CMMI Overview

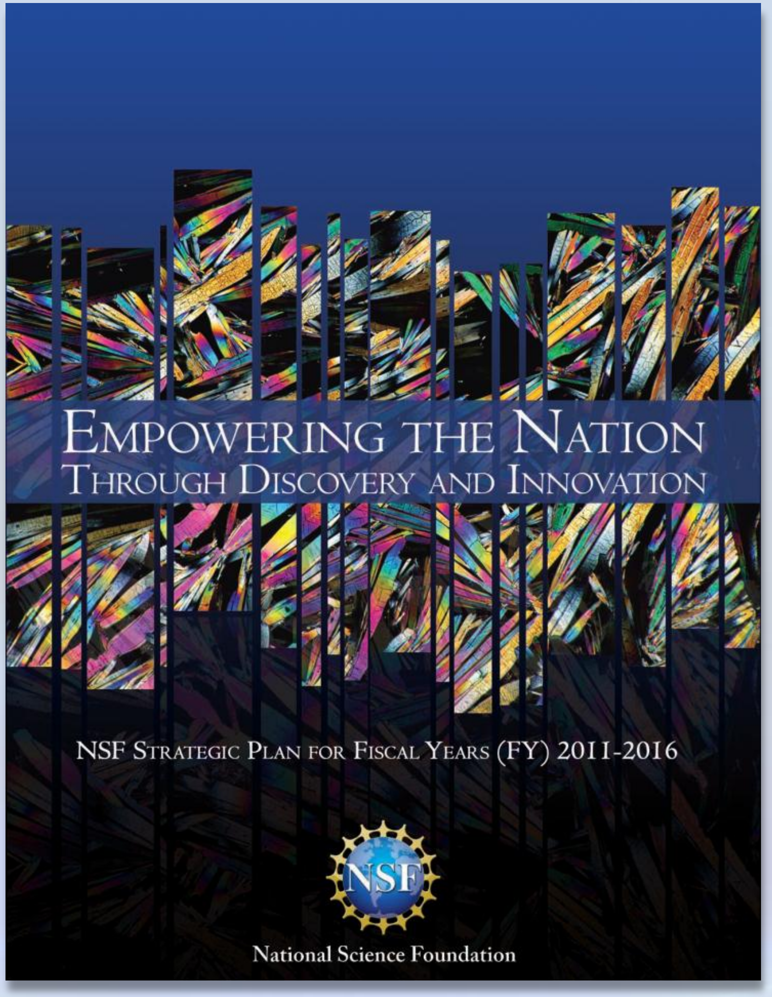
George A. Hazelrigg
Acting Division Director for
Civil, Mechanical and Manufacturing Innovation
Mary Toney
Acting Deputy Division Director

Context: NSF Strategic Plan, 2014-2018

- **Transform the Frontiers of S&E --** promotes the progress of science, creates opportunities for transformational advances.

- **Stimulate Innovation –** emphasizes broader impacts to advance national health, prosperity, welfare, and to secure the national defense.

- **Excel as a Federal Science Agency --**emphasizes the importance of NSF as an exemplar of an agency that expects to attain excellence in all operational aspects.



http://www.nsf.gov/news/strategicplan/

CMMI Historical Perspective (2006)

CMS (FY 2006)
$88.4 Million
12 Programs
10 Program Directors
~1400 Proposals

DMI (FY 2006)
$66.1 Million
7 Programs
7 Program Directors
1,126 Proposals

CMMI FY 2009
$232.6 Million
4 Clusters
20 Programs
18 Program Directors
17 Staff Members
2,923 Proposals

CMMI FY 2014
$199.5 Million (FY13)
4 Clusters
18 Programs
18+2 Program Directors
12+3 Staff Members
3,165 Proposals

CMMI in 2014

Division Director
George Hazelrigg (Acting)
Deputy Director
Mary Toney (Acting)

Interdisciplinary and Cross-Divisional Activities
Bruce Kramer

Integrative Activities
J. Culbertson

Support Staff
Wayne Plummer

Advanced Manufacturing

- Manufacturing Machines and Equipment (MME) — *ZJ Pei*
- Manufacturing Enterprise Systems (MES) — *E. Romeijn*
- Materials Engineering and Processing (MEP) — *M. Toney, A. Lewis, G. Hsuan*
- Nano Manufacturing (NM) — *K. Cooper*

Mechanics and Engineering Materials

- Geomechanics and Geotechnical Systems (GGS) — *R. Fragaszy*
- Mechanics of Materials (MOM) — *T. Siegmund*
- Biomechanics and Mechanobiology (BMMB) — *D. Carter*

Resilient and Sustainable Infrastructures

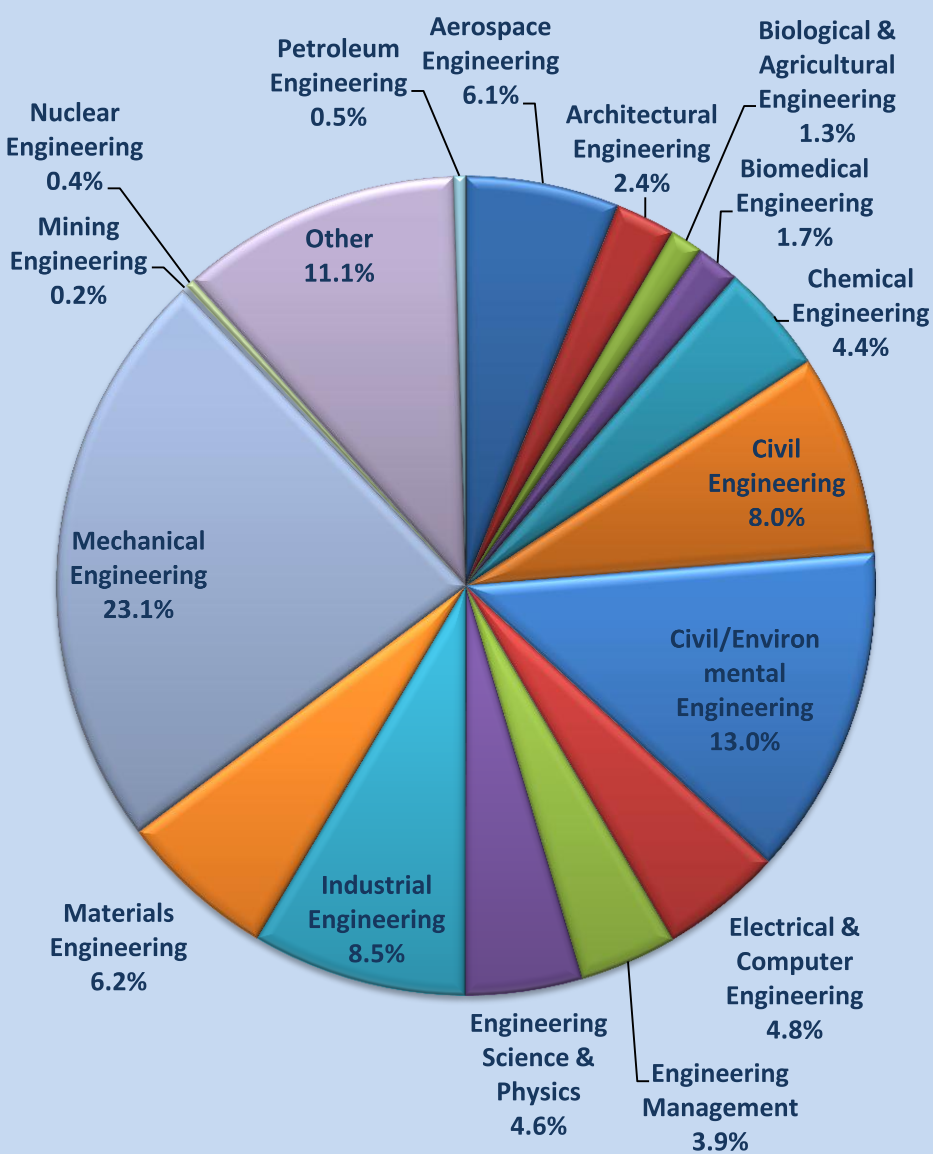
- Civil Infrastructure Systems (CIS) — *K. Triantis*
- NEES — *J. Pauschke*
- Geotechnical Engineering (GTE) — *R. Fragaszy*
- Hazard Mitigation & Structural Engineering (HMSE) — *K. Mehta*
- Infrastructure Mgmt. and Extreme Events (IMEE) — *D. Wenger*

Systems Engineering and Design

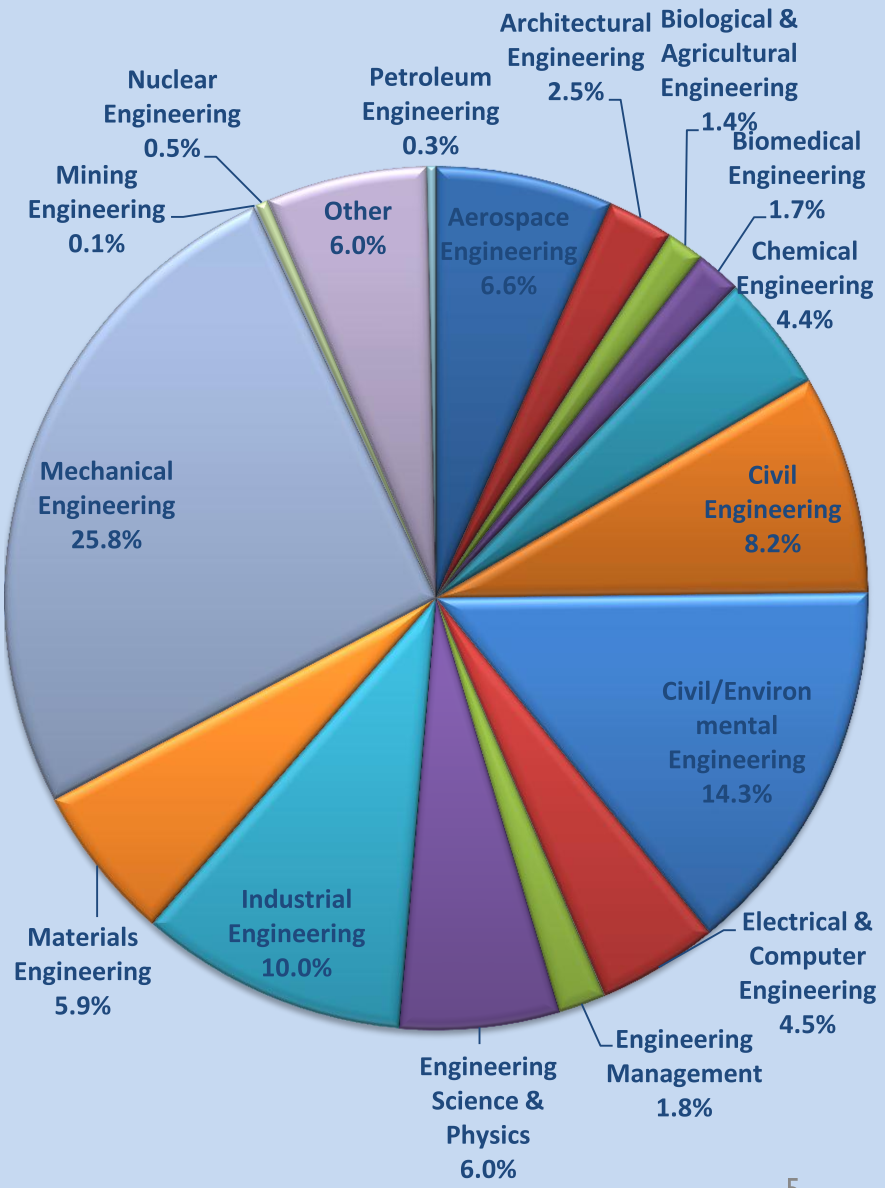
- Control Systems (CS) — *New 4/1*
- Dynamical Systems (DS) — *M. Ruzzene*
- Engineering and Systems Design (ESD) — *C. Paredis*
- Systems Science (SYS) — *C. Paredis*
- Operations Research (OR) — *S. Jacobson*
- Sensors and Sensing Systems (SSS) — *New ~6/2*
- Service Enterprise Systems (SES) — *E. Romeijn*

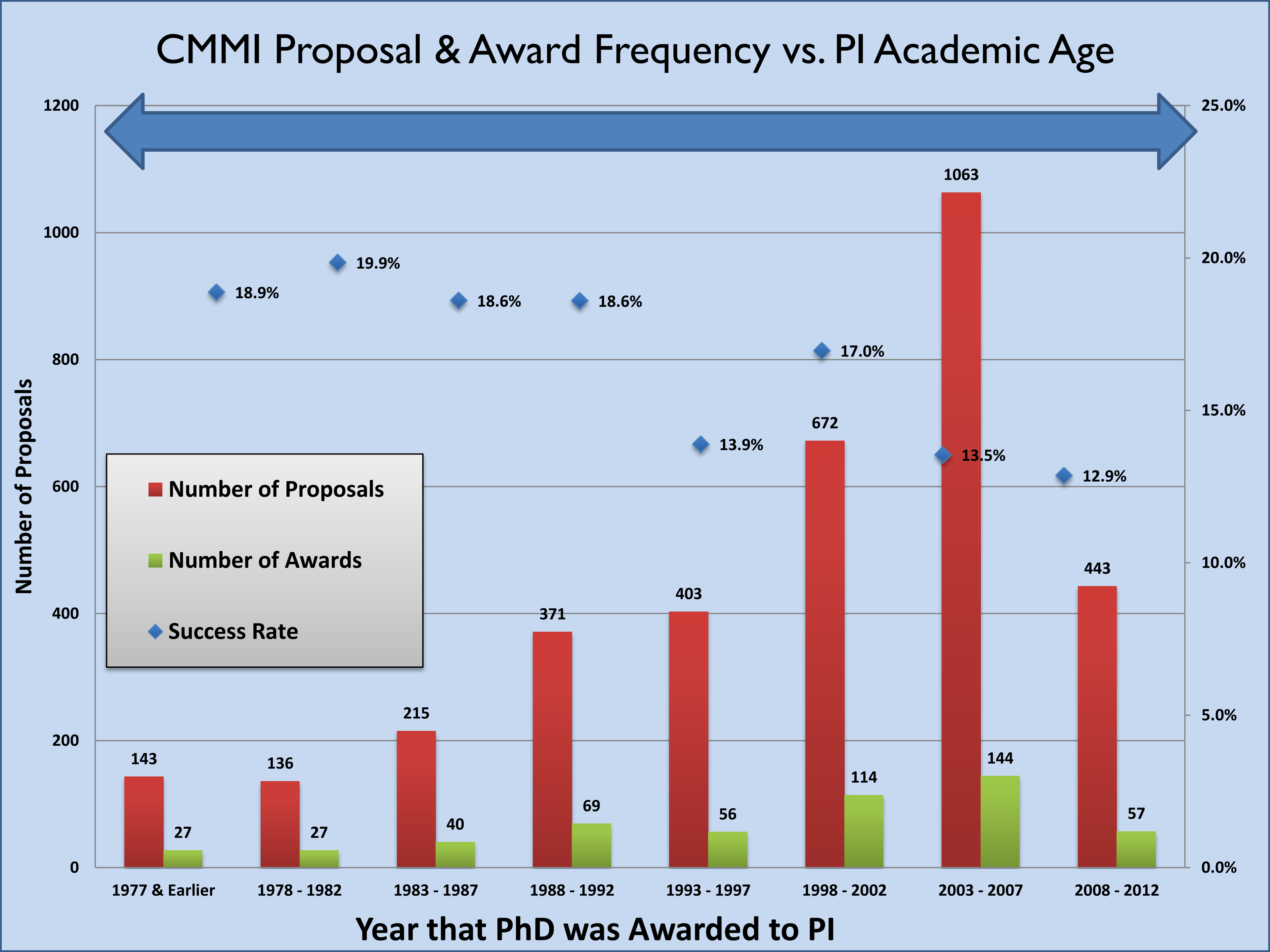
CMMI Disciplinary Breadth

CMMI Reviewers

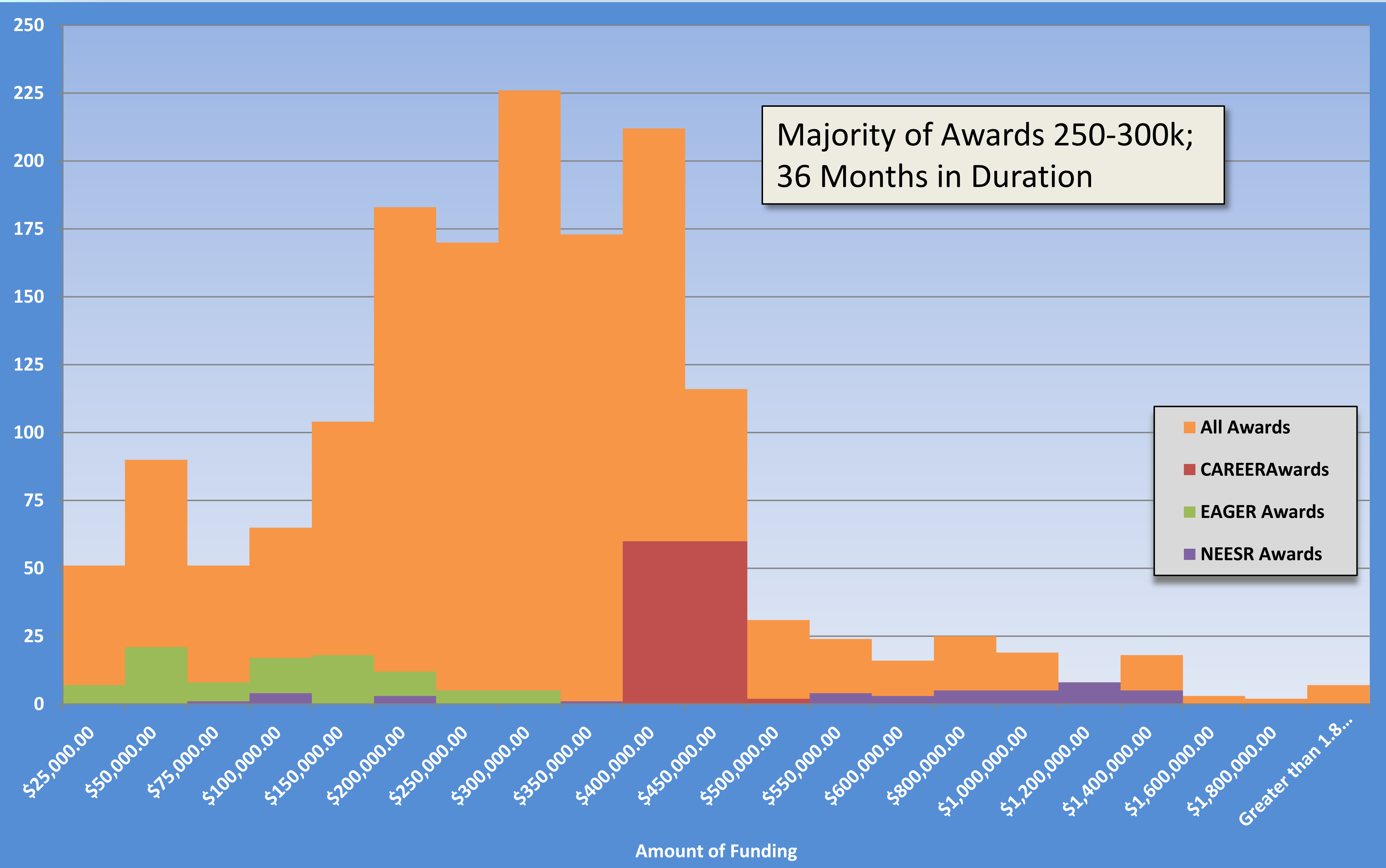


Principal Investigators




CMMI Proposal & Award Frequency vs. PI Academic Age
Number of Proposals
Year that PhD was Awarded to PI
Number of Proposals
Number of Awards
Success Rate
1200
1000
800
600
400
200
0
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
1977 & Earlier
1978 - 1982
1983 - 1987
1988 - 1992
1993 - 1997
1998 - 2002
2003 - 2007
2008 - 2012
143
27
18.9%
136
27
19.9%
215
40
18.6%
371
69
18.6%
403
56
13.9%
672
114
17.0%
1063
144
13.5%
443
57
12.9%

CMMI Award Profile



Advanced Manufacturing

- MME—To accelerate the transition from skill-based to knowledge-based manufacturing
- MES—To enable efficient and effective strategic design, tactical planning, and operational control of manufacturing systems
- MEP—To uncover mechanisms responsible for process-structure-property-performance relationships for material systems driven by their end-use application
- NM—To advance manufacturing processes that enable novel nano-scale structures, devices and systems
- SNM – To identify and overcome the fundamental scientific and engineering barriers to the large-scale production of nanoscale devices and systems

Mechanics and Engineering Materials

- BMMB—To understand the role of mechanics in biological form and function
- GGS—To understand, predict, and improve the engineering properties of geologic materials for application to civil infrastructure
- MOM—To understand the fundamental processes in the deformation and failure of solid materials under external and internal forces
- DEMS—To establish methodologies for accelerated and performance metrics based design of engineering material systems

Resilient and Sustainable Infrastructures

- CIS—To enable good decision making in an interdependent systems contexts where people are a part of the system
- NEESR—To enable performance-based design of multi-hazard resilient and sustainable civil infrastructure
- NEESOps—To provide experimental and computational tools and data sharing in support of multi-hazard resilient and sustainable civil infrastructure research
- GTE—To improve the resilience and sustainably of geostructures in civil infrastructure
- HMSE—To prevent natural and anthropogenic hazards from becoming disasters through innovative structural engineering of the civil Infrastructure
- IMEE—To enable resilient and sustainable disaster recovery linked to mitigation

Systems Engineering and Design

- CS—To merge control theory with decision theory, accounting for differences in the time constant, sequential decision making and swarming
- DC—To improve modeling and simulation of large-scale systems
- ESD—To create and implement a framework for rational design decision making
- OR—To enable optimization of larger, more complex systems accounting for uncertainty
- SSS—To enable new sensing modalities and to better collect, interpret and use sensed data
- SES—To enable and promote the application of engineering principles in the service sector, with the goal of maximizing efficiency and effectiveness

Systems Engineering and Design

- SYS—To facilitate good decision making in the systems context
  - Understanding group processes through the application of game theory
  - The use of mechanism design to align preferences of engineers working together to design a system
  - Including design of the organization into the overall design process
  - Accounting for the life-cycle of a system—includes distribution/sales, operation/maintenance, disposal in the design process
  - Understanding supply chains in the context of systems engineering—cost vs. uncertainty factors
  - Define the limits of rationality in systems design
  - Determine approaches to limit bad decision making in group processes (damage control)
  - Improving common system design practices, e.g., continuous improvement
  - Proper use of models in systems decision making
  - Explore the mathematics of outsourcing
  - Theory of geometrical design and tolerancing
  - Prediction of system behavior

Planning For for CMMI of the Future:

Influence of Community and Context (From 2009 timeframe)

Interagency Studies, Workshops, And Coordination

National Initiatives

NRC / NAS / NAE

CMMI Success Rates

- Depends on the proposal:
  - Well conceived and written proposals, 85-90%
  - Poorly conceived and written proposals ~0%
- Divisional averages are meaningless
- There are clear dividing lines between well conceived and poorly conceived proposals

Well Conceived Proposals

- Contain four elements:
  - A clearly stated research objective
  - A well thought out plan to accomplish the stated research objective
  - A convincing argument that the PI(s) can competently carry out the plan
  - A convincing argument that the research is worth doing (Intellectual Merit, Broader Impact)

NSF Funds Research

- The research objective appears to be the hardest part—speaks to a general weakness of training in framing research
  - Most proposals we receive propose developmental activities
  - Proposals with developmental objectives almost always review poorly

Research vs. Development

- Research is the process of learning something we don't already know—new knowledge
  - If the objective is knowledge, it's research
  - If the objective is an artifact (device, product, system, process, etc.), it's development
- A typical research objective is to test a valid scientific hypothesis—testable and falsifiable

Ethics

- Persons submitting proposals to the Federal government are held to high standards of conduct
- Misbehavior can be dealt with quite severely
  - PI barred from submission to NSF up to 2 years
  - Permanently barred from proposal review
  - At least two cases of jail time (Grimes case, 42 months in Federal prison)

Major Forms of Misbehavior

- Plagiarism—uncited reproduction of the work of others
- Falsification—intentional misrepresentation of data or results (progress reports)
- Fabrication—making up data
- Double charges—billing the government twice for the same work

Train and Verify

- Faculty and students should be trained annually—consequences should be made explicit
- Institutions need to perform oversight
- Institutions themselves need to operate in a culture of compliance

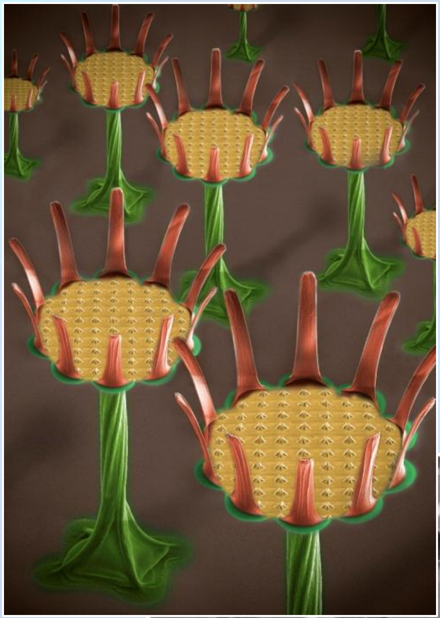
CMMI Research: Engineering for Society

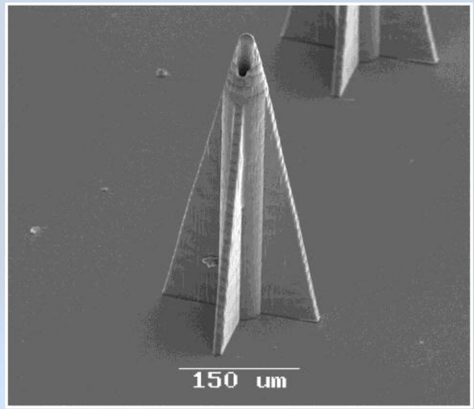
New mathematical models for the distribution of aid after disasters

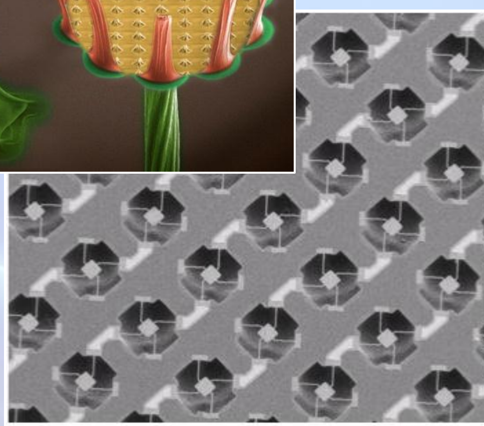
Optimizing the yearly design of the Flu Vaccine under uncertainty

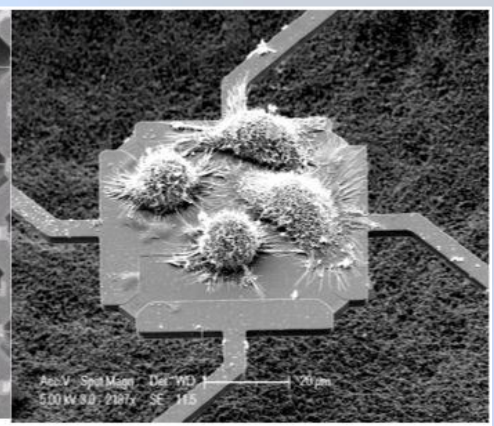
Computer-driven disease models to plan optimal Diabetes Treatment

CMMI Enabling the Frontiers of Research At all Scales









Nanoscale to Infrastructure Scale Research

Thank you

George A. Hazelrigg
Acting Division Director for
ghazelri@nsf.gov
703-292-7068