COMMITMENT TO EXCELLENCE

in Civil And Mechanical Systems Research and Education

Planning for the Future of the
Division of Civil and Mechanical Systems (CMS),
Directorate for Engineering (ENG),
National Science Foundation (NSF)
4201 Wilson Boulevard, Arlington, Virginia 22230 USA

CMS program directors on a day in 2004, when all were in the office except Drs. Mujumdar and Ulsoy. (From left to right, back to front, Drs. McCabe, Wenger, Chong, Fragaszy, Chung, Pauschke, Liu, Tomizuka, Pestana, de la Garza and Balaguru).

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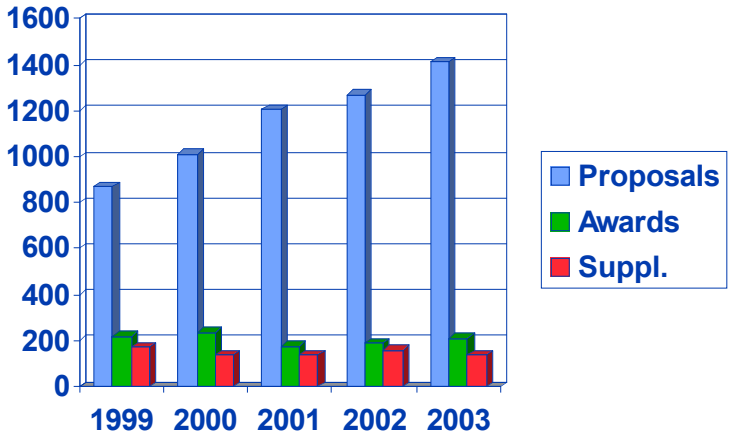


The proposals submitted to CMS have been steadily increasing, while the number of awards and supplements remain fairly constant. There has been some increase in award size and duration. However, overall success rates have been declining.

EXECUTIVE SUMMARY

The Civil and Mechanical Systems (CMS) Division of the Engineering (ENG) Directorate at the National Science Foundation (NSF), to serve society, and in partnership with the civil and mechanical engineering research and education community, is committed to excellence in carrying out its *mission*:

> To expand the *fundamental knowledge* base for the engineering profession in application to mechanical systems and the constructed environment, to support the *transmittal of that knowledge to new generations*, and to support the rapid development and deployment of research to mitigate risks induced by natural and man-made *hazards*.

The CMS division supports research and education related to the structures and machines we encounter in our daily lives. The division's activities are clustered into three main areas: (1) *engineered materials and mechanics*, (2) *intelligent civil and mechanical systems*, and (3) *infrastructure systems and hazard mitigation*.

CMS builds upon the widely recognized strengths and core values of NSF in terms of funding research at the *frontiers of discovery, learning and innovation* based upon rigorous, competitive *merit review*. This document summarizes the results of a one-year strategic planning effort undertaken by CMS, and puts forth statements of vision, mission, goals, objectives and values. The report includes specific recommendations and actions to achieve those objectives. Those recommendations, detailed on pages 25-28, are grouped into four main categories and summarized here as follows:

1. *Leadership and communications in research and education for civil and mechanical engineering systems.* In partnership with the CMS research and education community, identify and articulate the benefits to society of civil and mechanical systems research and education through divisional-level workshops.
2. *Priorities for CMS research*: Investigator-initiated research; the Network for Earthquake Engineering Simulation cyberinfrastructure; nano- and bio- mechanics of materials; intelligent civil and mechanical systems; simulation-based engineering science; hazard mitigation and response for critical infrastructure protection.
3. *Proposal loads and success rates.* Make the case for increasing research investments in CMS research areas, take measures to limit the numbers of proposals; develop mutually beneficial partnerships with other agencies; improve all administrative processes.
4. *Assessment*. Carry out studies to identify the NSF role in seminal developments in civil and mechanical engineering over the past few decades; award a prize of national stature to recognize these most significant outcomes of CMS funded research; perform regular evaluations of all programs and solicitations, and objective surveys of research communities served by CMS.

INTRODUCTION

A scientist studies what is, whereas an engineer creates what never was –
Theodore Von Karman

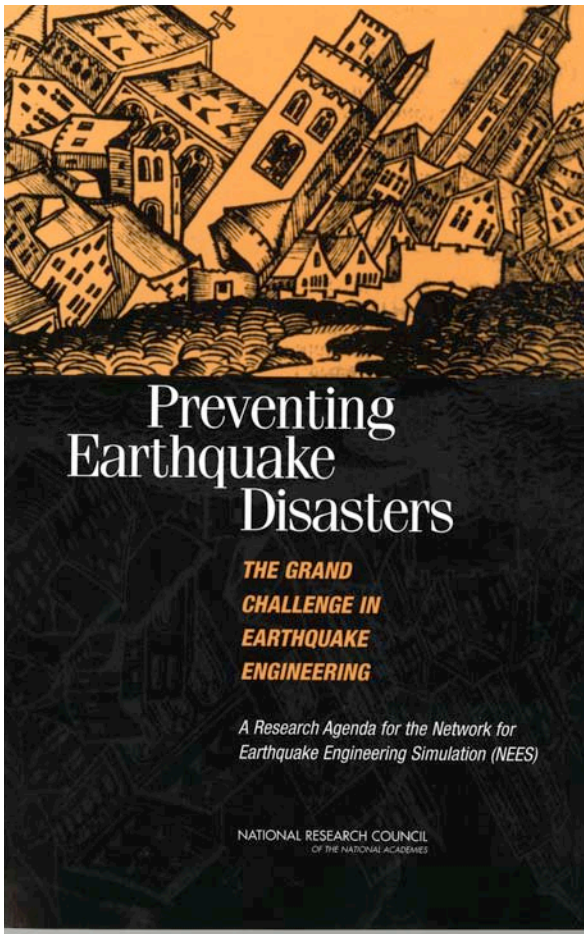
The 20th Century was transformed by engineering achievements that fueled the economy and led to longer and better lives for people all over the world [1]. These include revolutionary advances in the constructed environment (e.g., affordable housing, home heating and cooling, skyscrapers, bridges and tunnels), in mobility (e.g., automobiles, trains, aircraft), communications (e.g., telephones, television, satellites, internet), productivity (e.g., electric power, new materials, computers, automated machines, home appliances), and health (e.g., water distribution, sanitary sewers, medical devices and imaging). During the 20th century, average life spans increased by 30 years, from 45 to 75 years, and the majority of that increase came not only from advances in medicine, but also from the widespread availability of clean drinking water and sanitary sewers. The disciplines of civil and mechanical engineering played a dominant role in delivering these benefits to society during the 20th Century.

Prof. Paul Lauterbur, 2003 Nobel Laureate in medicine, was funded by CMS in the early 1980's to refine nuclear magnetic resonance into a routine diagnostic technique.

As we begin the 21st Century, research progress in civil and mechanical systems continues with advances in materials, micro- and nano- scale systems, intelligent civil and mechanical systems, biomechanics and biomedical devices, hazards mitigation, and many other areas. Such discoveries, as well as the researchers who make them, are the engines that drive our economy. The Civil and Mechanical Systems (CMS) Division, Directorate for Engineering (ENG), National Science Foundation (NSF), represents the national investment in ensuring new discovery, learning and innovation at the frontiers of civil and mechanical engineering. CMS funds research related to the structures and machines that we all encounter in our daily lives.

BACKGROUND

During 2003-2004 the Civil and Mechanical Systems (CMS) Division, Directorate of Engineering (ENG), National Science Foundation (NSF), conducted strategic planning to develop a shared vision, a clear statement of mission, specific common goals and actions; to capture emerging opportunities; and to improve processes and organization. This effort began with a self-assessment to identify strengths and weaknesses, and to establish trends and issues. The collection of data for the self-assessment was also the basis for preparation for a visit to CMS in March 2004 by an external Committee of Visitors (CoV), representing the civil and mechanical engineering research community.



During construction of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), the CMS division funded a National Academy of Engineering study to identify the grand challenges in earthquake engineering research that NEES can help to address [9].

There is a long history of strategic planning at NSF, in ENG and in CMS. There is a CMS strategic plan from 1987 [2], and the ENG *Long View* [3], while the *NSF GPRA Strategic Plan for FY2001-2006* [4] was recently updated in 2004. CMS often funds workshops for our research communities that are aimed at research planning (e.g., [5-10]). The Division, in its planning, has worked within the framework of the priorities of the President's National Science and Technology Council and other national efforts in engineering research, education and innovation [11-15], and CMS has also participated in the ENG planning activities of the past year (e.g., advisory committee, workshop and retreat in August 2003, workshop in August 2004) [16-17].

Within CMS, this past year, we held a CMS retreat in December 2003 (see Appendix C). The retreat had two breakout groups: (1) New directions in Civil and Mechanical Engineering for CMS Program Officers, and (2) Streamlining CMS Operations for CMS staff. The first group concluded that we partner with our research communities to lead the development of new areas important to Civil Engineering (CE) and Mechanical Engineering (ME). Also, they noted the need to enhance the image of these fields and possibly reorganize and/or rename our own activities to support that. The second group noted the need for improvements in various CMS activities from incoming proposals, to panels, to jackets, to hiring and office interactions.

During March 2004, the CMS Division also hosted its Committee of Visitors, which has written a very thorough and supportive report [18]. In preparation for the CoV, we collected data on aspects of CMS activities, identified trends such as increasing proposals and proposal loads, the increasing percentage of fenced funds, falling success rates, etc. Some of that data are summarized in Appendix A of this document. These studies also revealed improvements in emerging vs. maturing areas, dwell times, reduced mortgaging of funds, funding demographics, etc. The CoV report was very complimentary overall, advised us to prevent further erosion in our success rates by reducing the numbers of proposals, noted the importance of NEES to CMS and ENG, and new potential opportunities due to the emphasis on security, etc. A brief summary of the CoV report, and the CMS response, is included in Appendix B of this document.

This draft document began to take shape during the half-day CMS retreat held on 8/25/04 (see Appendix C). Our goal was to follow up on the earlier CMS planning efforts through the efforts of several working groups, with specific focused topics, as described in Appendix C. This draft strategic plan for CMS was then compiled by a team, led by the CMS Division Director, which included the leaders of the breakout groups from the 8/25/04 retreat. The draft was then distributed for further discussion and refinement within and outside the Division. This report is, thus, an evolving document that summarizes the CMS Division vision, mission, goals, and reinforces our commitment to excellence in carrying out that mission.

VISION, MISSION, GOALS, OBJECTIVES AND PROCESSES

The National Science Foundation celebrated its 50th anniversary in 2000 and has developed a worldwide reputation for excellence and leadership in scientific and engineering research and education [19]. Organizations like NSF, that have achieved sustained greatness, have done so based on consistency of values, principles and practices [20-21]. It is in this context that CMS has developed the following statements of its vision, mission, goals and objectives.

VISION

The National Science Foundation (NSF) vision is [4]:

Enabling the Nation's future through discovery, learning and innovation

In the Civil and Mechanical Systems (CMS) Division of NSF, we share this vision and take primary responsibility for **the areas of civil and mechanical engineering systems.**

We envision CMS as the acknowledged leader in advancing the frontiers of civil and mechanical engineering research, innovation and learning, in partnership with the civil and mechanical engineering community, and in service to society and the Nation.

Georgia Tech students use the P-Quake system to assess damage to buildings surrounding the site of the September 11, 2001 terrorist attacks on the world trade center.

MISSION

The NSF Mission is [4]:

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

The CMS Division plays the leadership role in achieving this mission as related to the **constructed environment, structures, machines and mechanical systems.**

More specifically, the Mission of CMS is:

- to expand the **fundamental knowledge** base for the engineering profession in application to **mechanical systems** and the **constructed environment**,
- to support the **transmittal of that knowledge to new generations**, and
- to support the rapid development and deployment of research to **mitigate risks induced by natural and man-made hazards.**

Pat Galloway, former President of the American Society of Civil Engineers (ASCE), and CMS Program Director Ken Chong, meet with CMS and ASCE staff in 2004 to discuss topics of mutual interest.

VALUES

The CMS Division *shared values*, consistent with those of the NSF and ENG [3-4, 17], are:

- Awards are directed at the *frontiers* of engineering research, learning and innovation.
- Careful attention is paid to potential *conflicts of interest*, or the appearance thereof, for managers, program officers, staff, reviewers, panelists, etc.
- Awards are made based upon a rigorous, high-quality and timely *merit review* process.

- Award decisions will be based on two *merit review criteria*: (1) *intellectual merit*, and (2) *broader impacts* (including societal benefits and broadening participation of underrepresented minorities and women).
- Award decisions will encourage the *integration of research and education*, through graduate student support, research experiences for undergraduates, curriculum development, etc.
- *Partnership with the research community* will be encouraged, through visiting committees, workshops, rotators, reviewers, etc.

GOALS

The NSF goals include investing in *people, ideas, tools and organizational excellence* [4]. Again, CMS assumes responsibility for leadership in achieving these goals **in the areas of civil and mechanical systems.** We enumerate specific CMS objectives, related to each of these goals, in the following section.

Attendees at the 2003 Workshop for Young Engineering Educators from Underrepresented Groups in Civil and Mechanical Engineering. Such a workshop has been funded by CMS and held every other year since 1995. The focus is mentoring of young faculty, especially from underrepresented groups.

OBJECTIVES

Specific objectives, to achieve the above goals, are summarized for each goal. Each objective includes one or more possible metrics.

- **People Goal:** Nurturing of excellent next generation talent in CE and ME through:
  - Support of faculty research with graduate students
    - Metric: Over 90% of awards include graduate students
  - Support of junior faculty
    - Metric: Over 30% of awards made to new PI's
    - Metric: Success rate for CAREER awards equal to or greater than the overall CMS success rate

- Increased participation from underrepresented groups
  - Metric: Percent of proposals from underrepresented groups greater than their percent representation on the faculty of civil and mechanical engineering departments
- Support of research experiences for undergraduates and for teachers, and outreach to K-12
  - Metric: Maintain or increase numbers of REU and RET supplements each year.
- Support of international cooperation and collaboration
  - Metric: Maintain or increase numbers of awards co-funded with the OISE each year.

CMS Program Director Ken Chong with attendees of the first Nanomechanics Summer Institute at Northwestern University. The goal is to educate mechanics faculty and graduate students so they can contribute to the emerging area of Nanomechanics.

- **Ideas Goal:** Discovery at the frontiers of CE and ME knowledge through:
  - Support of research excellence at the frontiers of:
    - Engineered Materials and Mechanics
      - *Mechanics and Structure of Materials*
      - *Surface Engineering and Materials Design*
      - *Infrastructure Materials and Structural Mechanics*
      - *Nano and Bio Mechanics of Materials*
    - Intelligent Civil and Mechanical Systems

- *Information Technology and Infrastructure Systems*:
- *Sensor Technologies for Civil and Mechanical Systems*
- *Dynamic Systems*
- *Control Systems*

- Infrastructure Systems and Hazard Mitigation
  - *Geotechnical and Geohazards Systems*
  - *Structural Systems and Hazard Mitigation of Structures*
  - *Network for Earthquake Engineering Simulation (NEES)*
  - *Infrastructure Systems Management and Hazard Response*

- Metric: Ensure that at least 95% of funds are awarded based upon rigorous merit review.
- Metric: Over 90% of awards made are to proposals highly recommended in merit review.
- Metric: Identify, through longitudinal assessment studies, the NSF/CMS role in seminal research developments in civil and mechanical systems (e.g., see MRI, page 4).

Attendees at the April 2004 workshop on Simulation Based Engineering Science. The CMS division works with leaders in the research communities to identify emerging research opportunities through such workshops [10].

- Interdisciplinary Research Involving CE and ME

- Nanoscale Science and Engineering, Biocomplexity in the Environment, Human and Social Dynamics, Sensors and Sensor Networks, Cyberinfrastructure, etc.

  - Metric: Ensure that at least 25% of awards include multiple PI's from different disciplines.

- **Tools Goal**: Excellent facilities to support research and education in CE and ME through:
  - Major Research Equipment Facilities and Construction (MREFC): Leadership role in the Network for Earthquake Engineering Simulation (NEES), and participation in other potential MREFC projects (e.g., CLEANER, DUSEL).
    - Metric: Ensure the success of the investment in NEES by providing, directly or through partnerships, funding for research to utilize at least 50% of the NEES capacity.
  - Major research instrumentation awards
  - Funding of equipment in research grants and supplements
    - Metric: Maintain instrumentation and equipment expenditures of at least 5% of CMS funds annually.

University Of Minnesota's Network For Earthquake Engineering Simulation (NEES) facility for full-scale testing of structural subassemblies. CMS funds not only ideas and people, but invests in world-class research facilities, such as NEES.

- **Organizational Excellence Goal**: High-quality and efficient service to the CE and ME research and education communities through:
    - High-quality review by external experts
        - Metric: Ensure diverse group of reviewers from active members of the research community.
    - Partnership with the research community (e.g., rotators, reviewers, experts, workshops, blue ribbon panels, Committee of Visitors)
        - Metric: Involve a diverse group of over 500 people from the research community in CMS activities each year.
    - Efficient review processing of proposals
        - Electronic processing (e.g., Fastlane, e-Jacket, PIMS)
        - Metric: Full electronic processing of all declinations and awards by the end of 2005
        - Dwell time
        - Metric: Continue to decrease the average dwell time for CMS (despite increasing proposal loads).
        - Metric: Continue to increase the percentage of CMS proposals processed in less than six months (despite increasing proposal loads).

CMS administrative support staff at 2003 holiday celebration.

- Facilitating and mentoring
  - Metric: Continue mentoring potential PI's, especially young PI's and PI's from underrepresented groups. Schedule appointment, respond to phone call or return e-mail within one week.
- Diverse workforce
  - Metric: Percentage of women Program Officers greater than the 10% of CE and ME faculty pool that are women.
  - Metric: Percentage of Program Officers from underrepresented minorities (i.e., African-American, Hispanic-American, Native-American) greater than the 5% of CE and ME faculty pool from underrepresented minority groups.
- Assessment
  - Government Performance Requirements Act (GPRA), nuggets, reports, etc.
  - Metric: Become ENG division with lowest percentage of overdue annual and final reports.
  - Metric: One major retrospective study per year to identify seminal developments in CE and ME where NSF/CMS awards made a contribution.
  - Metric: Regular objective assessment of all CMS programs and solicitations.
  - Metric: Regular objective surveys of CMS activities by members of the research community.

PROCESSES

To effectively and efficiently achieve the above-stated objectives, the CMS Division has in place a number of processes, and is working on their *continuous improvement*. These processes are summarized below:

Small Grants for Exploratory Research (SGER) constitute 4% of the CMS award portfolio, which is one of the largest percentages at NSF. The SGER awards, of up to $200,000 and one year, support innovative high-risk research and rapid-response research. Metric: Maintain leadership among ENG divisions in percentage of CMS awards dedicated to SGER awards.

- Proposal Processes
  - Funding based upon merit review:
    - Unsolicited proposals
    - Proposal solicitations
    - Centers

- Funding without merit review
  - Workshops
  - Small Grants for Exploratory Research (SGER)
  - Supplements
- Overage proposals
- Project reports
  - Annual reports
  - Final reports
  - Overdue reports

Workforce diversity. The CMS Division is committed to enhancing its workforce diversity. During 2004 the four Program Officers recruited to CMS were all Hispanic. One of the two Program Assistants recruited to CMS was African-American and the other Caucasian. Metric: Percent of Program Officers from underrepresented groups, including women, greater than the percentage in the CE and ME national faculty pool from which they are recruited.

- Personnel Processes
  - Competitive hiring (Program Directors, Program Assistants, etc.)
  - Professional and supportive work environment
  - Workforce diversity
  - Performance evaluations
  - Assistance to new employees
  - Adherence to Human Resources regulations

- Administrative Processes
  - Budgets
  - Travel
  - Equipment

- Reporting and Communications
  - GPRA, CoV, etc.
  - Web site, picture board, brochure, reports, etc.
  - Visitor reading materials (awards, workshop reports, etc.)
  - Develop a program officer's orientation manual

FRONTIERS:
EMERGING AREAS IN CIVIL AND MECHANICAL SYSTEMS RESEARCH

CMS funds research that contributes to the knowledge base and intellectual growth in the areas of infrastructure construction and management, geotechnology, structures, dynamics and control, mechanics, and materials, sensing for civil and mechanical systems as well as the reduction of risks induced by earthquakes and other natural and

technological hazards. The Division encourages cross-disciplinary partnerships at the intersections with traditional civil and mechanical engineering disciplines, to promote discoveries using technologies such as adaptive systems, nanotechnology and simulation to enable revolutionary advances in our nation's civil and mechanical systems.

As part of our strategic planning activities, we identified several broad and forward-looking themes that can be used to organize our activities, and clearly articulate them to external constituencies. Consequently, we have grouped the growing number of emerging research topics relevant to civil and mechanical engineering under the three overarching themes of *Better Economy*, *Better Health*, and *Improved Security and Safety* [16]. We also provide a few sample descriptions, to provide a flavor of the topics listed.

Development of alternate (non-fossil-based) energy sources, including wind energy, fuel cells based on hydrogen and other fuel sources, etc.. The US consumes 20 million barrels of oil each day, over 56% of which are imported. At the same time, combustion of fossil fuels in the United States results in the emission of over 1.5 billion tons of carbon dioxide into the atmosphere every year. To mitigate potential climate impact and improve energy security, we need to explore and develop other sources of energy not directly based on fossil fuels. Successful development of alternative energy technologies is not only good for our environment and energy security, but also good for job creation and economic development. As countries in Asia, Eastern Europe, and Africa continue their industrialization, they will face similar environmental and energy issues that will need the same kind of solutions. Asserting our leadership in this area may someday enhance our export activities and yield significant economic dividends.

- **Better Economy**
  - Energy and environment
    - Energy independence for the nation
      - Conservation, transmission losses,
      - Alternative sources
    - Hydrogen economy
      - Hydrogen infrastructure
      - Control of fuel cells
    - Sustainable development

High-durability infrastructure materials. Infrastructure systems (e.g., highways, roads, bridges, electric grids, water mains and sewers) are the lifeblood of each country. The materials we use in these systems have remained essentially unchanged in the last century. The material selection is often based on initial installation/construction cost, rather than life-cycle cost. With improved engineering and manufacturing, we can develop infrastructure materials with low cost, as well as high durability.

  - Advanced materials
    - Smart materials, self-repairing materials
    - Material design at nanoscale
    - Environmentally benign materials
    - High durability infrastructure materials
  - Complex Systems

- Intelligent Civil and Mechanical Systems
  - Infrastructure systems
  - Semi-active control of buildings and bridges
  - Mechatronics
- Simulation-Based Engineering Science
  - Multi-scale, multi-phenomenon computational modeling
  - Dynamic Data Driven Application Systems (DDDAS)

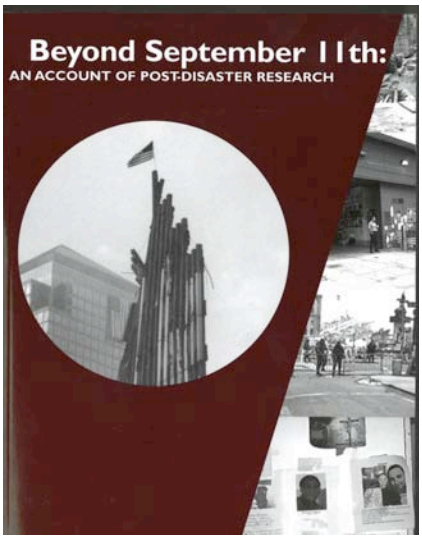
Complex engineered and natural systems. We know quite a bit about how neurons operate in the human brain, but are far from understanding consciousness. Other examples of complexity in systems, both man-made and natural, include ecosystems, the world-wide web, metabolic pathways, economic markets, spread of HIV infections, and the power grid. With such systems, decomposition and analysis of subsystems does not necessarily explain the behavior of the whole. Complex systems can display emergent behavior, where they provide organization without a central organizing principle There is a maturation and convergence, from many different fields of inquiry, of ideas relevant to complex systems and system engineering, for natural and engineered systems. We seek common principles and a unifying theory, as well as methods to analyze and synthesize such systems. The need is clear: we must understand how the brain learns, manage our environment for future generations, build infrastructure systems (e.g., power, transportation and information networks) that are not brittle, develop systems to produce and deliver clean and abundant energy, and understand and manage our vast global financial markets.

- Cyberinfrastructure
  - Network for Earthquake Engineering Simulation (NEES)

Advanced materials engineering and design for improvement of energy efficiency in transportation, heating and cooling of buildings. Materials with higher strength-to-weight ratios used in cars, trucks and aircraft will improve fuel efficiency. Recent laboratory studies suggest that nanocomposites may lead to dramatic improvements in strength without loss of fracture toughness. Advanced simulation, design and surface engineering hold promise for marked reduction in frictional losses and hence improved efficiency. Low thermal conductivity materials used to protect the space shuttle and high-temperature turbine blades can much improve insulation in buildings, thus reducing energy consumption in heating and cooling. It is sobering to note that a typical car in the US will save 180 gallons of gas a year if the fuel efficiency improves from 25 mpg to 40 mpg, while cutting the carbon dioxide emission from 4 to 2.5 tons a year – and there are over 200 million cars in the US.

- **Better Health**
  - Infrastructure systems for water and sewage.
    - Leakage, in-situ robotic repair,
  - Biomechanical devices and medical instrumentation
    - Mobility assistance for elderly
    - Wearable biosensors
    - Biomedical implants
  - Converging Technologies
    - Nano, info, bio, cogno

Engineering systems to produce potable water. From a biological, socioeconomic, geopolitical or military point of view, water has to be the most important liquid. In many parts of the world, potable water is simply not available. Even within the U.S., we have concerns about contaminated ground water, or city supplies with excessive lead or other chemicals. Surprisingly, apart from the use of activated carbon, reversed osmosis and orthophosphate treatment, there is limited research on the science and technology of water purification and treatment systems.



CMS Funded Several Research Studies Related to the Collapse of the World Trade Center Towers in The 9/11/2002 Terrorist Attack. These were also Collected in a Publication, and Presented at A Symposium [8].

Critical infrastructure systems. Natural hazards (e.g., the recent Indian Ocean Tsunami), cascading system failures (e.g., the recent massive power outages in North America), or terrorist attacks (e.g., those that occurred on 9/11/2001) on critical infrastructure could disrupt the direct functioning of key business and government activities, as well as have cascading effects throughout the Nation's economy. The facilities, systems, and functions that comprise our critical infrastructures are highly sophisticated, interdependent and complex. They include human assets and physical and cyber systems that work together in processes and networks that are highly interdependent. Research and development efforts can enable the integration of modeling, simulation, and analysis into national infrastructure and asset protection planning and decision support activities; develop economic models of near- and long-term effects of terrorist attacks; develop critical node/chokepoint and interdependency analysis capabilities; model interdependencies across sectors with respect to potential conflicts between sector alert and warning procedures and actions that must be initiated; conduct integrated risk modeling of cyber and physical threats, vulnerabilities, and consequences; and develop models to improve information integration.

- **Improved Security and Safety**
  - Hazard prevention, mitigation and response
    - Earthquakes, wind (hurricanes, tornadoes), wild fires, floods, landslides, volcanic eruptions, tsunamis, terrorist attacks
    - Fire safety
    - Structural health monitoring

- Transportation safety
  - Vehicle active safety systems
- Defense, military and space systems
  - MEMS and micro satellites
  - Self-repair and maintenance

Collaborations

The CMS division engages in many collaborations in its funding of research and education related to civil and mechanical systems. To provide some feel for the extent of such collaborations, examples are listed in the bulletized list below. It is estimated that over 50% of all CMS funded activities involve significant collaboration.

Other Divisions within Engineering:

- Joint initiatives and co-funding with BES
- Co-funded workshop on sustainability with BES
- Planning 4th workshop on Retention of Underrepresented faculty with BES
- CLEANER activities with BES
- Co-funding with Engineering Education and Centers Division to develop an Education and Outreach Strategic Plan for NEES.
- Cluster Leader for EERCs with EEC
- Working on Retention Workshop with EEC
- Co-funding of three research proposals with DMII
- Joint panel review with DMII

Other Divisions and Directorates within NSF

- Co-funding and co-reviews with DRMS program in SBE; jointly funded six projects
- HSD Solicitation (Leader of DMR subarea)
- CISE as part of the ITR initiative
- CISE as part of NEES Consortium shared cyberinfrastructure and NEES research
- Geosciences – Earth Sciences Division as part of NEES research
- Co-funding of workshop and awards with INT
- Co-funding of workshop with EHR
- ENG member of NSF-wide RUI working group
- MPS/PHY working group for DUSEL
- Co-funding award with MPS/MTH
- Co-funding awards with EHR/DUE
- Co-funding of award and workshop with GEO/EAR
- Co-funding of awards and a workshop with DMR
- Co-funding of awards with DMS

Public Sector Agencies and Organizations Outside of NSF

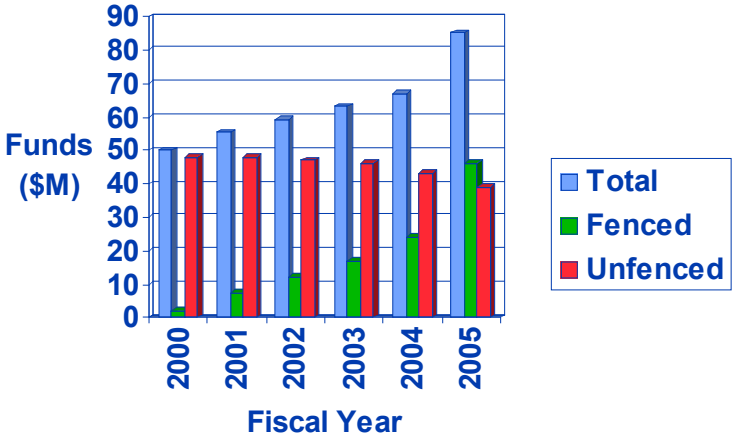
- Joint initiatives with Sandia National Laboratory of DOE

- Joint initiatives with NIH
- Co-funding of Natural Hazards Center at the University of Colorado with FEMA, USGS, NOAA, NASA, USDA, Army Corps of Engineers, EPA, DOT, and CDC
- Collaboration with USGS, FEMA, and NIST on NEHRP
- Co-funding with HUD on PATH
- Collaboration between NEES and the Japanese National Research Institute for Earth Science and Disaster Prevention
- Collaboration with DOT and FHWA

Private Sector Agencies and Organizations Outside of NSF

- Working relations with ASCE, ASME, and others.
- FIATECH, research roadmap was vetted in a NSF-sponsored workshop
- GOALI proposals, and IUCRC and ERC's, include industrial partners

It is expected that CMS develop partnerships with other mission-oriented agencies, where it makes sense intellectually to do so, in order to leverage the limited funds available. Such partnerships will also provide the participating researchers a better opportunity to transition basic research discoveries to innovative new technologies with the mission agencies. For such partnerships, we look for annual budget of at least $3M, with at least half of that budget coming from the partner agency. In these partnerships, we provide the proposal processing through FastLane, maintain the NSF merit review process and criteria, and involve program officers from the partner agencies in that review process.



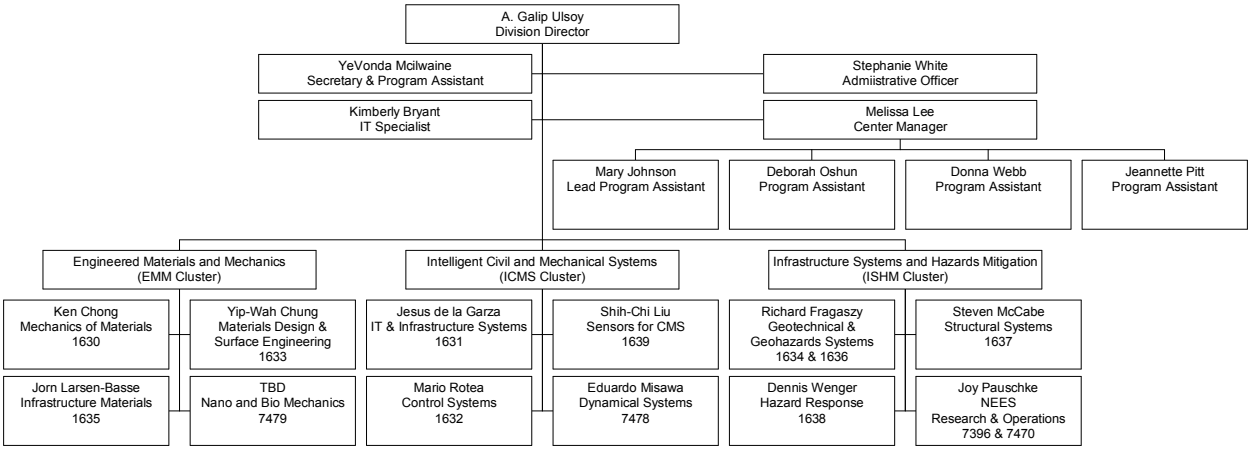
The CMS total budget has been increasing, however, more than half of the budget is now "fenced" for priority areas and initiatives, including NEES research and operations.

As part of the strategic planning process, the CMS division was reorganized into three clusters: (1) *Engineered Materials and Mechanics*, (2) *Intelligent Civil and Mechanical*

Systems, and (3) *Infrastructure Systems and Hazard Mitigation* to highlight three higher-level themes within which the 12 CMS programs are clustered. This reorganization uses the available program officer positions to best respond to increasing proposal pressures in emerging areas such as nanomechanics, biomechanics, mechatronics and smart structures. It also accommodates the important transition from the construction phase to the operations and research phase for NEES. The new CMS Organization is detailed in the next section of this report.

CMS PEOPLE AND ORGANIZATION

The Civil and Mechanical Systems Division is organized into three clusters, each with four programs, as described below. As shown in the following organization chart, each of the 12 programs has a Program Officer, and the division also has a Division Director and 8 support staff (i.e., 4 Program Assistants, a Secretary, an Information Technology Specialist, a Center Manager, and an Administrative Officer). This structure provides for coherent visibility of the division activities externally in terms of three higher-level interdisciplinary themes: (1) *Engineered Materials and Mechanics*, (2) *Intelligent Civil and Mechanical Systems*, and (3) *Infrastructure Systems and Hazard Mitigation*. It also enables the individual programs to operate independently, with a clear programmatic focus and responsibility. The new structure responds to the opportunities in emerging areas (e.g., nanomechanics, biomechanics, smart structures, mechatronics).



CMS Division Director Galip Ulsoy presents a plaque to program director Cliff Astill at his retirement celebration, December 2003. CMS is a dynamic organization which effectively blends rotators from the research community, like Galip, with permanent staff, like Cliff, who has a long and distinguished record of service to NSF. The CMS Division mourns the death of Cliff Astill from cancer one year after his retirement from NSF and fondly remembers his many contributions to NSF and the Nation.

The ENGINEERED MATERIALS AND MECHANICS cluster focuses on Mechanics and Structures of Materials, Materials Design and Surface Engineering, Infrastructure Materials and Structural Mechanics, and Nano- and Bio- Mechanics.

Program Directors:

- Ken Chong. *Mechanics and Structure of Materials (1630)*: computational, theoretical, analytical and experimental solid mechanics, model based simulation and constitutive models; and the link of microstructure to nano-, and meso-scale mechanical behavior. The program also supports experimental and analytical research on deformation, fatigue, and fracture.
- Yip-Wah Chung. *Materials Design and Surface Engineering (1633):* links between microstructure design and control and properties, performance, and engineering of materials and surfaces for novel applications in civil and mechanical systems and components; 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.

- Jorn Larsen-Basse. *Infrastructure Materials and Structural Mechanics (1635)*: properties and application of advanced structural materials; repair, retrofit, and rehabilitation of structural components; and durability of structural materials and components, including effects derived from interaction with the natural and constructed environment; development and constitutive characterization of new construction materials; and the behavior of infrastructure materials and structural components.
- Vacant, *Nano and Bio Mechanics of Materials (7479)*: mechanical properties of engineering materials and systems containing nanoscale features, such as grains, layers, precipitates or composites; mechanical properties of biological materials, which include cells, 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; computational and experimental tools to study nano and bio mechanics of materials.

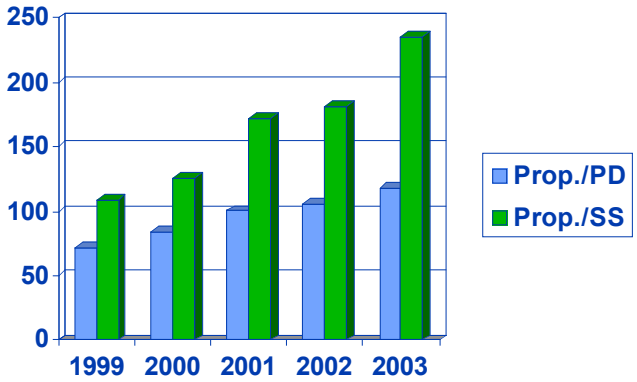
The INTELLIGENT CIVIL AND MECHANICAL SYSTEMS cluster includes programs on Information Technology and Infrastructure Systems, Sensor Technologies for Civil and Mechanical Systems, Control Systems, and Dynamical Systems.

Program Directors:

- Jesus de la Garza. *Information Technology and Infrastructure Systems (1631)*: information technology applied to: infrastructure construction management, operation, and life-cycle engineering; infrastructure system sensing and monitoring; distributed and remotely wireless micro devices with built-in sensors and processors for management of infrastructure systems and networks; internet-based data systems and networking technology; and voice and data communications technologies for infrastructure systems application; infrastructure system and network management, including intelligent transportation systems; infrastructure system modeling, simulation, and performance optimization.
- Mario Rotea. *Control Systems (1632)*: advances and novel developments in control system technologies and strategies with broad applicability to both mechanical and civil systems; real-time control and mechatronic systems; nonlinear, adaptive and intelligent control of physical systems from nano, micro to macro scales.
- Shi-Chi Liu. *Sensor Technologies for Civil and Mechanical Systems (1639)*: acquiring and using information about civil and mechanical systems to improve their safety, reliability, cost, and performance; knowledge base for development of advanced sensors for solution of inverse problems related to system identification and characterization, and for implementation of real time adaptive system performance, and dynamic response control, capabilities that use the sensed information; innovative sensor technologies and wireless networks,

analytical tools and strategies for health monitoring and diagnosis, and smart structures.

- Eduardo Misawa. *Dynamic Systems (7478)*: fundamental advances in the understanding, design and operation of dynamic systems, including acoustics, vibrational response, and kinematic relationships; active noise and vibration control technologies; modeling and simulation of nonlinear time-varying and distributed systems.



Due to increasing numbers of proposals, and steady staffing levels, the number of proposals per program director (PD) and per support staff (SS) have risen steadily in CMS.

The INFRASTRUCTURE SYSTEMS AND HAZARD MITIGATION cluster includes programs on Geotechnical and Geohazards Systems, Structural Systems and Hazard Mitigation of Structures, Network for Earthquake Engineering Simulation (NEES), and Infrastructure Systems Management and Hazard Response.

Program Directors:

- Richard Fragaszy. *Geotechnical and Geohazards Systems (1634 & 1636)*: geostructures (foundations, retaining structures, excavations, tunneling, soil and rock improvement technologies and reinforcement systems); experimental soil and rock mechanics and dynamics; constitutive and numerical modeling and verification; site characterization; non-destructive and insitu testing; bio-geo engineering; geohazards mitigation (earthquake, tsunami, landslide, erosion/scour); remediation and containment of geoenvironmental contamination.
- Steven McCabe. *Structural Systems and Hazard Mitigation of Structures (1637)*: design and performance enhancement of structural systems; dynamic behavior and response of structural systems subject to natural hazards (e.g., earthquakes, tsunamis, windstorms); safety and reliability of constructed systems; analysis and model based simulation of structural behavior and response including soil-structure interaction.

- Dennis Wenger. *Infrastructure Systems Management and Hazard Response (1638)*: system risk management under environmental loads and extreme events; contributions of infrastructure to hazard preparedness and response, including societal and economic impacts; and conceptual and theoretical bases of infrastructure construction and operation as a scalable enterprise.
- Joy Pauschke. *Network for Earthquake Engineering Simulation (NEES) (7396 & 7470):* innovative research using the NEES network of 15 major earthquake engineering experimental research equipment sites networked through the high performance Internet via the NEESgrid cyberinfrastructure.

RECOMMENDATIONS AND ACTION PLAN

In times of change, learners inherit the earth; while the learned find themselves beautifully equipped to deal with a world that no longer exists
– Eric Hoffer

This section summarizes the major *recommendations for change* arising from the CMS Division's 2003-2004 strategic planning efforts. Some of these recommendations have already been, or are in the process of being, implemented. Other recommendations are expected to be implemented in the next year or two, typically in coordination with ongoing parallel strategic planning efforts in the Engineering Directorate. Some recommendations may be difficult to implement in the near term due to resource constraints.

The recommendations for CMS are grouped into four main categories as follows:

1. *Leadership and communications in research and education for civil and mechanical engineering systems.*
    a. In partnership with the CMS research and education community, organize divisional-level workshops. This is in addition to usual workshops held at the programmatic level. These divisional workshops can help bring diverse disciplines together, identify emerging research opportunities which often occur at interfaces between disciplines, promote closer linkages between discovery and innovation, and create new directions for curricular innovations. Required investment approximately $0.1M per year.
    b. Support summer institutes, similar to those held recently on nanomechanics and surface engineering, to develop faculty (and future faculty) expertise in rapidly emerging new research areas, so "no professor is left behind." Required investment approximately $0.25M per year.

c. Continue to support career development workshops for young faculty, especially from underrepresented groups, in CE and ME. Increase frequency, perhaps in partnership with other divisions, to one per year (instead of every other year). Required investment $0.2M per year.

d. Organize the CMS Division around several broad, and forward looking themes, into which current and new programs can be clustered. Required investment is in people's time and effort. Implemented during January 2005, but needs to be updated and refined on an ongoing basis.

2. *Priority Areas for CMS research.*

a. *Investigator-initiated research* (including CAREER) is a proven source of innovative high-impact discovery. We recommend a long-term goal that 80% of the overall portfolio be such unsolicited proposals (see discussion in Appendix E). Required investment is $60M per year, and is currently at about $35M per year.

b. Innovative research that utilizes the *Network for Earthquake Engineering Simulation* cyberinfrastructure. (see discussion in Appendix D). Required investment is $40M per year, and is currently at only $10M per year.

c. *Nano- and Bio- Mechanics of Materials*, under the Nanoscale Science and Engineering (NSE) priority area, has emerged as a major area of innovative proposals in CMS. A new program has been established in this area, and provides a home for such proposals as the NSE priority area ramps down. Required investment is approximately $5M per year, and is currently at about $2.5M per year.

d. *Intelligent Civil and Mechanical Systems*, which utilize sensing, actuation and control technologies as an integral part of the constructed environment and machines, are a rapidly growing area of innovative research. Total annual investment required is $20M, and is currently at about $9M per year. This cluster has been established, and now contains 4 programs as described in the Organization section.

e. *Simulation Based Engineering Science* addresses the need for computational tools to solve engineering problems dealing with multiple phenomena across multiple spatial and time scales. This is a broad interdisciplinary area, and a blue ribbon panel has been established to identify research challenges (investment $0.1M). Required longer term investment is $40M per year.

f. Hazard mitigation and response for critical infrastructure protection. Research aimed at reducing the risk due to natural (e.g., earthquake, windstorm, tsunami, flood, landslide and volcanic eruptions) and man made (e.g., terrorist attacks) hazards, and the response to such hazards for critical infrastructure protection, continues to be a major focus in CMS.

Including NEES, this area represents over 50% of the total CMS portfolio, and an investment of approximately $50M per year.

g. Other opportunities. CMS stands ready to partner with other divisions and directorates in new opportunities, such as the current NSE initiative, potential new initiatives in Discovery-Innovation Institutes, Critical Infrastructure Protection and Complex Engineered and Natural Systems, etc. Also, we plan to partner in future MREFC opportunities (e.g., CLEANER and DUSEL). Required investment is estimated at $5 to $15 M annually in the near-term.

3. *Proposal loads and success rates.*

   a. Make the case for additional funding to bring the success rates up from the current levels of around 15%. A longer-term goal for success rates is 25% to 30%. This requires an additional $50M per year for CMS.

   b. As appropriate, limit solicitations, restrict the number of proposals submitted per Principal Investigator (PI) or co-PI per deadline, focus program descriptions, use letters of intent and preproposals, and develop other similar measures to stem the tide of increasing proposals. Requires additional human resources and IT support.

   c. Develop mutually beneficial partnerships with other funding agencies to leverage available research funds, as well as to provide continuity in research funding as ideas progress from discovery to innovation. Requires investment of Program Officer and Division Director time.

   d. Develop partnerships, within NSF and with external agencies, to strengthen and expand research opportunities that utilize the pioneering investment that has been made in the NEES infrastructure. Requires investment of Program Officer and Division Director time.

   e. Through ongoing self-assessment, work on continuous improvement of all CMS processes, from proposal processing to personnel to budgets. For example, reduce overage proposals and overdue reports. Requires investment of staff time.

4. *Assessment.*

   a. Longitudinal studies to understand the contributions that NSF funding has made to seminal developments in the fields funded by CMS during the past few decades. Requires resources of approximately $0.5M per year.

   b. Award a CMS (or ENG) prize of national stature to recognize and publicize the most significant outcomes of CMS funded research. Requires Program Officer and Division Director time and $0.5M annually.

c. Regular, objective, assessment of programs and solicitations to ensure high-quality. Requires Program Officer and Division Director time and IT support.

d. Conduct regular, objective surveys of CMS activities by members of the research community served by CMS. Requires IT support, and an initial investment of $0.2M to develop a web-based system.

The table below summarizes the budgetary implications for CMS over the next 5 years in order to fully implement the recommendations in this report. The table is similar to the data provided in Table A.2 for FY2001 to FY2005 in Appendix A. However, the table below is a planning tool that looks 5 years ahead from the current FY2005 to gradual implementation of these recommendations over 5 years to full implementation by FY2009. To fully implement the recommendations in this planning document will necessitate a doubling of the CMS budget over 5 years from $81.98M in FY2005 to approximately $162M in FY2009. This also assumes that measures have been taken to halt the increase in proposals to maintain them at or below their FY 2005 levels.

The Five-Year CMS Budget Plan for FY2005 to FY2009 Based Upon Recommendations in This Strategic Planning Report

	FY2005 Plan	FY2006 Plan	FY2007 Plan	FY2008 Plan	FY2009 Plan
FENCED FUNDS	**$9,560,211**	**$10,000,000**	**$12,500,000**	**$15,000,000**	**$20,000,000**
UNFENCED FUNDS	**$43,419,789**	**$55,000,000**	**$62,500,000**	**$70,000,000**	**$80,000,000**
CAREER	$7,200,000	$8,000,000	$10,000,000	$15,000,000	$20,000,000
CMS SOLICITATIONS, SUPPLEMENTS, SGER	$15,300,000	$15,000,000	$17,000,000	$18,000,000	$20,000,000
UNSOLICITED	$31,269,500	$32,000,000	$35,500,000	$37,000,000	$40,000,000
Total CMS (w/o NEES)	**$52,980,000**	**$65,000,000**	**$75,000,000**	**$85,000,000**	**$100,000,000**
NEES	**$29,000,000**	**$35,000,000**	**$40,000,000**	**$50,000,000**	**$60,000,000**
NEES Operations	$20,000,000	$21,000,000	$21,000,000	$22,000,000	$22,000,000
NEES Research	$9,000,000	$14,000,000	$20,000,000	$30,000,000	$40,000,000
Total CMS	**$81,980,000**	**$100,000,000**	**$116,000,000**	**$137,000,000**	**$162,000,000**
Leveraging of Funds via Interagency Partnerships	$1, 500,000	$3,000,000	$6,000,000	$7,500,000	$9,000,000
Total CMS Plus Partners	**$83,470,000**	**$103,000,000**	**$122,000,000**	**$144,500,000**	**$171,000,000**

APPENDIX A – CMS Facts and Figures

Strategic planning begins with data collection and self-assessment. The CMS division, in preparation for the March 2004 Committee of Visitors, did extensive data collection and analysis [18, 22]. Some of that data is summarized here in Appendix A, to support the discussions and recommendations in this planning document.

Table A.1 Research Proposals, Research Awards, Success Rate

	FY2001	FY2002	FY2003	FY2004
No. of CMS Research Awards	174	188	208	183
No. of CMS Research Proposals	1,202	1,270	1,412	1,311
Success Rate-CMS Research Proposals	14%	15%	15%	14%

Table A.2 CMS Budgets FY2001-FY2004 and FY2005 Request

	FY2001 Actual	FY2002 Actual	FY2003 Actual	FY2004 Actual	FY2005 Plan
NSF FENCED FUNDS	**$5,386,039**	**$9,096,461**	**$10,109,198**	**$14,141,527**	**$9,560,211**
NANO	$2,780,000	$5,270,000	$4,470,000	$7,268,227	$4,810,000
BE	$580,712	$738,000	$1,200,000	$1,200,000	$1,200,000
ITR/CI	$1,400,000	$2,307,450	$2,542,500	$2,542,500	
MATH				$561,667	$561,667
HSD				$500,000	$500,000
Other (Gen. Tax, Stipend Correct., CLEANER, ADVANCE)	$625, 327	$781,011	$1,896,698	$2,069,133	$2,488,544
UNFENCED FUNDS	**$47,883,961**	**$46,993,539**	**$53,120,802**	**$42,928,373**	**$43,419,789**
CAREER	$10,249,023	$10,097,660	$8,219,550	$5,391,839	$7,200,000
SOLICITATIONS, SUPPLEMENTS, SGER	$6,365,438	$6,992,324	$7,859,262	$9,760,732	$15,300,000
UNSOLICITED	$31,269,500	$29,903,555	$37,041,990	$27,775,802	$20,919,789
Total CMS (w/o NEES)	**$53,270,000**	**$56,090,000**	**$63,230,000**	**$57,069,900**	**$52,980,000**
NEES	**$28,138,000**	**$24,400,000**	**$13,471,860**	**$18,150,100**	**$29,000,000**
NEES MREFC	$28,138,000	$24,400,000	$13,471,860	$8,050,000	$0
NEES Operations					$20,000,000
NEES Research				$10,100,100	$9,000,000
Total CMS	**$81,408,000**	**$80,490,000**	**$76,701,860**	**$75,220,000**	**$81,980,000**

Table A3. Funding Rates for Research Proposals (NSF, ENG, CMS)

	NSF	ENG	CMS
2004	21%	15%	14%
2003	24%	17%	15%
2002	27%	22%	15%
2001	27%	20%	14%
2000	30%	23%	23%
1999	30%	27%	25%

Table A4. Funding Rate Demographics for CMS

	CMS Women	CMS Black	CMS Hispanic
2004	18%	10%	14%
2003	21%	31%	20%
2002	21%	15%	18%
2001	17%	16%	16%
2000	34%	25%	21%
1999	38%	18%	28%

Table A5. Average Proposal Dwell Times in CMS (months)

	FY2001	FY2002	FY2003	FY2004
Average Dwell Time (months)	7.6	6.3	5.4	5.2

Table A6. Funding of New Continuing Grants in CMS

	FY2001	FY2002	FY2003	FY2004
Dollar Amount of New Continuing Grants	$29.5M	$17.0M	$10.3M	$9.4M

Table A7. Faculty Early CAREER Awards Made By CMS

	FY2002	FY2003	FY2004
Proposals	177	149	181
Awards	25	21	18
Success Rate	14%	14%	10%

COMMENTS ON THE CMS RESEARCH PORTFOLIO IN TABLE A.8 BELOW

The CMS portfolio analysis is based upon 24 categories selected by the Program Officers, plus the category "other." These categories are used to sort 939 awards, of various size, duration and type, that were active as of 12/31/04. Most of the 24 categories

represent about 1% to 5% (approximately $2M to $14M) of the total investment. The categories with more than a 5% share include:

- Nanomechanics 6% $17.2M
- Infrastructure systems management $7% $20M
- Sensors and actuators $7% $20M
- Hazard mitigation of structures 6% $18M
- Earthquake engineering 23% $64M

Table A.8 Summary of the CMS Division Award Portfolio 12/31/04

Code	Tally	Expected Total	% by $
Solid mechanics	53	$ 10,536,325.00	4%
Structure of materials	9	$ 2,495,829	1%
Materials design	54	$ 12,416,049	4%
Surface engineering	46	$ 10,609,616	4%
Infrastructure materials	53	$ 11,077,831	4%
Structural mechanics	16	$ 3,839,894	1%
Nanomechanics	50	$ 17,150,324	6%
Biomechanics	13	$ 3,270,047	1%
Civil infrastructure	7	$ 1,875,323	1%
Infrastructure systems management	66	$ 19,911,230	7%
Control systems	44	$ 8,998,729	3%
Mechatronics	20	$ 4,141,288	1%
Sensors and actuators	75	$ 20,205,535	7%
Smart structures	26	$ 6,587,041	2%
Dynamic systems	29	$ 5,261,954	2%
Noise, acoustics, vibrations	23	$ 4,959,152	2%
Geotechnical engineering	76	$ 15,023,599	5%
Foundation engineering	15	$ 4,199,525	1%
Structural systems	43	$ 11,753,057	4%
Hazard mitigation of structures	70	$ 17,909,868	6%
Hazard and Disaster Reduction	44	$ 13,234,361	5%
Hazard and Disaster Response	28	$ 7,500,622	3%
Earthquake engineering	64	$ 63,916,891	23%
Cyberinfrastructure	2	$ 516,593	0%
Other	13	$ 4,248,650	2%
Totals	939	$ 281,639,333	100%

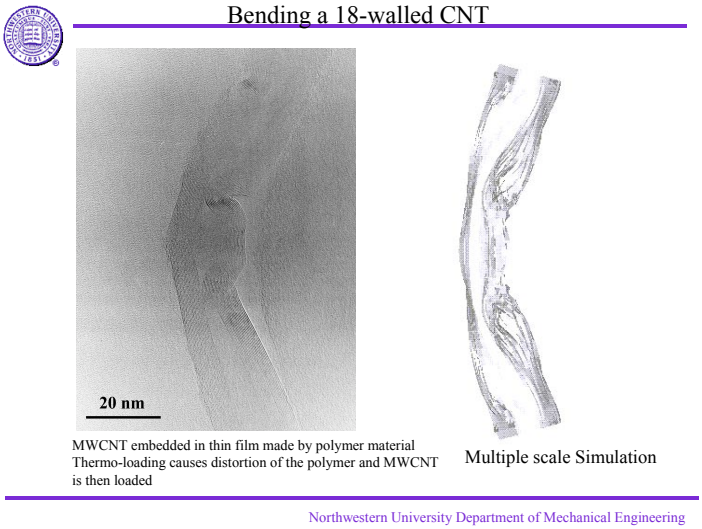
The large *Nanomechanics* investment reflects the CMS participation in the Nanoscale Science and Engineering (NSE) priority area. The large *Infrastructure systems management* investment reflects the DOT-NSF joint solicitation and the investment in the Institute for Civil Infrastructure Systems. The large *Sensors and actuators* investment reflects CMS participation in the Sensors and Sensor Networks initiative. The large

Hazard mitigation of structures investment reflects the long-standing Learning from Earthquakes and Natural Hazards Center investments. Finally, the huge investment in *Earthquake engineering* reflects the Network for Earthquake Engineering Simulation (NEES) construction, operations and research. Earthquake engineering, without NEES, is still about $33M or 12%.

Our CMS strategic plan identifies NEES as a major priority, and so that will continue to be a very large part of our overall portfolio. Currently NEES is $31M (11%) of this portfolio analysis, but will grow to at least $35M/yr or $105M over 3 years (about 40%). We have also identified critical infrastructure systems and hazard mitigation and response (currently w/o NEES this is about $90M or 32%) as a continuing major area of emphasis. In addition, we envision growth areas of nano and bio mechanics (currently about $28M or 10%) and intelligent civil and mechanical systems (currently about $70M or 25%).

The three clusters in CMS are: (1) Engineered Materials and Mechanics (EMM), (2) Intelligent Civil and Mechanical Systems (ICMS), and (3) Infrastructure Systems and Hazard Mitigation (ISHM). Currently, EMM and ICMS have about 25% of the awards, while ISHM (including NEES) has about 47%. However, our most recent group of proposals received 12/1/04 was 40% in EMM, 30% in ICMS and 30% in ISHM.

Our division is directly involved in managing the three earthquake engineering research centers at Buffalo, Berkeley and Illinois. The $6M in EERC funding will move in FY 2007 from the EEC division to CMS to support NEES research. We are also directly involved in managing the Vanderbilt education ERC. Finally, we participate as appropriate in other ERC and STC reviews, site visits, etc.



Experimental and computational investigation of the bending properties of carbon nanotubes (CNT)

APPENDIX B – CMS Committee of Visitors 2004

TO: John A. Brighton, Assistant Director, ENG

FROM: A. Galip Ulsoy, Director, CMS

DATE: August 25, 2004

SUBJECT: Response to Report of the Committee of Visitors for the CMS Division

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On behalf of the Division of Civil and Mechanical Systems (CMS), I thank the Committee of Visitors (CoV) for their thoughtful and thorough report covering FY2001-2003, and for the opportunities for improvement it provides the Division, the Directorate for Engineering (ENG) and the National Science Foundation (NSF). We are delighted that the CoV states: "Overall, the CoV finds that the CMS Division is doing a very good job in managing its programs. The Division has been successful in helping the Foundation to achieve desirable outcomes in its investments in people, ideas, and tools."

We are also pleased that in many of the suggested areas for improvement in the previous CMS CoV review in 2001 (covering FY1998-2000) substantial progress has been made. These improvements included better use of the broader impacts criterion, better mix of reviewers, reduced dwell times, larger award size and duration, more emphasis on high-risk and high-return projects, continued emphasis on diverse workforce, emphasis on environmental area, joint activities with the SBE Directorate, emphasis on co-funding and joint solicitations, internal strategic planning , priority on NEES, vision for earthquake engineering research, etc.

The CoV encouraged the proper balance between "fenced" and "unfenced" activities, to ensure a continued source of new innovative ideas from the research community. The CoV also noted the challenges posed by the increase in proposals, leading to increased workloads and reduced success rates. Certainly we need more resources, but we are also exploring other ways to address these issues.

The CoV highlighted the importance of the Network for Earthquake Engineering (NEES) cyberinfrastructure to CMS, ENG and NSF. We recognize the importance of NEES, and the leadership role for CMS, and have made this our main divisional priority. NEES is nearing successful completion, and we continue our efforts to ensure that the investment in NEES will be fully utilized to achieve important breakthroughs in earthquake engineering and in the emergence of cyberinfrastructures to support engineering research and education.

The CoV recognized the significant role that CMS has played in the NSF response to the terrorist attacks of September 11, 2001 and encouraged CMS to continue its role in supporting the nation's security needs. Our strength in multi-hazard mitigation makes this a natural direction for CMS, and we will certainly follow this advice to capitalize on that strength.

The detailed response to the CoV report below is organized in terms of the major topics highlighted in the Executive Summary of the CoV report. It includes a brief synopsis of those topics, and a brief response from the CMS division.

Topic In Executive Summary	CMS Response
The CoV finds the Division to be effective in assuring the integrity and achieving efficiency in its program processes and management. Proposals selected for funding are of high quality. In spite of continuing increases in the number of proposals handled, average dwell time has decreased to less than six months. It is an average 5.4 months, which is an excellent record.	Systems such as FastLane and e Jacket have helped achieve these results despite rapidly increasing proposal loads. CMS staff are extremely conscientious, yet we need to find ways to increase staff or limit the number of proposals. We have already gone to one deadline per year, and are considering other measures (e.g., limit number of proposals per Principal Investigator) to limit proposals.
The documentation in the jackets is very good. CMS uses the panel review process, supplemented with mail reviews. This process has been implemented effectively and fairly, and a good distribution of reviewers has been achieved in terms of geographic location, gender, and minority representation. Likewise, the CMS portfolio of funded projects has an appropriate distribution in terms of geography, gender, and minority representation.	With implementation of e Jacket, we have further enhanced the consistency and content of documentation in the jackets. We will continue our efforts, as well as to participate in ENG and NSF efforts, to improve reviewer databases and to encourage diversity.
The use of the broader impacts criterion improved over the three-year period of CoV evaluation. The reviewers now appear to be cognizant of the importance of broader impacts and use the criterion in their assessments. The interpretation of the meaning of broad impact varies significantly among the panels. It is therefore desirable to seek a more consistent understanding and application of the criterion in future panel reviews.	We use a one-page description of the merit criteria, and Program Directors go over that with the panels. They often use a plane with the two criteria as the two axes to summarize the ranking of proposals in the panel. We also routinely return proposals that do not address both criteria in the summary and the proposal itself.
In general, it was difficult to assess the expertise and qualifications of reviewers on the basis of the information provided in the jackets. The CoV recommends that reviewers be asked to provide short biographical sketches, and that this information be included in the jackets.	We are participating in efforts in ENG and NSF to improve the reviewer database. Currently, the SBIR and CTS divisions in ENG have implemented pilots. This issue would be addressed as part of those efforts.
The CoV judges that CMS has been successful in meeting the outcome goals in people, ideas, and tools. Specific examples illustrating the Division's success in each of these areas are given in the report.	These successes often become most evident decades after the funding of the research, and we will continue our efforts to document the long-term impact of the CMS research funding.
The Program Directors are commended for supporting first time researchers. Approximately 30% of CMS funding has been directed to first time researchers, thus providing the entrance and experience base for those seeking careers with a strong component of research. Especially noteworthy is CMS support of CAREER awards, which constitute about 50% of the funding for first time researches, or 15% of the research portfolio.	We will continue our priority on developing the next generation of researchers nationally in the areas relevant to CMS.
The COV notes that about half of CMS funding is pre-committed to research initiatives and other mandated projects, or "fenced". Combined with budget reductions, the net result is that the success rate for proposals within the CMS core competencies may fall to less than 10% for FY 2004. We advise carefully monitoring the ratio of fenced funds to total funds to ensure enough funds remain available for flexible use. We recommend that a proper balance be maintained between fenced initiatives and the funding of core competencies.	We agree that it is important to maintain balance in this regard. The unsolicited proposals are a constant source of new ideas and innovation. Adequate funding for such proposals allows us to adapt to changing priorities and to rapidly pursue new opportunities.
To meet the challenge of increasing numbers of proposals, the COV recommends that additional staff be assigned to CMS at both the PD and support staff levels. Additional funds are also sorely needed to support the many worthy projects that are proposed, but unable to be funded. The COV recognizes significant increases in funding may not be available in the near term. Therefore, it may be necessary to	We do need additional staff, and will also look for other ways to restrict the number of proposals in order to maintain high quality.

deal with increasing proposal loads under the assumption of relatively flat funding. Options include, but are not limited to, restricting the number of proposals from a single PI and readjusting the levels of support provided for various activities.	
NEES should be a top priority at the division, directorate, and upper management levels of NSF. This project provides the opportunity to explore the use of the cyberinfrastructure in its application to geographically distributed experimental facilities for cost-effective investments in large scale experimentation through shared-use facilities and experiments and more efficient utilization of major research equipment. NEES also provides unique opportunities with respect to database management and retrieval, advanced computational modeling, and linkage with the research, academic, industrial, and K-12 communities. It involves not only significant technical challenges, but entails social and cultural challenges as members of the civil engineering and computer science communities work together at an unprecedented level of collaboration. The potential payoff is very high. Much can be learned and applied from NEES that is relevant to future projects at NSF. It is in the interest of all to ensure the success of NEES.	NEES is a top priority for CMS, as well as ENG and NSF, and is an exciting new venture, which will require all our support over the coming years. We plan to develop partnerships, with other directorates and agencies, and with international partners, to fully utilize the investment that has been made in NEES.
Large-scale research programs such as NEES place a heavy burden on NSF professional and support staff. It is vital that PDs have adequate resources to perform their work effectively. In particular, they should receive the necessary travel assistance to visit equipment and research sites on a regular basis, and to maintain close contact with key individuals within the research and user communities.	We agree. The lack of Program Director time and travel funds continue to be a concern.
It appears that resources are not sufficient within CMS and the Engineering Directorate to realize the full potential of NEES. Furthermore, funds will be reallocated from other programs at the division and directorate levels just to support NEES with a resource base significantly below its capabilities. The COV does not believe that NEES should drain resources from other programs in CMS and the Engineering Directorate. Because of the importance of this project for NSF, the COV strongly recommends exploring with NSF upper management ways to obtain additional funds for NEES as a supplement to the Engineering Directorate budget.	We agree, and will work hard to leverage these available resources via partnerships (e.g., international partners such as Japan and Europe, interagency partnerships, as well as partnerships within NSF).
There is an excellent opportunity for CMS to take a continuing lead role in developing and directing NSF research in the area of homeland security. The Division has distinguished itself to date by undertaking a major research effort on the effects of September 11, 2001, which culminated in a special publication and press conference dealing with the research results. The COV recommends that CMS pursue research on homeland security issues and continue to pursue leadership position in this area.	We agree, and will continue to build on past activities in this area.
It would be advantageous to have a mechanism for division-level strategic advice. The COV is not well suited to this mission. Its charge is to assess program-level technical and managerial matters pertaining to program decisions. Moreover, the advice provided by the Engineering Advisory Committee to the Engineering Directorate is generally at a strategic level that addresses cross-cutting divisional issues and areas of broader NSF policy. The COV therefore recommends that consideration be given to establishing a division-level advisory committee composed of external experts from universities, industry, and government. It is likely that this recommendation applies to other divisions as well.	We would welcome strategic advice from the CoV members. We note that rotators, which constitute approximately half of CMS program directors, do also provide an ongoing mechanism for input and fresh ideas from the research community.

APPENDIX C- CMS RETREATS HELD 12/03 AND 8/04

THE RETREAT ON 12/2/03 & 12/3/03
Originally this retreat was to be a two-day, off-site, event. However, due to various financial and organizational restrictions, it was held during two afternoons in Stafford II:

DAY 1 - Tuesday 12/2/03, Room 565

1:30-3pm	PD Presentations of programs [15 min. each, including 5 min. for Q&A] K. Chong, Y-W. Chung, S. McCabe, P. Balaguru, M. Heller, D. Wenger
3-3:30pm	*Break*
3:30-5pm	PD Presentations of programs [15 min. each, including 5 min. for Q&A] M. Tomizuka, C. Liu, J. Pauschke, V. Mujumdar, C. Astill, R. Fragaszy

In the presentations each PD was asked to identify emerging and maturing areas within the program, and to provide basic program data regarding proposals, awards, dwell times, etc. Standard presentation templates were prepared and used and these presentations were utilized to both:

1. Educate one another on the various CMS programs
2. Prepare for the upcoming Committee of Visitors in March 2004

DAY 2 - Wednesday 12/3/03, Rooms 515 & 517

1-1:30pm	Plenary session [Introductory remarks by G. Ulsoy]
1:30-2:30pm	Parallel breakout sessions – one for PDs and one for staff Breakout for PDs: New Directions in CE and ME (Moderator: Tomizuka, Recorder: McCabe) Breakout for Staff: Streamlining CMS Operations (Moderator: Lee, Recorder: Johnson)
2:30-3pm	Report back, and wrap-up
3:pm	Adjourn

Summary of the New Directions in CE and ME Breakout Session
Attendees: Cliff Astill, P. Balaguru, Ken Chong, Yip-Wah Chung, Jesus de la Garza, Rick Fragaszy, Miriam Heller, Jorn Larsen-Basse, Chi Liu, Steve McCabe, Joy Pauschke, Juan Pestana, Masayoshi Tomizuka, Galip Ulsoy and Dennis Wenger.

Masayoshi Tomizuka made a brief presentation to introduce the discussion issues:

- Changing external environment
- Image of CE and ME
- Emerging areas
- Changing demographics

Brief summary of the discussion, as captured by the Recorder, follows:

Ken – CMS needs to take a leadership role in one major initiative.

Chi – change in internal CMS environment has been very positive; need to develop/maintain strong partnership with external research community.

Bala – emerging areas are important: nano, materials, IT and sensors; can be combined into multi-thrust programs.

Dennis – need to repackage CMS for modern image; but be clear about our audience; external CE and ME communities also facing this same issue. We should reconsider the one deadline – it has created problems for PIs (especially young PIs) and it is not clear it has reduced our proposal loads.

Rick – CE has no consumer products, so students do not see a path to wealth as in computer science; so not as attractive.

Joy – Industry and international connections important; CMS needs to recognize and keep up including computational research; need to effect change in undergraduate curricula.

Rick – need better collaboration I the profession; must start at the undergraduate level.

Jorn – In the future 80% of people will live in cities; Should we highlight/focus on urban engineering research? Currently we highlight mechanics/materials and structures/disasters; are we neglecting some important areas?

Juan – Image and marketing are important. Sustainable development could be good unifying theme.

Cliff – Serious problems exist, and "repackaging"is needed with substantial program realignment and name changes.

Jesus – Opportunity in integrating research and education, and affecting undergraduate (as well as graduate) curriculum. We also need to be part of a bold new K-12 effort, to attract students to the field.

Yip-Wah – The $6,000 travel budgets for non-IPA's is too small; sustainable development is an attractive theme; also modern construction. We need repackaging of CMS in terms of new themes.

Tomi – PD's can be very powerful, define/influence their programs and steer too much; they need to stay connected to their communities.

Steve – Fencing of funds, and unfunded mandates, are a serious problem; We need to provide leadership reflecting the ideas and priorities of the research communities in CMS.

<u>Summary points from discussion:</u>

1. Relations with community:
    - Partnerships to enhance image
    - Provide leadership to build communities

2. Sustainability or Urban Engineering Themes
3. Undergraduate curricula
4. Revisit single annual deadline; creates problems; does it reduce proposals?
5. Consider "repackaging" of CMS

Proposed action items:

1. Hold community workshops that are CMS-wide to define where CE and ME communities are going, and repackage CMS accordingly
2. Revisit the single vs. two deadline issue
3. Review/revise the names and descriptions of all CMS programs
4. Galip to explore issue of travel funds

Summary of the Streamlining CMS Operations Breakout Session

Attendees: Kim Bryant, Mary Johnson, Melissa Lee, YeVonda McIlwaine, Deborah Oshun, and Stephanie White.

Brief summary of the discussion, as captured by the Recorder, follows:

Incoming proposals – the Center Manager will maintain a master spreadsheet, and PDs are asked to screen incoming proposals as soon as possible. Any questions should be directed to Center manager, or to Lead Program Assistant.

Panels – the PAs would like early notification of panel dates from PDs.

Processing Jackets – the PDs should fill out the coding sheets prior to forwarding jackets to PAs. All should take e-Jacket training.

Hiring – need to interview and hire two new PAs.

Office Etiquette – PDs to notify PAs of their travel, and other absences from the office.

Proposed action items:

1. Jackets on back tables need to be processed more quickly by PDs
2. Panel dates need to be set as early as possible
3. All need to take e-Jacket training
4. Approve all annual and final reports in e-Jacket as soon as possible

AGENDA FOR 8/25/04 RETREAT

1:00-1:15	Review of agenda and meeting goals
1:15-1:30	Discussion of CMS strategic plan outline
1:30-2:30	Breakout into working groups (see below)
2:30-3:00	Break
3:00-4:00	Continue working groups

4:00-4:30	Report back from working groups with recommendations/actions
4:30-5:00	Wrap up discussion and next steps

WORKING GROUPS FOR 8/25/04 RETREAT

Each working group is asked to focus on a topic, and to come up with a short list of recommendation (from CMS to ENG and NSF) and actions (that CMS can take) on that topic. I have made the assignments to the working groups, but if you have strong objections, please let me know. The designated WG leader (denoted by an asterisk *) should facilitate the discussion and report back at the end of the day.

1. **Frontiers of discovery: emerging areas in civil and mechanical engineering**
   WG members: Chung*, Liu, Tomizuka, de la Garza

   Identify, and classify, the emerging areas in CE and ME. A draft list has already been included in this draft document as starting point. Update the list, and prioritize.

   Suggest how program officers can work with their research communities, and program officers at other agencies, to identify and develop emerging research areas on an ongoing basis.

2. **NEES Planning**
   WG Members: Pauschke*, Mujumdar, McCabe, Pestana, Mcilwaine

   The NEES construction ends 9/30/04, and research/operations starts in FY05. Develop a long term plan for success of the investment in NEES.

   Identify what NSF can do, and who at NSF can do what. Also, identify who else (NEES Consortium, other agencies, etc.) can play a role.

3. **Improving CMS Processes**
   WG Members: Lee*, Johnson, Pitt, Webb, Fragaszy

   This draft document includes a list of CMS processes. Update the list as needed, and identify areas for improvement.

   What are the one or two most important improvements that CMS can make. What are improvements we can suggest to ENG and NSF?

4. **Improving CMS Organization**
   WG Members: Wenger*, White, Larsen-Basse, Oshun

CMS will see some reorganization, since NEES construction is ending and a new senior advisor position has been added. Suggest one or more organizational structures for CMS.

We expect to have a division director, administrative officer, senior advisor, center manager, IT specialist, a secretary/PA, 4 PA's and 12 PD's.

5. **Improving assessment**

WG Members: Balaguru (Larsen-Basse)*, Ulsoy, Chong, Bryant

We thoroughly review proposals, but provide little post award assessment, except collection of GPRA nuggets and final project reports.

Shall we assess/select (and give prestigious national awards) to the best researchers?

Shall we do longitudinal studies to assess how our research investment have benefited society?

Shall we do surveys of our research community to improve CMS?

RECOMMENDATIONS AND ACTIONS FROM 8/25/04 RETREAT

During the 8/25/04 CMS retreat, each working group, for their focus topic, identified **recommendations** that we (i.e., CMS) can make to ENG and NSF as well as specific **actions** that we (i.e., CMS) can take on our own (as a Division and individually). These are briefly summarized below.

- **Frontiers of discovery: emerging areas in CE and ME**
  - Proactively organize division level workshops (in addition to programmatic workshops) to determine the emerging areas and education initiatives
  - Communicate results of workshops to the community, other PD's, and DD
  - Rewrite program description in two paragraphs – first paragraph generic, second paragraph showing these emerging areas
  - "Leave No Professor Behind" – the formation of summer institutes to inform and train researchers in frontier areas

- **NEES Planning**
  - Revise NEESR solicitation: revise budgets, include partnerships, integrate NEES and non-NEES labs, formalize processes

- Finalize longer-term plan for NEES partnership development; present to EMG
- Partnerships with GEO, CISE/SCI, NEHRP, etc.

- **Organization of CMS**
  - If a Senior Advisor position is established in CMS, it should report to the Division Director but not create another level of administrative hierarchy between the Division Director and the Program Officers. The Senior Advisor should facilitate and coordinate cross-directorate activities (e.g., MRI, ADVANCE, etc.) and personnel issues related to support staff.
  - Maintain budgetary independence of Program Officers, although they may be clustered in groups for organizational convenience. Foster input from Program Officers into the budget decision-making process.
  - Create several Science/Engineering Assistant positions to augment the current PA positions.

- **Improved processes**
  - Proposals – PDs to inform CMS staff of upcoming solicitations
  - Workshops – PI to provide a website link, which includes report. CMS secretary maintains a library of workshop reports.
  - SGERs – The SGER box on the proposal cover page must be checked.
  - Supplements – The jackets for REU and RET supplements are not forwarded to DGA, but awarded immediately.
  - Personnel needs include several science assistants and an additional program assistant, clarification of evaluations during change of Division Directors, and advance feedback during interim evaluation of performance issues.
  - Administrative improvements include more travel funds, better and more timely processing of travel, service contract for photocopy machine
  - Improve communications with general public through a CMS brochure, improved website, etc.

- **Assessment**
  - Action: regular (e.g., every three years) and independent assessment of each programs final reports to summarize/tabulate (e.g., number of students, papers). Special scrutiny for large and/or long-term awards. Ask grantees for nuggets.

- Action: regular longitudinal studies that focus on quality and major impact. Identify role that NSF funding played (e.g., seed/catalyst).
- Recommendation: medal of engineering research (a Nobel Prize like presidential award, maybe even a new Nobel Prize).
- Action/recommendation: regular professionally developed surveys to identify national perspectives on strategic issues of importance to NSF.

Left to right: Joy Pauschke, Mary Johnson, Ken Chong, Steve McCabe, Masayoshi Tomizuka at a luncheon break during one of the CMS retreats. The CMS Division met on several occasions during 2003 and 2004 to discuss how best to invest in Civil and Mechanical Systems research and education.

Appendix D – NEES Partnership Plan

George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)

On September 30, 2004, the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) completed its five-year National Science Foundation (NSF)-funded Major Research Equipment and Facilities Construction (MREFC) period (FY 2000 – FY 2004). During FY 2005 – FY 2014, the NSF/Engineering (ENG) Directorate/Civil and Mechanical Systems (CMS) Division is funding NEES Consortium, Inc. (NEESinc), to manage, operate, and maintain NEES as a national, shared use network of fifteen unique equipment sites linked by the NEESgrid cyberinfrastructure for research, education, and outreach to improve the Nation's capability for earthquake loss reduction. NEES is a component of the National Earthquake Hazards Reduction Program (NEHRP).

During the ten-year operations period, the bulk of research utilizing the NEES facilities will be funded through the CMS NEES Research (NEESR) program solicitation. NEESR offers the opportunity for CMS to develop collaborative and funding partnerships within NSF, with other federal and state government agencies, and with foreign funding agencies to: (1) foster new cross-disciplinary areas at the interfaces of engineering, computer science, education, public policy, and other fields, and (2) leverage the NSF investment in the NEES resources and available CMS NEESR funding. CMS has developed a preliminary outreach plan that identifies potential partnership opportunities. Developing these partnerships will be an ongoing activity for CMS during the ten-year operations of NEES. CMS has already partnered in FY 2003 with the ENG/Division of Engineering Education and Centers (EEC) to co-fund, through the Research and Related Activities (R&RA) appropriation, NEESinc to develop a long-term educational strategy for NEES. In addition, CMS is working with Program Officers in the Office of International Science and Engineering (OISE) to develop international connections and partnerships with foreign national ministries and the European Commission. CMS is also working with the Directorate for Geosciences (GEO), which has a number of established agreements abroad that NEES may be able to utilize.

The goal is to incorporate the research opportunities made available through these partnerships into future NEESR solicitations. Partnerships for the FY 2005 NEESR solicitation, issued in fall 2004, will include the following:

- Co-funding between ENG/CMS and the Directorate for Computer and Information Science and Engineering (CISE) Division of Shared Cyberinfrastructure (SCI) for the NEESR and the National Middleware Initiative (NMI) solicitations, respectively.
- Coordination between U.S.-Japan researchers to jointly utilize the NEES and E-Defense (E-Defense is the large shake table located in Miki City, Japan) facilities to study the seismic response of steel structures and bridges. NSF is developing an implementing arrangement with the Japanese Ministry for Education, Culture, Sports, Science, and Technology (MEXT) and NEESinc is developing a Memorandum of Understanding (MOU) with the Japanese National Research Institute for Earth Science and Disaster Prevention (NIED). Planning meetings were held in Japan in April 2004 and at NSF in July 2004. A third meeting is planned for 2005.
- Coordination with the NEHRP Federal Emergency Management Agency (FEMA) to fund basic research needed for the next development cycle of the NEHRP seismic provisions.
- Coordination/co-funding with the GEO/Earth Sciences Division (EAR) to utilize NEES equipment for earth science research in conjunction with the Incorporated Research Institutions for Seismology (IRIS), EarthScope, and Advanced National Seismic System (ANSS) facilities (based on research activities identified at a joint IRIS/EarthScope/NEES/United States Geological Society (USGS) April 2004 workshop).

CMS is also exploring partnerships for possible inclusion in the FY 2006 NEESR solicitation. Those under discussion so far include the following:

- Co-funding partnerships with other ENG Divisions.
- Federal Highway Administration (FHWA).
- European Commission – Directorate General (DG) for Environment Research. GEO and ENG currently have an implementing arrangement with this DG.

Other countries and regions (e.g., Japan, Korea, New Zealand, United Kingdom, Europe) are implementing activities similar to NEES. As a result of an international meeting organized by NEESinc and the NEESgrid team at the 13th World Conference on Earthquake Engineering in August 2004, international working groups are being established to coordinate worldwide NEES-related activities, especially at the cyberinfrastructure levels. NEESinc will provide the secretariat for these working groups. NEESinc had been funded through the CMS R&RA appropriation to sponsor an international workshop in FY 2005 that will continue the international dialog at the facility, cyberinfrastructure, and research project levels. The NEESgrid cooperative agreement has been extended by NSF for one year to develop tools to address additional user requirements, including incorporation of an international character set into the NEESgrid software to enable facilities abroad to more readily utilize the NEESgrid software when collaborating with U.S. researchers.

Table 1 shows the current estimated ENG/CMS expenditures for NEES operations and research during FY 2005 – FY 2009. CMS will help NEESinc identify NSF funding opportunities to leverage the NEES infrastructure for education and outreach activities.

Table 1. Estimated NEES Expenditures
(in millions)
(Pending future NSF Budget Requests and Appropriations)

Fiscal Year	**2005**	**2006** (Estimates)	**2007** (Estimates)	**2008** (Estimates)	**2009** (Estimates)
NEESinc Operations	$19.5	$20.5	$21.3	$22.2	$23.0
NEES Research	$9.5	$10.5	$17.3	$17.3	$17.6
Total	$29.0	$31.0	$38.6	$39.5	$40.6

Appendix E – Discussion On "Solicited vs. Unsolicited" Research

The following was drafted by Chi Liu and Masayoshi Tomizuka to summarize CMS strategic discussions regarding the appropriate balance in CMS between proposals generated by solicitations versus unsolicited proposals.

NSF is the only federal funding agency with a focus on investigator-initiated fundamental research. Traditionally this has been the largest portion (e.g., 75-80%) of the NSF research portfolio. Many high-impact discoveries have been made as a result of creative unsolicited research funded through open merit competition, rather than "managed" or "fenced" research. At present there is a trend that the proportion of "fenced" programs is increasing, and thus the proportion of "unfenced" programs decrease. Currently, the balance in CMS is about 60% fenced and 40% unfenced. The 2004 Committee of Visitors report expresses concerns regarding this trend. The tradeoff of this trend and the pros and cons of solicited vs. unsolicited research need to be carefully examined. Some pros and cons are listed below.

A. Reasons favoring increased solicited portion of the total program portfolio:

- Only big topics, like nano and IT research, can attract the attention of Congress and, thus, impact the agency's budget request.
- Current research is moving toward a mode that can be best carried out by teams of researchers of cross-disciplinary nature, and the current NSF unsolicited program setup has difficulty in accommodating such a trend.
- Topics of solicited programs should be developed and selected by integrating the wisdom of experts and visionaries in science/engineering to ensure that NSF research will always be at the forefront and define the current science and engineering.

B. Reasons that solicited program portion should not grow without bounds:

- It would hurt unrestricted research, which was primarily responsible over NSF history for most of the major impact breakthroughs achieved.
- NSF will eventually lose its unique character and identity among funding agencies and become another mission-oriented agency.
- Free and creative investigations will be curtailed and structured investigations will take over. Net impact: innovations will be restricted.
- NSF research will become more and more "process-dependent" rather than "intellectual-based" programs. An analogy might be the planned economy approach of the former Soviet Union, vs. the market economy approach of the western nations.
- Topics for "fenced" areas may become generated by a few management and program staff at NSF, and may not necessarily capture the best ideas in the research community.

C. Recommendations

- Protect the unsolicited program base, and do not let it be eroded by various pressures. A ratio of 80% to 20% for unsolicited vs solicited research could be a proposed target.
- Develop a consistent and high-quality merit-based process for generating the themes for the solicitations:
  - Develop a dynamic "think tank" with members made up of the best minds in science and engineering communities to explore future big-idea areas that will emerge and have long-lasting impact potential.
  - Conduct a Directorate-wide multidisciplinary annual forum targeting the development of integrated research program of sustainable impact.
- Continue efforts to generate quality "retrospective nuggets" so that Congress and general public see the value of unrestricted fundamental research.
- Improve the handling of cross-disciplinary proposals in the NSF unsolicited program structure.

Semi-active control) strategies have been shown to be particularly promising for structural control. Magnetorheological (MR) dampers were recently realized in several bridges and buildings based on NSF sponsored research (CMS Award 9900234)

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The CMS Division funded several research projects following the 9/11 terrorist attacks to collect structural data, as well as to study disaster response [8].