awards. Second, we would identify initiatives that are key to advancement both in the disciplines that are the focus of CMMI's programs and those that cut broadly across the full range of engineering fields.

ACHIEVING THE GOALS

Mechanisms

In addition to the specific actions noted above, CMMI will use the following mechanisms to accomplish its objectives:

- *Unsolicited research grants*: Grants to fund unsolicited research are the mainstay of NSF operations. The division's success hinges largely on attracting and funding high-quality research proposals.

- *SGER awards*: The SGER mechanism enables program directors to initiate research in totally new areas, and to conduct research on fleeting phenomena that otherwise would be lost. Using the SGER award, a program director can discuss ideas with PIs, encourage them to submit a proposal, and provide seed money to get research started quickly, even when the idea is so new that no base of reviewers exists to evaluate it. In the case of fleeting phenomena, such as earthquakes and tsunamis, SGER awards enable the division to react quickly to gather perishable data for later analysis.

- *CAREER awards*: CAREER awards provide a mechanism for the division to enable young faculty to initiate their careers in a positive way. The CAREER award supports a first step from Ph.D. dissertation research into new areas of independent research.

- *Solicitations, particularly through the Office of Emerging Frontiers in Research and Innovation (EFRI) Division*: Solicitations allow the division to encourage research in specific areas and to collaborate with other agencies in areas of mutual interest.

- *Collaborations with other federal agencies:* In areas of common interest, it is possible for the division to team with other federal agencies to create special initiatives and to co-fund research. Sometimes, other federal agencies will allow NSF PIs access to unique equipment for experimental or computational research. Sometimes, NSF PIs can collaborate with researchers from national laboratories or other federal agencies.

- *Supplements such as REU, RET and IREE (International Research in Education and Engineering):* Supplements can be used to accomplish several specific objectives, such as the involvement of students, outreach to K–12 teachers, or initiation of international collaborations.

- *Selection of reviewers by program directors*: A key duty of a program director is to select an appropriate set of reviewers for each proposal, and it is the principal way that a program director assures a competent and unbiased review for each proposal. But, through the selection of reviewers, program directors can accomplish more than just the review of proposals. For example, when young faculty or other experts that have never been on a review panel are selected as reviewers, they can better understand the NSF system and thus write better proposals themselves.

- *CMMI Grantees Conference:* CMMI sponsors a grantees conference every 18 months so that PIs can meet each other, become familiar with the research of their peers, potentially form collaborations, and hear about new NSF opportunities. The conference also affords an opportunity for NSF program directors to meet their grantees and review their progress in person.

- *Agenda-setting workshops*: Workshops to advise NSF Program Directors on appropriate research emphases are valuable mechanisms not only for establishing research program agenda, but also for informing potential PIs regarding program priorities. Reports of agenda-setting workshops provide guidance, particularly for young PIs, on what more senior researchers in their fields perceive as important. These workshops can also be the source of ideas for transformative research.

- *Workshops on writing proposals and developing research programs:* Many faculty find proposal writing difficult and challenging. Although several privately administered workshops provide assistance in learning to write a good proposal, the best advice comes directly from NSF program directors. These workshops enable NSF to provide assistance to targeted groups, such as EPSCoR states or underrepresented minorities, to enable these PIs to become more competitive.

- *Papers by program directors leading their fields*: Program directors have access to information or insights that could benefit their research community, often because of the overview position they hold. A program director might write a paper that can help guide the research community or provide insights that will enable the community to propose and perform better research.

- *Conference sponsorship, especially to enable student participation*: Although the division does not generally support conferences, it does provide support for conferences centered around entirely new areas of research, and it frequently provides support for student participation in conferences. This support may take the form of travel grants and may include a paper contest or other such competition designed to engage students and garner their interest and enthusiasm.

- *Program director, division director and deputy division director outreach to academic institutions*: The division's leadership team may participate in outreach with academic institutions. Outreach can include site visits to active PIs, the presentation of seminars, discussions of NSF opportunities, one-on-one time with prospective PIs, and in some cases assistance with proposal writing workshops held on campus.

- *Sponsorship of contests and competitions*: The division has historically provided support for a few competitive student activities that garner student interest and enthusiasm. Two examples are the support of a student design competition through the Society of Hispanic Professional Engineers and the Challenge X competition co-sponsored by the Department of Energy, the automotive industry and collaborating industries.

- *Interdisciplinary connections enabled by Program Directors:* Program Directors are often in positions to identify effective collaborations that cross disciplinary boundaries. They can facilitate such collaborations and encourage interdisciplinary research using grant mechanisms such as SGER awards.

- *Participation in cross-directorate and NSF-wide activities:* CMMI program directors commonly participate in cross-directorate activities, such as EFRI, and NSF-wide activities such as cyberinfrastructure and mathematics initiatives. Such participation helps to make multidisciplinary connections and may bring additional funds into the division.

- *Recognition awards*: NSF-wide awards, such as the Alan T. Waterman award, may be given to PIs in recognition of outstanding research and educational contributions. Awards help identify for the research community those activities that the Division feels are particularly noteworthy, and provide a guiding light for younger faculty.

- *One-on-one meetings with PIs and students*: Program directors can meet on the phone or in person with PIs to help them in many ways. They can give encouragement, guidance, mentoring and advice, and help PIs make connections and better understand NSF. They can provide valuable insights on the interpretation of proposal evaluations.

- *Committee of Visitors* (COVs): COVs give guidance and recommendations to the division on a three-year cycle.

- *Highlights*: Highlights are summaries of the outcomes of ENG-funded research. They provide a window that looks back to success stories and allows reveals what research works and what research spawned transformative technologies.

Collaborations

Collaborations enable CMMI's program officers to participate in larger-scale initiatives throughout NSF and beyond that could lead to breakthroughs that may not be possible with the division's limited financial resources. These collaborations also allow CMMI program directors to provide technical expertise and knowledge to foster new areas and concepts through the engineering and collaborative disciplines. CMMI's 20 programs participate in some form of collaboration to leverage both financial resources and program director knowledge and talent. These collaborations occur as intra-cluster and intra-divisional partnerships, as NSF-wide collaborations for funding and development of initiatives, and as collaborations with other federal agencies, nongovernmental agencies and international agencies.

Internal CMMI Collaborations

CMMI's diverse research programs regularly collaborate in the review and co-funding of proposals. The clustering of programs with similar or related research priorities are a means of enabling easier collaboration in the review of proposals and development of cross-cutting areas of research priority. This clustering allows for optimal use of each program's funding allocations and for greater funding for worthy proposals.

One program that actively participates in intra-cluster and inter-divisional co-funding is the Materials Processing and Manufacturing Program (MPM). MPM works closely with other programs in its Materials Transformation and Mechanics Cluster in making funding decisions on proposals of interest to both programs. MPM co-funded awards with Manufacturing Machines and Equipment program (MME), and has also co-funded CAREER grant writing workshops with MME and other division programs.

Collaborations within the Directorate for Engineering and across NSF

The CMMI program directors participate actively in initiatives throughout ENG and across NSF. CMMI leads NSF in coordinating research efforts in sensor technology for detection and prediction of explosives via the NSF-wide Explosives and Related Threats solicitation. As leaders in developing topics across ENG, CMMI Program Directors are active participants and leaders in the EFRI division.

Many programs focus on the ENG- and NSF-wide initiative to apply nanotechnology to various aspects of their programs, supporting NSF's efforts as the lead in the National Nanotechnology Initiative (NNI). Several programs fund proposals and help coordinate and manage various nano-related solicitations and awards throughout ENG.

CMMI programs also routinely collaborate with other programs in other ENG divisions to review and fund proposals. For example, the MPM program regularly holds a panel with the Thermal Transport/Thermal Processing (TTP) program in CBET to evaluate some unsolicited proposals. It is common for the two programs to co-fund one or two proposals. The Control Systems program also collaborates with the Power, Controls and Adaptive Networks (PCAN) Program in ECCS in the co-review and co-funding of proposals.

CMMI programs also collaborate with other research programs throughout NSF.

- The Mechanics and Structures of Materials (MSM) program collaborates with

CBET and EEC.

- The sensors program works with the Applied Mathematics program of MPS on funding research in sensors and smart materials technologies.
- The Structural Systems and Hazards Mitigation program has planned collaborations with the Atmospheric Sciences program in the Directorate for Geosciences (GEO).
- The MPM program has collaborated with the Ceramics Program in the Division of Materials Research (DMR) to co-fund two Focused Research Group (FRG) proposals in the past funding year.
- CMMI's Geoenvironmental Engineering and Geohazards Mitigation program is co-funding a workshop with CBET and another workshop with CBET and the Division of Earth Sciences (EAR) in GEO.
- Two program officers are involved in managing CMMI co-sponsored projects in the NSF-wide initiative Dynamic Data Driven Applications Systems (DDDAS).
- Misawa is also involved with is the aforementioned prediction of explosives and related support of research on threats.
- Other collaborations outside of ENG within NSF include collaborations with Social, Behavioral and Economic Sciences (SBE) on support for dynamics-based investigations of human behavior, proposals related to the Service Enterprise Engineering (SEE) program, and collaboration with MPS/DMS on aligning program focus coordinating workshops.
- CMMI programs routinely collaborate with the Grant Opportunities for Academic Liaison with Industry (GOALI) program to co-fund proposals that have significant industry partnerships. Several standard grants are being funded for FY 2007 throughout CMMI, including one in the MPM program that will fund a visiting researcher from an industrial partner to work at a university site to conduct research.

INTERNATIONAL COLLABORATIONS

Most programs also collaborate with the Office of International Science and Engineering (OISE) in funding workshops and student exchange programs, especially through the IREE supplement program. This supplement provides funding for a student to perform research in collaboration with an international research partner. The Sensors and Sensor Networks program is a good example of this collaboration with leveraged funding for student programs to Japan, Taiwan, China, Korea, and throughout the European Union.

The MPM program regularly works with this NSF office in offering evaluations and opinions of proposals pertaining to its research focuses. Collaboration is also occurring with OISE through a sponsored workshop by the Information Technology and Infrastructure Systems program.

The program director for Dynamical Systems program has been working with OISE on developing collaborations with researchers in Brazil and Japan as well as working in leading the ENG-wide initiative to secure seed funds for the Engineering Virtual

Organization grants program.

Another notable collaboration between a former CMMI program director and OISE has occurred through the initiation and development of the East Asia and Pacific Summer Institute (EAPSI) program for Singapore. His activities in starting this center included making contact with Singaporean universities, participating in drafting the EAPSI-Singapore agreement with the National Research Foundation (NRF) of Singapore, participating as a member of the NSF team in conference calls with NRF staff, and giving a presentation in April 2007 at the EAPSI student orientation.

COLLABORATION WITH OTHER FEDERAL AGENCIES AND BEYOND

In addition co-sponsoring support of research projects and initiatives through collaboration with NSF organizations, CMMI programs also have leveraged funds in cooperation with other federal agencies. For example, the MPM program has collaborated with the **Department of Energy** (DOE) to co-fund six research awards in the area of polymer composite processing and manufacturing. These grants are now in their third year. The MPM program is currently collaborating with DOE and three other programs in CMMI (Infrastructure Materials Applications and Structural Mechanics, Materials Design and Surface Engineering, and Mechanics and Structure of Materials) and the Division of Materials Research to review and co-fund proposals in the area of Advanced High Strength Steel (AHSS). The group has also co-funded (along with an industrial partnership with auto and steel companies) a workshop to identify and discuss the fundamental research challenges in the area of AHSS. Proposals were reviewed in April 2007. CMMI also collaborates with DOE through a partnership with its **Sandia National Labs** in a multi-year joint initiative on life-cycle engineering.

Many of CMMI's programs interact with the various research offices of the **Department of Defense (DOD)**. These collaborations include a partnership between CMMI's Sensor Innovation program and most Department of Defense agencies on autonomous engineered systems for mitigation of threats. The Nano-Biomechanics program has also collaborated with DOD agencies including the Office of Naval Research, the Army Research Office and the Air Force Office of Sponsored Research in funding a workshop on Smart Systems for Mitigation of Exogenous Threats Using Autonomic Response. CMMI's Dynamical Systems program participants in several defense related collaborations in the realm of prediction of Improvised Explosive Devices, and also co-funds joint workshops and co-reviews proposals. This program is also involved in a collaboration with the **Department of Homeland Security** in funding work focused on predicting and detecting of nuclear devices.

Additional collaborations with several other federal agencies include sponsoring research initiatives as well as workshops for setting research agenda. One such collaboration is an ongoing multi-agency and multi-program effort in the development of Simulation-Based Engineering and Science that also includes the **World Technology Evaluation Council** (WTEC), a nongovernmental organization.

Additional collaborations exist between the Infrastructure and Structural Mechanics program and the **Federal Highway Administration** (FHWA) on Long Term Bridge Performance, and the **U.S. Department of Agriculture**'s Forest Products program on nanotechnology in timber products. The Structural Systems and Hazards Mitigation program collaborates with NIST on fire research.

Another program with much collaboration within the Federal government and beyond is the Mechanics and Structure of Materials program. It has recently collaborated with the Air Force Office of Scientific Research, the **Army Research Laboratory**, Sandia National Labs, the **National Institutes of Health (NIH)**, nongovernmental organizations such as WETC, and Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT).

The MPM program is involved in an interagency working group for Metals and for Polymers as well, and the Materials Design and Surface Engineering program is involved in the Interagency Metals Research Group. One other novel collaboration exists between the Dynamical Systems program and the U.S. Department of State. This program's director serves on a joint commission on science and technology with Brazil and coordinates activities with the Brazilian Embassy in such activities.

Several programs have collaborations with NIH institutes. The MSM, Nano-Biomechanics, and Materials Design and Surface Engineering programs collaborate with NIH and many others in the **Interagency Modeling and Analysis Group** (IMAG). This collaboration includes monthly meetings to discuss progress of the program Multi-scale Modeling in Biomedical, Biological and Behavioral Systems, participating in organized seminars, and attending the program's grantees conference. SEE has also collaborated with NIH by sponsoring a workshop with the **National Institute of Biomedical Imaging and Bioengineering** (NIBIB) in June 2006.

Management

The division also pursues its goals through its management, mainly through organization and policy.

Organization

In concert with its objectives, CMMI constantly will evaluate its organizational structure and be amenable to change whenever appropriate (although not necessarily frequently). CMMI seeks to achieve an organizational structure that accomplishes the following objectives:

- To be flexible and responsive to the research community that the division serves
- To accommodate innovation and to provide an opportunity for the funding of novel and innovative engineering research and educational projects

- To be a leader in innovation, and to encourage the research community to move into and take advantage of new research areas and recent breakthroughs
- To provide clarity to the research community, providing well-defined distinctions for research funding opportunities and research programs
- To foster the effective use of division resources
- To minimize duplication of effort and to enable the research community to make effective use of research results across disciplines

Policy

The division sets policy that is intended to accomplish the following objectives:

- Promote consistency across the division, consistent with the policy of NSF and ENG.
- Promote transparency of the division's operations, particularly in its dealings with the outside community
- Promote predictability in the division's dealings with its community, particularly in its enforcement of the policies of NSF and ENG
- Promote equity and fairness in the treatment of all individuals, both within the division and within the community it serves.
- Promote efficiency in the division's operation

To promote its policy, the division has established a Web page where division staff can go to determine best practices and policy. For example, these policies include the division's interpretation of the NSF Grant Proposal Guide (GPG) and the extent to which the division will return without review proposals that do not meet GPG requirements. The site also helps in division staff work to assure that REU and RET supplements are awarded consistently across the division.

Work Performance Standards

The division seeks to establish work performance standards for its staff. These standards are intended to set minimum expectations so that all members of the division understand their responsibility to the other division members and their roles in accomplishing the division's goals and objectives.

Oversight and Accountability

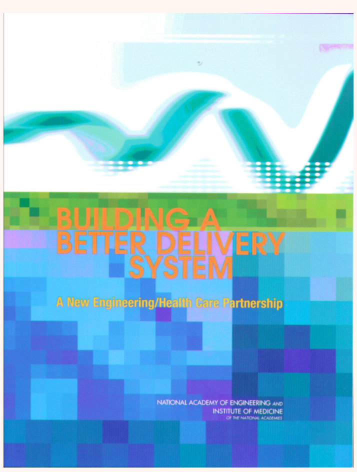
The division uses several mechanisms to accomplish oversight and accountability. The major oversight function is the triennial Committee of Visitors review. The first review is scheduled for the division's third year of operation in spring 2009 . This review will be conducted in accordance with all applicable NSF procedures in place at the time of the review.

The division also supports assessments and evaluations of activities and research areas through studies by the National Academy of Sciences and professional societies such as the American Society of Mechanical Engineers, the American Society of Civil Engineers (ASCE), American Academy of Mechanics (AAM), Materials Research Society (MRS) and WTEC. These studies provide insights into research areas not covered by division funding, and outlines areas of opportunity in which additional or focused funding would be particularly effective.

Individual programs or groups of programs may also, from time-to-time, support *ad hoc* workshops to assess individual research areas and to make recommendations to the respective program directors on research agenda and program priorities.

Individual programs generally fund studies and assessments. However, consortia of programs and agencies may also fund studies that may the basis for later collaboration between the funding agencies. WTEC studies are a good example.

In addition to seeking external controls and oversight, the division also works to guard against waste, fraud and abuse, both from within and across its research community. Frequently, reviewers are the guardians of abuse for the research community. Reviewing new proposals in light of prior NSF support and accomplishments provides a quality control mechanism for future awards. Reviewers are also encouraged to report instances of plagiarism, patent infringement or breach of confidentiality. Such cases are reported to the NSF Inspector General for further investigation and resolution. Where possible, the internal management of the division will be structured to guard against waste, fraud and abuse from within as well. The division will use NSF accounting and program management tools to guard against abuses from within, and the division director and deputy division director will jointly monitor expenditures such as travel and equipment purchases.



CMMI sponsored a report by the National Academy of Engineering and the Institute of Medicine on the application of engineering principles to the delivery of health care. The report found that a systems engineering approach using such techniques as statistical process controls, queuing theory and failure-mode effects and analysis should be used to transform the U.S. health care sector.

Mechanisms / Goals	Unsolicited Research Grants	SGER Awards	CAREER Awards	Solicitations, especially EFRI	Collaborations with other Federal Agencies	Supplements (REU, RET, IREE)	CMMI Grantees Conference	Agenda-setting workshops	Proposal writing and research program development workshops	Papers by Program Officers leading their fields	Conference Sponsorship, enabling student participation	Program Director, DD and DDD outreach to academic institutions	Sponsorship of contests and competitions	Interdisciplinary connections enabled by Program Officers	Participation in cross-directorate and cross-Foundation activities	Recognition Awards	One on one meetings with PIs and students
Discovery																	
1	X	X	X	X	X			X	X	X		X	X	X	X	X	X
2		X		X				X		X		X		X	X		X
3		X		X	X					X		X		X	X		X
Learning																	
4	X	X	X	X		X					X		X		X		X
5																	
6	X	X	X			X	X	X	X		X	X	X	X		X	X
Research Infrastructure																	
7				X	X		X	X	X			X		X	X		
8	X	X			X			X	X			X		X	X		
9				X								X		X			
Stewardship																	
10	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X
11	X	X	X	X	X	X									X		
12	X	X	X	X													
13							X	X	X			X					X
14												X				X	X

This matrix correlates CMMI's goals to particular mechanisms available to achieve these goals.

CMMI PEOPLE

The CMMI staff currently includes a division director, deputy division director, 18 program directors (one of whom is also the deputy division director and another CMMI engineering advisor), an administrative officer, a financial officer, a science assistant, an information technology specialist, and 12 support staff.

Over time, program directors will be completing their service at NSF. Recruiting committees have been appointed, and recruitment is ongoing.

The science assistant hired into DMI is now in CMMI and is proving to be of great value in providing support to the deputy director, deputy division director, and program directors.

CMMI has excellent management in its support staff, headed by a program support manager and an operations specialist, both of whom are devoted to their duties. The support staff however is understaffed, resulting in high workloads. In order to mitigate this, the division plans to maintain support staffing at a level where two programs are supported by each support staff person, with a staff member supporting three programs only when those programs are relatively small.

During recruitment, the division will strive to increase its diversity. Recruitment, particularly for program directors, will include broad dissemination of position descriptions to attract as diverse a set of candidates as possible.

CMMI pays special attention to developing program directors and staff, and a mentoring program will be developed for new program directors. The CMMI engineering advisor will coordinate the training and mentoring of new program directors. The most experienced program director within each thematic programmatic cluster usually is also a mentor. Each cluster is composed of several programs that have similar focuses and areas of interest to encourage closer collaboration in funding and in program development. A document describing best practices is being developed for mentoring program directors. NSF-wide training and the NSF Academy will also be utilized. The CMMI administrative management staff will be involved in the development of staff members as well as coordinating the mentoring and training of new staff members.

CMMI CONTRIBUTIONS TO KEY ENGINEERING AREAS

> *"My experience has been that creating a compelling new technology is so much harder than you think it will be that you're almost dead when you get to the other shore." Steve Jobs*

CMMI plays an important role in the five ENG key areas in research and education for 2007–2008, and is leading ENG activities in simulation-based engineering and science. The following is a summary of these contributions.

Innovation

CMMI is uniquely positioned to have a significant impact on supporting research that strengthens engineers' abilities to conceptualize and create innovative products and services. The combination of program areas, spanning the scale from nanotechnology to earthquakes, materials design to hazard mitigation, and product design to infrastructure systems management, provides an environment for collaboration that supports innovative solutions to emerging problems and worldwide economic challenges.

When faced with complex situations, such as Hurricane Katrina and the clean-up and rebuilding of New York after September 11, the public looks to engineers for technical solutions. Innovative solutions are needed to solve the complex problems of aging infrastructure and maintaining our leadership in new product development. CMMI supports research that has a direct impact on how to handle extreme situations and disasters, that creates new materials and processes, and that helps in conceptualizing and producing new products.

NEXT PARADIGM SHIFT IN MANUFACTURING

CMMI supports the ENG initiative in manufacturing through the activities of several programs. The CMMI NanoManufacturing program supports research on manipulation of matter at the atomic and molecular scales and on the incorporation of nanoscale elements into larger systems to exploit their functionality. The division also supports nanomaterials research through the Materials Processing and Manufacturing program.

Multiscale modeling is supported through the Mechanics and Structure of Materials program and the Manufacturing Machines and Equipment program.

Research on information technology as it relates to manufacturing is supported in several programs.

Additionally, the Division represents NSF in the Interagency Working Group on Manufacturing Research and Development.

CMMI aims to promote a paradigm shift in manufacturing technology. This shift will come about as products are made of new materials, and as the processing of materials becomes more advanced through new methods in machining, forming, joining, finishing, assembling and quality control. A significant research thrust is the improvement of manufacturing processes via the implementation of advanced sensors and control theory. Coupled with an improving understanding of the physics of manufacturing processes, advanced controls offer the possibility of assembly that is more accurate and efficient. They could also improve quality control and lessen the environmental impact of the manufacturing process overall.

ENERGY AND ENVIRONMENT

CMMI supports the development of a novel and diverse energy infrastructure. New manufacturing and materials processing technologies can enable the cost-effective scale-up of fundamental breakthroughs in energy harvesting and production. A key example is the manufacture of large-area solar modules based on nano-structured materials. CMMI supports fundamental research in self-assembly, continuous reel-to-reel processing of amorphous silicon laminates, and casting fuel-cell module supports in high volume as crucial techniques for improving energy producing systems.

CMMI will continue to invest in the fundamental research to improve the cost, sustainability and security of the global energy system. Research in the design and engineering of enterprise systems and the built environment to lower environmental impact is a strategic priority of CMMI. The behavior of existing material-use systems, their impact on the environment and their interaction with social processes has been a major initiative in CMMI. This initiative supports the priority of developing a system-level quantitative understanding of materials-energy-environment interactions and the impact of these systems on society.

NEW FRONTIERS IN NANOTECHNOLOGY

CMMI proactively is supporting and aligning with the national priority research area of nanotechnology, under the National Nanotechnology Initiative. CMMI (through its antecedents CMS and DMI) has established two new programs specific to nanotechnology support: the NanoManufacturing Program (established in fiscal year 2001) and the Nano- and Bio-Mechanics Program (established in fiscal year 2005). Through these and other CMMI programs, the division significantly has leveraged funding for the NSF-wide Nanoscale Science and Engineering initiative (NSE), through awards to Nanoscale Science and Engineering Centers (NSEC), Nanoscale Interdisciplinary Research Teams (NIRT) and Nanoscale Exploratory Research (NER) as well as core program awards in nanotechnology research.

CMMI has leveraged its resources to support nanoscale education via funding for various Nanoscale Science and Engineering Education (NSEE) awards, including the Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT) at Northwestern University.

In fiscal year 2006, CMMI predecessor divisions contributed core funds of $16.5 million to the $9.96 million NSE contribution, for a total of $26.46 million in CMMI-related nanotechnology awards. The division manages more than 160 active nanotechnology awards, including four large-scale cooperative agreements to NSECs (at UCLA, University of Illinois at Urbana-Champaign, UC Berkeley and the University of Massachusetts Amherst). Nanotechnology research areas of CMMI awards include nanoscale surface and interfacial phenomena, theoretical modeling and simulation, nanostructured materials and nanoscale processes, nanomechanical devices and systems, and nanomanufacturing. Awarded projects often include understanding societal, ethical, legal, educational and human resource development aspects of these technologies. CMMI currently is spearheading new research directions in nanomechanical biomimetics, nanomanufacturing of infrastructure and bio-manufacturing, congruent with the NNI Grand Challenge and CMMI NanoManufacturing program for fiscal year 2007–2008.

COMPLEX SYSTEMS

The United States faces a variety of challenges: the sustainability of many critical infrastructures such as healthcare delivery, changes in the nation's civil infrastructure, environmental challenges ranging from global warming to water resources, and safety and security challenges including threatened air travel, sea cargo, and food and water supply. There are also economic challenges. Several countries, particularly in Asia, have caught up with the United States in terms of various indices of innovation and are producing huge numbers of talented college graduates, particularly in engineering. This trend challenges both U.S. industry in terms of how to best compete and the U.S. academic community in terms of educating people with competitive knowledge and skills.

These systems—healthcare, infrastructure, environment, security, and the economy—are complex systems. They involve large numbers of interacting elements. The stakeholders are many and often have differing objectives and needs. With many stakeholders acting and reacting, the response of these systems can be unpredictable.

Similar needs also exist in finding fundamental principles stemming from quantum to nano and macro scales that are relevant to the analysis and design of novel materials, biological systems, manufacturing systems and devices and systems that will improve the quality of life for society in general. Such systems are good examples of being complex and require support for further breakthroughs.

The common aspect of these complex systems is the large number of nonlinear interactions among "components" that collectively lead to the emergence of unanticipated "complex behavior." The current knowledge allows simulation-based investigation on complex systems, but knowledge and tools that lead to formal analysis, synthesis, optimization and design of complex systems are lacking.

Many CMMI programs are sponsoring research that will lead to better understanding of the phenomena of complexity. Several workshops and meetings coordinated by members of the CMMI staff will lead to a coordinated investment strategy within the division and ENG that will catalyze new breakthroughs in term of new knowledge and tools built on existing knowledge, as well as in the emerging "science of complexity."

SIMULATION-BASED ENGINEERING AND SCIENCE

CMMI is leading the ENG emphasis on simulation-based engineering science (SBES). This effort is expected to stimulate the science and education required to transform scientific and engineering research and practice through the integration of data, models, and people *via* cyberinfrastructure. It will allow for the effective use of these resources with the aid of important advances in computing power, data analyses, the evolution of the Web, and the resulting changes to the culture of science and engineering. Moreover, this shift will change engineering and science education, creating a class of engineers and scientists better able to respond to real-world problems via accurate and appropriate simulation. Currently, students may become experts in the use of simulation tools but few are able to develop and understand them.

Realization of this transformation and paradigm change requires new types of physical models beyond classic, powerful continuum models, bridging downward to small, fast molecular and nanometer scales and upward to process-scale, enterprise-scale, and global-scale systems. Finally, as predictive modeling underpins decision-making, simulation models and practice must advance from the calculation of hard numerical answers to the establishment of result probabilities and a means to use them to guide decision-making to be truly predictive. To do so, the models must change, and probability theory and decision theory must be integrated into engineering and science education and practice.

The SBE&S initiative will help initiate these changes and also complements NSF cyberinfrastructure initiatives by providing a central application of cyberinfrastructure hardware, software and network capabilities. It also builds on and extends the MPS Chemistry Division's initiative on Cyber-Enabled Chemistry and meshes well with other NSF investments such as Cyber-enabled Discovery and Innovation (CDI), as it provides a more encompassing vision of this area's potential with a specific application.

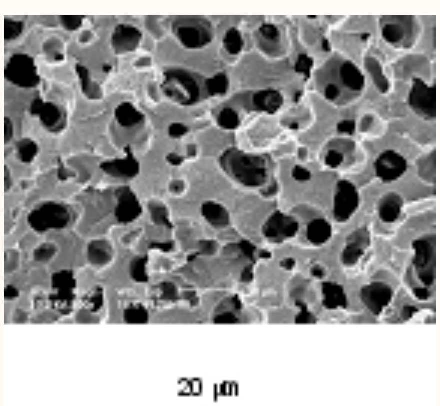
OPPORTUNITIES

> *"There is a theory that creativity arises when individuals are out of sync with their environment. To put it simply, people who fit in with their communities have insufficient motivation to risk their psyches in creating something truly new, while those who are out of sync are driven by the constant need to prove their worth. They have less to lose and more to gain."*
> *Gary Taubes*

Research areas funded by CMMI are experiencing rapid development and breakthroughs are imminent. One goal of CMMI is to find and promote such breakthroughs, thereby enabling and encouraging intellectual growth of the CMMI academic community and benefiting the nation. The following bullets identify a number of areas where breakthrough research is expected.

- Manufacturing: Manufacturing processes are inherently complex, and they involve decision making and optimization under uncertainty and risk. Furthermore, many manufacturing processes involve multiple physical phenomena acting together in complex and difficult-to-measure ways. Metal cutting is one such example. An understanding of metal-cutting processes can be obtained only through modeling. Chatter is a limiting factor in metal cutting, and it can be predicted only approximately. There exists a potential for improved understanding of many manufacturing processes through better modeling on large scales. Processes can also be improved, through the rigorous application of decision theory and through improved active control of these processes.

- Engineering Design: Engineering design has long been practiced in an *ad hoc* manner, using modeling and decision-making approaches that are not mathematically rigorous. The integration of sound mathematical practices and theories holds the promise to greatly improve engineering design decision making as well as to provide a basis for determining whether a new theory is valid or not. Key opportunities are to integrate into engineering design a rigorous theory of predictive modeling, social choice theory and modern normative decision theory.



Researchers at The Ohio State University have investigated the production of nanocomposite foams based on a combination of nanoparticle technology and supercritical fluids technology. The solubility of carbon dioxide in a polymer matrix and the rheological properties of nanoparticle-containing polymer with and without carbon dioxide were studied. Based on the results, the researchers designed a batch extrusion foaming process. Using this process, they have fabricated a variety of nanocomposite foams. Such foams may be used as fire-retardant insulation, electric shielding and tissue scaffolds in biomedical applications.

- Innovative Product and Complex System Design: Design methodologies are being explored to support application domains from bio-nano robotics to complex sensor networks to energy-efficient vehicles and buildings. Methods to support innovative ideation at the crucial stage of initial design will form the foundation for new, competitive products. New optimization and visualization techniques, which seek to capture the depth and breadth of many aspects of the overall design problem, promise to bring advances in information technology to benefit engineering design.

- Macro-Manufacturing via Nanotechnology: Large structures (10m–10^3km) include towers, bridges, aircraft, ships, submarines, and desalination plants. They are manufactured in-place and are significant contributors to the national infrastructure, wealth generation and employment. Research in nanostructured materials, nanoscale processes and nanosystems could greatly transform large infrastructures by replacing defect-prone and resource-demanding assembly with continuous processes and robotic rapid manufacturing based on nanotechnology.

- Bio-Manufacturing—the Cell as a Manufacturing Plant: Beyond chemicals produced via biotechnology, live cells and microbes can be engineered genetically. Enzymantic and viral reproduction can be engineered to create nanostructures, nanodevices and nanosystems having geometrical and material complexity. This manufacturing technique capitalizes on bioinformatics research in genomics and proteomics, as well as cancer research on uncontrolled cell multiplication, just-in-time reproduction and scale-up.

- Information Technology and Information Systems: Advanced information technologies will play a key role in and be necessary for standardizing and integrating various sensors and computer systems for better interoperability. Key information technology research areas involve: computer vision, reasoning, and pattern recognition for rapidly assessing a condition; distributed sensor networks for monitoring critical infrastructure; visual modeling and simulation to better manage resources and constraints; and algorithms for more efficient data mining and analysis.

- Decision Making Under Uncertainty: A central focus of the CMMI Operations Research program is research on quantitative tools to support decision-making. All real decisions involve uncertainty in some form, either uncertainty about the future or uncertainty about the appropriateness or accuracy of a model. Although the need to make decisions under uncertainty long has been known to be "the real problem", incorporating uncertainty into the decision-making process has been immensely challenging both theoretically and computationally. In recent years, however, solutions to this broad problem are coming within reach, and helping to find those solutions promises to be an important strategic goal for the Operations Research program.

- Mechanics and Structure of Materials: Meso-mechanics, which is not well

Since 2003, more than 370 professors, post doctorate researchers and others have participated in the NSF Summer Institute on Nano Mechanics and Materials. In 2005 there were 92 participants. This effort, funded by CMMI, plays a key role in workforce development in an important emerging area. It provides access to specialized courses in nanotechnology not available at many universities and stimulates the development of new course materials. Designed to be accessible to students with a BS degree in engineering, the courses provide an opportunity for students and researchers at many levels to enhance their understanding of frontier areas in nanotechnology.

understood, serves as the bridge between different size scales. According to the late Rick Smalley, the most challenging problems are at the interfaces between wet and dry materials. The mechanics of such interfaces, electronic materials, thin-films, smart materials and bio-inspired materials; multi-scale [spatial and especially temporal scales], multi-physics and multi-phenomena mechanics; and the mechanics involved in the integration of microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS) are some of the research frontiers.

- Bio-Geo Engineering: The area of bio-geo engineering offers the possibility of changing soil behavior through biological activity so that, for example, weak, compressible soils might be strengthened, thereby reducing or eliminating the need for costly deep foundations to support structures. Advances in non-intrusive site characterization techniques, based mainly on geophysical techniques, offer the possibility to "see" beneath the earth's surface in great detail to locate pipelines or other infrastructure; to predict tunneling conditions; and to obtain an accurate measure of spatial variation in soil properties. Integration of site characterization methods, preconstruction numerical modeling, real-time monitoring of excavation behavior and real-time updating of design can lead to significant improvements in urban underground construction safety and cost while speeding up construction and minimizing damage to neighboring structures and litigation.

- GeoEnvironmental Engineering and GeoHazards Mitigation: Research is focused on using biological, chemical and physical means to enable *in-situ* methods of mitigating soil liquefaction, such as occurs during earthquakes. These techniques will result in new technologies to reduce the effects of earthquake ground motion on existing structures. Research on municipal solid waste landfills will lead to decreased danger of groundwater contamination, increased methane collection for power generation and safer ways of sealing landfills after they reach their capacity. These landfill sites can then be safely reused. Research on drilling, tunneling and excavation in rock may lead to further development of geothermal energy resources, as well as methods for sequestering carbon dioxide and nuclear and hazardous wastes; and may facilitate increased use of underground space for environmental and national security needs.

- Hazard Mitigation for Civil Infrastructure: A healthy and functioning civil infrastructure is vital for the continuing operation of our society. This infrastructure, however, is vulnerable to natural and manmade hazards. Currently, infrastructure design codes account for one type of hazard but not others. In addition, most codes are aimed toward preventing collapse during the largest hazard level considered, leaving buildings vulnerable to relatively less extreme (and sometimes more frequent) hazards. As a result, protection of human life is not considered uniformly across all hazards, and protection against the many types of damage possible is not considered explicitly. Developing a process to ensure that performance-based design accounts for many hazards would be a large step toward building a resilient and sustainable civil infrastructure. This approach would consider all potential costs of hazards to society, not just the costs to a specific structure or facility. Realizing this change will require a systems approach to hazard mitigation. Risk measures would be uniform across all hazards, and performance objectives would be defined by hazard level.

- Supply Chain Management and the Management of Disaster Relief: Moving goods in a timely way is crucial for disaster relief. Industrial engineers have refined “just in time” and other supply chain concepts that improve efficiency and resist disruption. These concepts are fueling breakthrough applications in disaster relief. In applying these ideas, emergency managers will learn more about useful supply chain concepts, and researchers will learn about how supply chains perform under stress.

- Coupled Oscillator Theory (resonant and/or networked): The advances in this area will lead to breakthroughs in understanding and/or synthesizing oscillators in a multitude of applications. For example, carbon nanotube resonators are examples of ultra-high frequency devices that can function as RF filters, transistors, mixes, modulators, demodulators, zeptogram-level mass sensors and memory elements; micro- and nanomechanical resonators can also be used as sensors with unprecedented resolution for application in biomechanics and biophysics of cellular and subcelllular structures. Many discoveries will be enabled in biology, from macro scale (such as in human biomechanics) to nanoscale (such as the “repressilator” involved in gene transcriptions), and including understanding the functioning of the brain and neural systems.

- Advances in Analysis and Design of Large-Scale Complex Dynamic Systems: New theories will lead to innovative architectures and understanding of a system’s inherent abilities and limitations resulting from properties of the system’s components and properties of the whole system. Breakthroughs in this area will enable new integration methods that account for complex dynamic interaction between components. A prominent area that will benefit from these developments will be in mechatronics with smart components and self diagnosing, self-healing systems and materials.

- Human Behavioral Modeling in Service Enterprise Modeling: Integration of human behavioral modeling into service enterprise modeling is a key driver for engineering more effective service systems. Increasingly sophisticated brain imaging data allow us to understand the components of the brain that are engaged during decision making, and why our decisions may not conform to a formal reconstruction of the decision problem. Building this understanding into our service system design is an emerging frontier.

CMMI Priority: Modeling and Simulation in Engineering

With the high capital and labor costs associated with conducting experiments and the difficulties associated with the intelligent design of experiments and the control of important experimental parameters, the development and pervasive application of modeling and simulation in essentially all disciplines of engineering and science are of critical and growing importance. Effective use of modeling and simulation can reduce the number and complexity of experiments required and the time required to gain insight into important physical phenomena and systems.

Modeling and simulation in engineering is a field that cuts across engineering disciplines. Researchers, supported by CMMI, are laying the groundwork for initiatives in predictive modeling and in simulation-based engineering and science. Predictive modeling underlies all of engineering practice and relies on the application of probability theory, in which engineering has seriously lagged behind corresponding mathematical developments. Serious challenges exist in bridging the multiple spatial and temporal scales from nano to micro to meso and macro, as well as simulating multi-physics, multi-phenomena problems. New approaches both to these subject areas and to the conduct of research in them must be sought.

In many cases, such as predictive modeling, the knowledgeable research community is quite small, and experts are not located near each other. Therefore, the need is to enlist and encourage geographically dispersed investigators to collaborate. Virtual groups are one possible approach. Such groups would start small and grow as new investigators become experts in the emerging area. They would mature as the new technology permeates engineering research and engineering curricula across the nation. Establishing the virtual center would require about $1 million annually in funding. This amount would grow to several million annually as the activity matures. In the fully mature stage, multiple investigators would coalesce at leading institutions, and the virtual center would fragment into real clusters of investigators doing group research.

In other cases, such as simulation-based science and engineering, there is a strong need for collaboration across many disciplines. Again, the virtual center model might be a good approach, but require modification to enable the types of close collaborations that require physical presence as a part of the overall plan. As a result, the start-up budgets would be a bit higher, perhaps $2 million annually, and may grow to higher levels, especially given the potential need for experimentation.

CMMI STRATEGY

"The inertia of the human mind and its resistance to innovation are most clearly demonstrated not, as one might expect, by the ignorant mass – which is easily swayed once its imagination is caught – but by professionals with a vested interest in tradition and in the monopoly of learning. Innovation is a twofold threat to academic mediocrity: it endangers their oracular authority, and it evokes the deeper fear that their whole, laboriously constructed intellectual edifice might collapse. The academic backwoodsmen have been the curse of genius from Aristarchus to Darwin and Freud; they stretch, a solid and hostile phalanx of pedantic mediocrities, across the centuries." Arthur Koestler, the Sleepwalkers, Hutchinson of London, 1969. The Parting of the Ways, the Burden of Proof, Galileo's Triumph, Page 427.

Strategy

CMMI seeks to invest its resources so as to maximize its return to the academic community and society. In doing so, CMMI will follow these guidelines:

- Sustain strong support in areas of research that form the base from which significant advances emerge.
- Provide an environment that encourages innovation, particularly an environment that accepts risky and highly innovative proposals from knowledgeable and credible PIs.
- Balance funding for research against funding for equipment and facilities that enable frontier research in key research areas CMMI has determined to be important.
- Keep out-year commitments low and controled funds to assure flexibility in the selection of year-to-year priorities.
- Promote high quality through strategic use of both external and internal merit review, and through the judicious management of programs. Such management includes consolidating or eliminating programs when needed, creating new programs, or shifting CMMI research emphases.
- Assure clarity and transparency through standardization across the division and adoption of best practices. Best practices include automatic return without review of proposals that fail to meet the Grant Proposal Guide requirements
- Assure effective use of research funds through periodic assessments, both internal and external, and through frequent workshops that set program agenda and priorities that complement extant opportunities, national needs and the priorities of the research communities.

- Provide both participation in and leadership of ENG- and NSF-wide initiatives in key areas of interest to the division.

- Seek to leverage division resources by collaborating with other federal and non-federal agencies.

Indicators

The following are indicators that provide insight into how well CMMI is accomplishing its objectives. The use of objective or numerical metrics is avoided as the real goal is to foster high quality, and that is not measured numerically. The objective is not to maximize any of these indicators, but rather to achieve a balance among them.

- Agenda-setting workshops conducted
- Proposal-writing workshops conducted
- REU/RET supplements given
- Adherence to the **Government Performance and Results Act** (GPRA) requirement for 70% of all proposals to be processed within 6 months.
- Avoidance of conflicts-of-interest
- Diversity of reviewers
- Program and research area assessments
- Representation of diverse demographic groups in awardees
- COV assessment
- Student involvement
- External assessments conducted, for example, by WTEC and the National Academy of Engineering
- Major honors received by awardees
- Major honors received by CMMI staff

ACTION ITEMS

CMMI will pursue the following action items will be undertaken by CMMI in pursuit of organizational excellence.

1. An ongoing effort will be training program directors in methods for reviewing and processing proposals, and in dealing with conflicts of interest. New program directors will be assigned a mentor to help bring them up to speed on NSF procedures and electronic systems, and training will be provided as available through the NSF Academy. In addition, during fiscal year 2007, CMMI will develop a set of training activities and provide training opportunities for all program directors.

2. Develop of a set of best practices for addressing program director conflict of interest in a panel meeting, or for dealing with other types of conflicts, or for selecting panelists, and so on. Best practices will be implemented through check lists for important activities, such as setting up and running panels. Best practices will be kept on a Web page accessible to CMMI staff.

3. Appoint search committees to begin the search process for replacing program director positions that are now or will soon be vacant. These committees will include standing committees available for recruitment actions as necessary. CMMI will likely need to replace four to five program director positions each year.

4. Recruit support staff to fill vacant positions. The goal is to fill any new all open positions within 90 days.

5. Train for program directors and program assistants on making travel arrangements. Because of problems with FedTraveler, CMMI will appoint a FedTraveler point-of-contact. This person will expedite all travel actions and trouble-shoot all problems. The divisional goal is to have all travel reimbursements for staff and panelists made within 30 days of the date of return from travel.

6. Establish themes and key topics for ENG and NSF, looking at the roles of new fields and their integration into CMMI programs, as well as the integration of CMMI technologies into emerging areas. CMMI will continue to improve and develop its means of enabling transformative research.

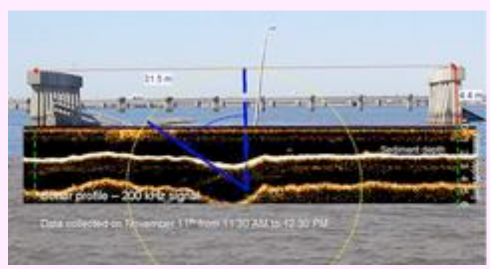
APPENDIX A: PROGRAMS

> *"There's certainly a connection between mental illness and 'thinking out of the box.' If you're going to be anything like a genius, you have to think out of the box." John Nash*

CMMI enables a globally competitive and sustainable future for the nation by supporting fundamental research that advances the frontiers of knowledge. Support is focused on areas related to designing, building and securing critical civil infrastructure and the nation's manufacturing and enterprise systems. CMMI also invests in engineering education by supporting activities that promote an adaptable, creative and knowledge-enabled engineering workforce for the future. The twenty research programs that comprise CMMI provide funding to advance engineering across the Division's focus areas.

NEES

A significant portion of CMMI's portfolio supports the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). It is a unique system of 15 geographically distributed, shared-use, experimental facilities located at universities across the United States that work together via the NEES grid cyberinfrastructure and a central data depository with a curator.



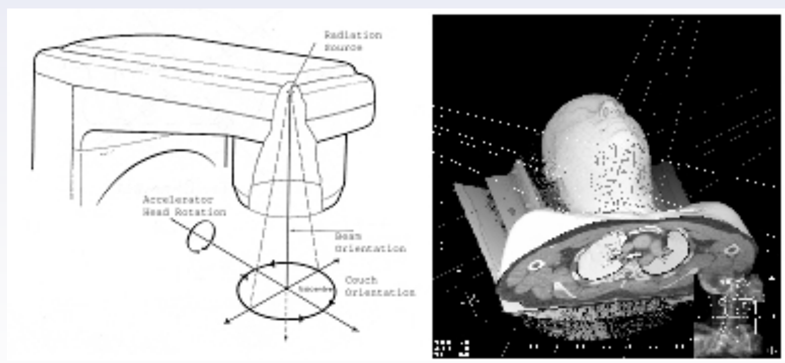
Programs in CMMI's Engineering Infrastructure Systems Cluster have sponsored immediate scientific response to such natural disasters as flooding in New Orleans caused by Hurricane Katrina in September 2005 and research in the aftermath of the December 2004 Great Sumatra-Andaman Earthquake and Tsunami. Photo Credits: Credit: Professor Toshitaka Katada, Gunma University, Japan; Dante Fratta and Carlos Santamarina, University of Wisconsin-Madison

This unique research facility addresses important challenges in earthquake and tsunami engineering research, and is complemented by core programs such as the Infrastructure Systems Management and Hazards Response program.

Investments in fundamental research in these areas allowed ENG to quickly send research teams to gather ephemeral data following Hurricane Katrina. These data can be used now to design systems to mitigate damage and loss of life from similar natural hazards.

Manufacturing & Service Systems Research

CMMI's design, manufacture and service portfolio is the largest of the federal agencies that support fundamental research and discovery that is not product- or mission-driven. This unique role has led to early investments in solid-modeling systems that today are the critical technical link in design and manufacturing enterprises; optimization and network methods that are the basis for supply chains and Internet services; and processes that not only provide solid representations directly from digital data, but also scaffolding to enable engineered processes for growing tissue. This curiosity and innovation-driven research at universities has contributed to increases in productivity and enabled the creation of new enterprises that have benefited the nation.



CMMI's Service Enterprise Engineering program supported research leading to the development of new models for radiation therapy. The models allow for adaptive treatment planning, in which treatment plans are adjusted daily to meet the needs of a patient. This allows greater options for treatment based on optimization of beam directions. Image Credit: H. Edwin Romeijn, University of Florida

Nanomanufacturing and Nano/Bio-Mechanics

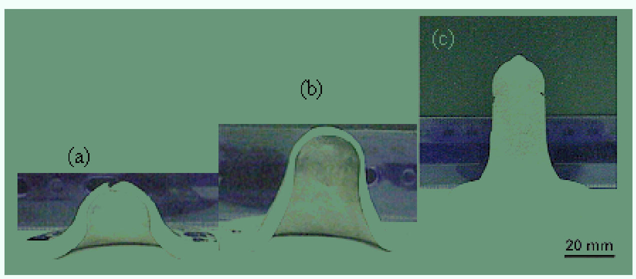
CMMI also supports nanoscale science and engineering in the Materials Transformation and Mechanics cluster through the NanoManufacturing and Nano/Bio-Mechanics programs. These programs have a critical role in converting nanoscience discoveries into innovations that benefit society, and are a key component of the ENG New Frontiers in Nanotechnology priority area in meeting the grand challenges for the National Nanotechnology Initiative.

A range of manufacturing discoveries and innovations are needed to design the systems and processes to deliver products, devices and components that take advantage of the unique properties of nanoscale elements. Simultaneously, an entirely new manufacturing workforce needs to be educated and trained in nanotechnology to bring to fruition the many exciting opportunities that nanotechnology has opened. CMMI's NanoManufacturing program will continue to support research on improving human performance through the integration of nanotechnology, biotechnology, information technology and cognitive science.

Cross-cutting research

CMMI also supports many crosscutting activities. This research focuses on systems that are inherent to many CMMI programs and enables connectivity between the division and priority areas across NSF. CMMI Program Directors have led or participated in NSF priority areas for the ENG such as the Materials Use: Science, Engineering, and Society (MUSES) on Biocomplexity in the Environment (BE), which supports the design and synthesis of new materials that have environmentally benign impact on biocomplexity systems. In addition, CMMI program directors have participated in the Mathematical Sciences priority area, which offers multidisciplinary opportunities in partnership with the Division of Mathematical Sciences for advances in mathematical theory needed for innovations across size scales. CMMI assumes the lead role in ENG's participation in the Human and Social Dynamics priority area as well. CMMI program directors also work with other federal agencies including NIH, AFOSR, DOT, DOE, and NIST on various initiatives and collaborations.

The division also supports the development of people through NSF-wide programs and supplements, such as CAREER, ADVANCE, REU and RET.



Researchers at the University of Missouri-Rolla have studied the use of friction stir processing to refine grains of metal alloys. Friction stir processing uses mechanical mixing of metals to alter the grain structure. Potential applications of this research are in the automotive and aviation sectors. This work on the fundamental understanding of the role of alloy chemistry and process parameters on friction-stir-processed microstructure and superplasticity can further enrich this solid-state processing technology.
Photo Credit: Rajiv Mishra, University of Missouri-Rolla

Programs and Program Directors:

MATERIALS TRANSFORMATION AND MECHANICS CLUSTER

Mechanics and Structure of Materials: Supports research on computational, theoretical, analytical and experimental solid mechanics, model-based simulation and constitutive models; thin-film mechanics; viscoelasticity; plasticity; size and strain-rate effects; and the link of microstructure to nano- and meso-scale mechanical behavior. The program also supports experimental, numerical and analytical research on deformation, fatigue and fracture due to mechanical and environmental forces as well as interfaces of wet and dry materials.

Infrastructure Materials and Structural Mechanics: Supports research to advance the knowledge base on properties and the application of advanced structural materials; on the repair, retrofit, and rehabilitation of structural components; on the durability of structural materials and components, including effects derived from interaction with the natural and constructed environment; on innovations and constitutive characterization of new construction materials; and on the behavior of infrastructure materials and structural components.

Geomechanics and Geotechnical Systems: Supports research in geotechnical engineering, foundation engineering, soil and rock mechanics and dynamics, underground construction, and mining engineering. Supports research that will increase geotechnical knowledge for foundations, slopes, excavations and other geostructures, including technologies for strengthening soil and rock and reinforcement systems. Also funded is research on constitutive modeling and verification in geomechanics; transferability of laboratory results to the field scale; and non-destructive, remote and *in-situ* evaluation of soil and rock properties.

Nano- and Bio-Mechanics and Materials: Supports research in mechanical properties of engineering materials and systems containing nanoscale features, such as grains, layers, precipitates or composites; mechanical properties of biological materials, which include cell, tissues, muscles, bones and prosthetic implants; design of materials suitable for prosthetic implants; relationship between nanomechanics, adhesion and tribological properties; effects of environment, surface chemistry and temperature; and computational and experimental tools to study nano- and bio-mechanics of materials.

Materials Design and Surface Engineering: Supports generic research on links between microstructure design and control and properties, and on performance and engineering of materials and surfaces for novel applications in civil and mechanical systems and components. Research is also included that expands the knowledge base on: the design of materials, coatings, and surface treatments for service under extreme conditions; tribology, corrosion, friction and wear; novel materials solutions for life-cycle design, ecomaterials, nano-technology, and biomedical applications; and related model-based simulation and computational materials engineering.

Materials Processing and Manufacturing: Supports research to expand the fundamental knowledge base that is needed to realize desired product attributes through the application of the systematic integration of processing-material-performance relationships. Also supports research activities that incorporate connectivity of this materials processing knowledge to sensing systems for process control.

NanoManufacturing: Supports fundamental research at the nanoscale, and supports the transfer of developments in nanoscience and nanotechnology discoveries from the laboratory to industrial application. The program emphasizes scale-up of nanotechnology for high-rate production, reliability, robustness, yield and efficiency, and for reducing costs, in manufacturing products and services. NanoManufacturing capitalizes on the special material properties and processing capabilities at the nanoscale, and promotes integration of nanostructures to functional micro devices and meso/macroscale architectures and systems. It also addresses issues inherent to interfacing across dimensional scales. The program provides support for education in nanoscale phenomena and manufacturing.

The seven-story, 275-ton reinforced concrete structure tested on the University of California-San Diego, NEES shake table demonstrated a less costly seismic design method for residential structures in southern California. This test involved collaboration between researchers at the University of California, San Diego, and a consortium of California engineering and design companies and was supported by funding from CMMI's George E. Brown, Jr. Network for Earthquake Engineering Simulation program (NEES).

Photo Credit: Professor Jose Restrepo, Department of Structural Engineering, University of California, San Diego

THE ENGINEERING INFRASTRUCTURE SYSTEMS CLUSTER

Geoenvironmental Engineering and Geohazards Mitigation: provides support for projects on geoenvironmental engineering, including physical, chemical, thermal and biological processes that affect the properties of geologic materials; contaminant transport and hydraulic properties of geologic materials involved in surface and subsurface flow; and construction for remediation and containment of geoenvironmental contamination. The program also supports research in geological engineering and engineering geology, geotechnical earthquake engineering and strong-ground motion, piping (particle erosion, transport, and deposition), scour, tsunamis (earthquake- and non-earthquake-generated), landslides and debris flows.

Network for Earthquake Engineering Simulation: formally the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES),it comprises a network of 15 earthquake engineering experimental equipment sites. These sites host shake tables, geotechnical centrifuges, a tsunami wave basin, unique large-scale testing laboratory facilities, and mobile and permanently installed field equipment. The NEES networking cyberinfrastructure connects, via Internet2, the equipment sites and provides telepresence, a central data repository that has a curator. It also connects simulation tools and collaborative tools for facilitating on-line planning, execution, and post-processing of experiments. As an integrated network, NEES offers opportunities for conducting earthquake engineering research investigations at a large scale, or at the systems level, in a more systematic way than previously possible through use of multiple, independent equipment sites. The expected result is more accurate characterization of how structures and geomaterials respond to seismic loading. This research is needed to extend theory; to realize model-based simulation; to design computational and visualization tools; to design practice and codes in earthquake engineering; to create cost-effective technologies for design, retrofit and remediation; to improve experimental simulation techniques and instrumentation; and to use sensor technology.

Information Technology and Infrastructure Systems: supports research focused on the renewal of civil infrastructure systems—such as transportation, water supply, sanitation, power generation and the built environment—by promoting application of advanced information technologies for assessing conditions and deterioration, and for asset-management sciences. It also creates scientific and engineering knowledge for the design, construction, maintenance, operation and decommissioning of the built environment.

Infrastructure Management and Hazard Reduction: supports research on multidisciplinary issues concerning the impact of natural, technological, and human-generated hazards on critical infrastructure systems and on society. The program seeks to integrate research from engineering, social and behavioral sciences, political sciences and economics approaches. Also supported is research related to preparedness for, response to, recovery from, and mitigation of disasters resulting from natural, technological and human-generated hazards.

Structural Systems and Hazard Mitigation of Structures: supports experimental, analytical and computational research on designing structural systems and enhancing their performance. The program supports research on new technologies for improving the behavior and response of structural systems subject to natural hazards; fundamental research on safety and reliability of constructed systems and of indoor environmental conditions; innovative developments in analysis and model-based simulation of structural behavior and response including soil-structure interaction; design concepts that improve structure performance and flexibility; and the application of new control techniques for structural systems.

Manufacturing Machines and Equipment: supports research leading to the understanding and modeling of fundamental manufacturing processes, such as cutting, drilling, grinding, electrical discharge machining, and the various additive processes related to solid freeform fabrication, utilization and integration of sensors into the manufacturing process, and machine and manufacturing system operation and control. The latter includes closed-loop control of manufacturing machines, tool path generation and operation sequencing, parts feeding, holding and fixturing, metrology, and quality control and manufacturing in machine design.

The CMMI Service Enterprise Engineering program funded researchers at Texas Tech University and the University of Illinois at Urbana-Champaign to develop an innovative approach to representing the performance of existing and proposed airport baggage screening technologies using a cost-benefit analysis approach to define each systems absolute and relative costs and risks. They found that investment in new baggage screening technologies is only justified when baggage-prescreening systems are accurate enough to be appropriately targeted on high-risk passengers. The results have been presented to the Transportation Security Administration (TSA) to assess how investments in new technologies balance detection accuracy with the ability to effectively deploy such technologies.

Credit: Rajan Batta, Colin Drury, and Li Lin, University of Buffalo

INNOVATION SCIENCES AND DECISION ENGINEERING CLUSTER

Control Systems: supports research and education in the prediction and control of complex systems, with broad applicability to civil and mechanical systems. The program considers proposals for innovative advances in control theory and control technology. Control theory refers to the mathematical framework to analyze, design, or validate control systems. Control technology refers to the integration of sensing, actuation, and computation with physical or information systems to realize a working control system. The control technology component also considers innovative advances in actuation concepts.

Dynamical Systems: supports advances in the understanding, design and operation of dynamic systems, such as nonlinear, hybrid, time-varying, multi-energy domain and distributed dynamical systems. Examples of application areas include acoustics and vibration analysis, noise and vibration control technologies, kinematic relationships, biological systems, micro- and nano-scale systems, multi-scale dynamic systems, large-scale interconnected complex systems, integrated analysis and design of dynamic systems, theory and application of dynamical systems (modeling, analysis, simulation and synthesis), and simulation-based engineering and science.

Engineering Design: supports research in the fundamental theories and tools supporting the product realization and innovation processes. The program supports research based on a framework for design that includes synthesis and integration methods for conceptual design, identification and definition of preferences, analysis of alternatives, effective accommodation of uncertainty in decision-making, methods and measures for validation of models, innovative information technologies and systems, automation techniques and visualization, and the effective use of computational techniques that integrate human desires and experiences.

Manufacturing Enterprise Systems: provides support to address research on design, planning and control of operations in manufacturing enterprises, from shop floors to the associated procurement and distribution supply chains. Contributions affect and extend the range of analytical and computational techniques to extended enterprise operations, and/or advance novel models offering policy insights or the prospect of implemental solutions for manufacturing applications.

Operations Research: supports research leading to fundamental advances in the science of models and algorithms arising in the study of operations of large-scale systems. This program supports research in three main directions: optimization, simulation and stochastic models, and novel enterprise-wide models based on integrating operations research methodology with advanced high-end computing. The overall emphasis of the program is on research that improves modeling and computational capabilities in operations research.

Service Enterprise Engineering: supports focused research on design, planning and control of operations and processes in commercial and institutional service enterprises that extend the range of analytical and computational techniques available to these systems and advances novel models offering policy insight or the prospect of solutions for implementation in the ever growing in importance service industry.

Sensor Innovation Systems: supports research on acquiring and using data on civil and mechanical systems to improve their safety, reliability, cost and performance. It also supports development of advanced sensors for engineering systems; smart sensing and innovative actuating capabilities that use the sensor data; innovative sensor technology development; and analytical tools and strategies for monitoring health and making diagnosis, and for engineering for smart structures.

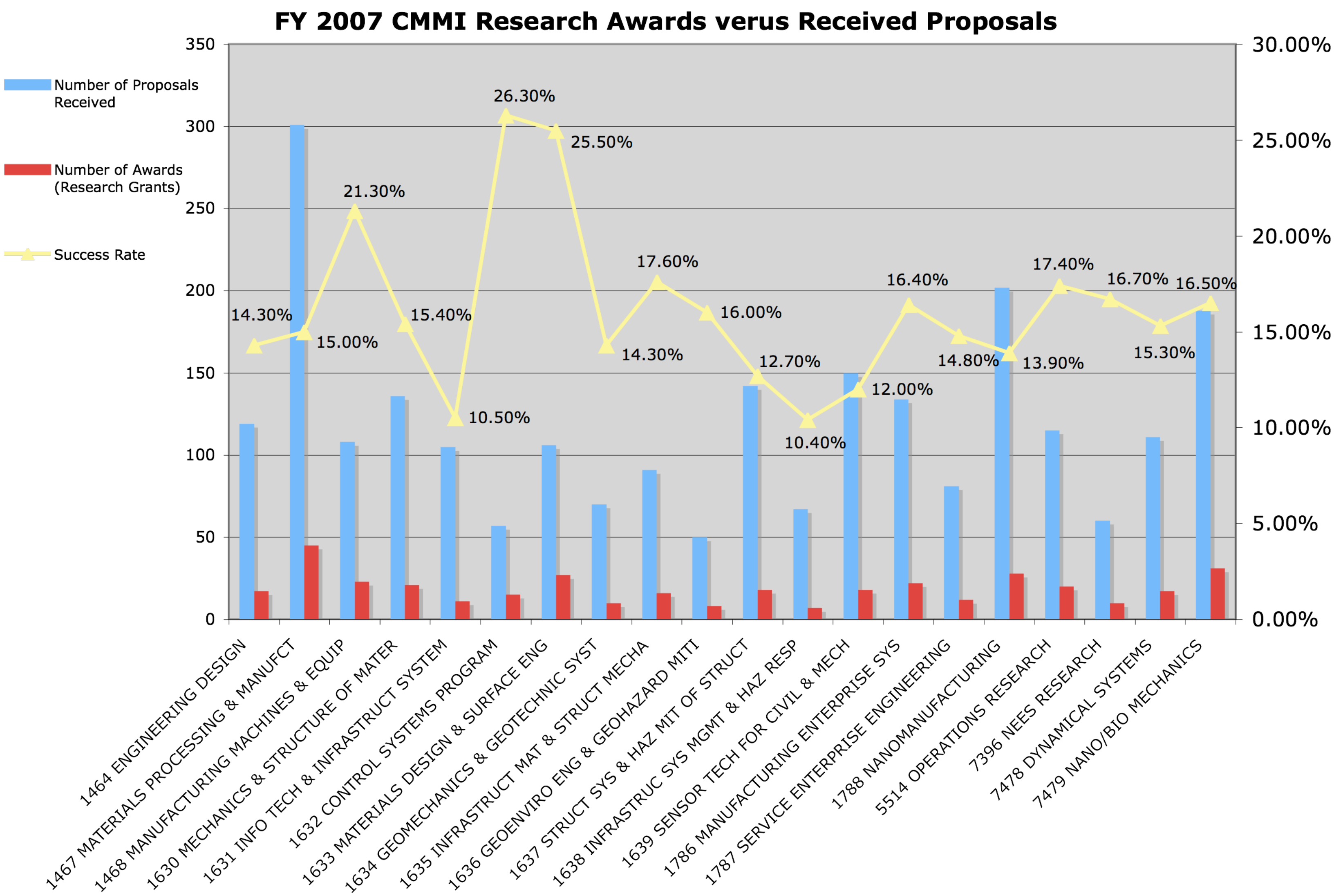
APPENDIX B: SELECTED STATISTICS ON CMMI PROGRAMS AND AWARDS

Table B1: Proposal Dwell Time Statistics for CMMI Core Programs, FY 2007

Program	Number of Proposal	Average (Months)	Standard Deviation (Months)	0-6 Months	>6-9 Months	>9-12 Months	>12 Months
1189 MAJOR RESEARCH INSTRUMENTATION	42	6.56	0.63	29%	71%	0%	0%
1464 ENGINEERING DESIGN	124	5.77	1.12	80%	19%	1%	0%
1467 MATERIALS PROCESSING & MANUFCT	304	6.02	1.21	54%	41%	5%	0%
1468 MANUFACTURING MACHINES & EQUIP	117	4.52	1.47	95%	1%	4%	0%
1630 MECHANICS & STRUCTURE OF MATER	148	5.76	1.50	53%	46%	1%	0%
1631 INFO TECH & INFRASTRUCT SYSTEM	111	5.02	1.45	95%	3%	3%	0%
1632 CONTROL SYSTEMS PROGRAM	60	7.18	2.08	23%	57%	20%	0%
1633 MATERIALS DESIGN & SURFACE ENG	108	6.98	1.59	28%	67%	6%	0%
1634 GEOMECHANICS & GEOTECHNIC SYST	72	6.28	1.77	68%	21%	11%	0%
1635 INFRASTRUCT MAT & STRUCT MECHA	93	4.65	1.78	88%	10%	2%	0%
1636 GEOENVIRO ENG & GEOHAZARD MITI	54	6.05	1.84	72%	17%	11%	0%
1637 STRUCT SYS & HAZ MIT OF STRUCT	157	5.54	1.93	80%	13%	6%	0%
1638 INFRASTRUC SYS MGMT & HAZ RESP	73	5.21	1.78	85%	11%	4%	0%
1639 SENSOR TECH FOR CIVIL & MECH	152	5.87	1.24	74%	21%	5%	0%
1786 MANUFACTURING ENTERPRISE SYS	135	5.63	1.40	82%	16%	1%	0%
1787 SERVICE ENTERPRISE ENGINEERING	87	5.44	1.30	79%	20%	1%	0%
1788 NANOMANUFACTURING	208	4.89	1.07	87%	12%	0%	0%
5514 OPERATIONS RESEARCH	117	5.35	1.35	91%	4%	5%	0%
7396 NEES RESEARCH	64	5.70	0.78	91%	8%	2%	0%
7478 DYNAMICAL SYSTEMS	115	6.59	1.62	23%	67%	10%	0%
7479 NANO/BIO MECHANICS	198	5.76	1.69	82%	14%	4%	1%

Table B2: Core Program Proposal Funding Statistics, FY 2007

Program	Number of Proposals Received	Number of Awards (Research Grants)	Success Rate	Average Award Amount	Average Award Duration
1464 ENGINEERING DESIGN	119	17	14.30%	$332,705.47	3.27
1467 MATERIALS PROCESSING & MANUFCT	301	45	15.00%	$282,587.44	2.61
1468 MANUFACTURING MACHINES & EQUIP	108	23	21.30%	$317,788.00	2.97
1630 MECHANICS & STRUCTURE OF MATER	136	21	15.40%	$340,004.69	3.31
1631 INFO TECH & INFRASTRUCT SYSTEM	105	11	10.50%	$234,398.80	3.00
1632 CONTROL SYSTEMS PROGRAM	57	15	26.30%	$233,682.47	3.20
1633 MATERIALS DESIGN & SURFACE ENG	106	27	25.50%	$260,034.77	3.38
1634 GEOMECHANICS & GEOTECHNIC SYST	70	10	14.30%	$288,547.50	2.68
1635 INFRASTRUCT MAT & STRUCT MECHA	91	16	17.60%	$209,922.60	2.93
1636 GEOENVIRO ENG & GEOHAZARD MITI	50	8	16.00%	$286,617.00	2.86
1637 STRUCT SYS & HAZ MIT OF STRUCT	142	18	12.70%	$258,040.67	2.97
1638 INFRASTRUC SYS MGMT & HAZ RESP	67	7	10.40%	$306,026.50	2.83
1639 SENSOR TECH FOR CIVIL & MECH	150	18	12.00%	$295,111.40	3.33
1786 MANUFACTURING ENTERPRISE SYS	134	22	16.40%	$327,280.79	3.21
1787 SERVICE ENTERPRISE ENGINEERING	81	12	14.80%	$325,349.50	3.20
1788 NANOMANUFACTURING	202	28	13.90%	$275,321.30	2.74
5514 OPERATIONS RESEARCH	115	20	17.40%	$299,783.56	2.89
7396 NEES RESEARCH	60	10	16.70%	$1,123,371.80	2.90
7478 DYNAMICAL SYSTEMS	111	17	15.30%	$279,899.06	3.19
7479 NANO/BIO MECHANICS	188	31	16.50%	$204,813.26	2.71



This figure represents funding rates of the 20 CMMI Core programs from FY 2007 as a function of the number of proposals received versus the number awarded as well as each program's success rate.

Table B3: Selected CMMI GPRA Statistics

Core Programs	Percent of Research Awards to New PIs	Percent of Proposals Processed w/in 6 Mos. of Receipt	Average Duration of Research Grants	Average Award Size	Percent of Reviews Addressing Both Review Criteria	Reviews Without Review Criteria	Percentage of Reviewers from Under Represented Groups	Reviewers from Under Represented Groups
1464 ENGINEERING DESIGN	35%	89%	3.33	$113,239	85%	76	37%	11
1467 MATERIALS PROCESSING & MANUFCTURING	30%	92%	3.07	$111,967	94%	60	38%	15
1468 MANUFACTURING MACHINES & EQUIPMENT	7%	100%	3.10	$111,248	95%	82	9%	2
1630 MECHANICS & STRUCTURE OF MATERIALS	12%	89%	3.43	$106,129	92%	39	26%	6
1631 INFO TECH & INFRASTRUCT SYSTEM	50%	98%	3.75	$90,856	93%	28	27%	7
1632 CONTROL SYSTEMS PROGRAM	20%	71%	3.17	$84,886	96%	6	30%	7
1633 MATERIALS DESIGN & SURFACE ENG	30%	56%	3.25	$84,896	96%	14	27%	6
1634 GEOMECHANICS & GEOTECHNIC SYST	20%	68%	3.00	$82,974	98%	7	25%	9
1635 INFRASTRUCT MAT & STRUCT MECHANICS	27%	99%	3.40	$91,133	97%	38	59%	10
1636 GEOENVIRO ENG & GEOHAZARD MITIGATION	27%	88%	2.55	$78,167	94%	12	35%	19
1637 STRUCT SYS & HAZ MIT OF STRUCTURES	33%	77%	3.36	$74,957	94%	32	38%	15
1638 INFRASTRUC SYS MGMT & HAZ RESPONSE	57%	57%	1.89	$110,212	96%	28	53%	9
1639 SENSOR TECH FOR CIVIL & MECHANICAL SYSTEMS	29%	97%	3.18	$94,417	98%	29	52%	12
1786 MANUFACTURING ENTERPRISE SYSTEMS	33%	95%	3.00	$86,135	95%	26	31%	11
1787 SERVICE ENTERPRISE ENGINEERING	53%	72%	3.25	$122,049	94%	47	31%	15
1788 NANOMANUFACTURING	45%	79%	2.98	$119,658	95%	77	33%	16
5514 OPERATIONS RESEARCH	43%	93%	3.21	$102,147	87%	101	16%	4
7396 NEES RESEARCH	14%	91%	3.07	$272,161	96%	23	42%	15
7478 DYNAMICAL SYSTEMS	7%	80%	3.26	$73,337	100%	10	23%	10
7479 NANO/BIO MECHANICS	13%	42%	2.63	$85,121	90%	16	31%	8

APPENDIX C: RECENT SPONSORED WORKSHOPS

Workshops are an important way that CMMI plans for future research focuses via community involvement. The list below is a representation of workshops funded by CMMI programs during fiscal year 2006:

Workshop Title	Sponsoring Program(s)
Workshop for the Investigation, Documentation, and Dissemination of National Science Foundation Research Validation Testbeds at the National Institute of Standards and Technology	Information Systems Management and Hazard Response
The Fourth United States - Japan Workshop on Wind Engineering	Structural Systems and Hazard Mitigation of Structures
Workshop on Modeling Errors and Uncertainty in Engineering Computations; Savannah, Georgia; February 22-24, 2006	Engineering Design, Computational Mathematics (MPS), Applied Mathematics (MPS)
SGER: US-Pakistan Workshop on Collaborative Research, Education, & Development Strategies for Earthquake Hazards Mitigation in Pakistan	Structural Systems and Hazard Mitigation of Structures
Workshop: Advanced Manufacturing Workshop; Arlington, VA; Spring 2006	Engineering Design
INTERNATIONAL WORKSHOP: MICRSOSTRUCTURE AND MICROMECHANICS OF STONE BASED INFRASTRUCTURE MATERIALS	Infrastructure Materials and Structural Mechanics
A Focused Conference on Frontiers in Boundary Lubricating Films	Infrastructure Materials and Structural Mechanics
Workshop: NSF CAREER Proposal Writing Workshop; Wichita State University, Wichita, Kansas; April 6, 2006	Operations Research, Service Enterprise Engineering, Manufacturing Enterprise Systems, GOALI, Manufacturing Machines and Equipment, Materials Processing and Manufacturing, Engineering Design
Workshop: Healthcare Systems Engineering (HSE); Arlington, Virginia; 15-16 June 2006	Service Enterprise Engineering
Workshop for Biologically Inspired Design; Atlanta, Georgia; Spring 2006	Engineering Design
Workshop: A Systems of Systems Colloquium; to be held, Lone Wolf, Oklahoma; Date TBD	Manufacturing Machines and Equipment
Workshop: Solid Freeform Fabrication (SFF) Symposium; Summer 2006; Austin, TX	Manufacturing Machines and Equipment
International Workshop on Predictive Modeling of Composite Materials	Mechanics & Structures of Materials
An International Workshop on Smart Materials and Smart Structures	Sensor Innovation and Systems
Workshop: Smart Systems for Mitigation of Exogenous Threats Using Autonomic Response	Nano-Bio Mechanics, Dynamical Systems, Sensor Innovation and Systems, Control Systems Program, Statistics (MPS)
Workshop: Nanomanufacturing Occupational and Environmental Health & Safety Workshop; Cincinnati, Ohio; December 4-8, 2006	Nanomanufacturing
International Workshop on Bio-Soil Interactions and Engineering	Geobiology & Low Temperature Geochemistry (GEO), Geomechanics and Geotechnical Systems, Environmental Engineering (CBET)
TDR 2006 Third International Symposium and Workshop on Time Domain Reflectometry	Geomechanics and Geotechnical Systems
Study: Enhancing NAFTA Logistics: Synthesizing Opportunities for Companies and their Supply Chains	Manufacturing Enterprise Systems
SGER: Community-Based Research at HBCUs in Response to Community Crisis	Infrastructure Systems Management and Hazard Response
Workshop: Touting the Successes of Environmentally Benign Design and Manufacture: A Symposium; Arlington, Virginia	Service Enterprise Engineering, Engineering Design
WORKSHOP: Product Re-X: Recovery, Recycling, Reuse and Remanufacturing. Innovations in Business Models, Product Design and Economic Development; June 21, 2006	Engineering Design
NSF 2008 Design, Service and Manufacturing Grantees and Research Conference: Building for the Future; Knoxville, Tennessee; January 7-10, 2008	Manufacturing Machines and Equipment

A Workshop to Develop a Strategic Plan for Tsunami Research in the US	Geoenvironmental Engineering and Geohazard Mitigation
Sustainable Manufacturing: IV Global Conference on Sustainable Product Development and Life Cycle Engineering; held in Sao Carolos, Sao Paulo, Brazil; Oct. 3-6, 2006	Service Enterprise Engineering
NSF - Sandia National Laboratories Workshop on Predictive Methods of Analysis for Complex Jointed Structures	Mechanics & Structures of Materials
The World Forum on Smart Materials and Smart Structures Technology 2007 (SMSST'07)	Nano-Bio Mechanics, Dynamical Systems, Sensor Innovation and Systems, Information Technology and Infrastructure Systems, Mechanics and Structures of Materials, Statistics (MPS)
Workshop: Advanced High-Strength Steels: Fundamental Research Issues; Arlington, Virginia; October 23, 2006	Materials Processing and Manufacturing
The 5XME Workshop and Report	Dynamical Systems
Workshop: Frameworks for Integration of Atmospheric-Oceanic Science and Forecasting with Operational Decision-Making; Naval Postgraduate School, Monterey, CA; January 3-5, 2007	Service Enterprise Engineering
Collaborative Workshop on Bio-Nano Manufacturing for Cellular Engineering; March, 2007; NIST, Gaithersburg, Maryland	Nanomanufacturing
Second International Conference on Complementarily, Duality, and Global Optimization in Science and Engineering; Gainesville, Florida; February 28, 2007 through March 2, 2007	Operations Research
Frontiers in Dynamic Systems	Dynamical Systems, Control Systems Program, Sensor Innovation and Systems, Mechanics and Structures of Materials, Applied Math (MPS)