



# Mechanics of Materials and Structures (MoMS) Program

Kara Peters (Program Director)

[moms@nsf.gov](mailto:moms@nsf.gov)

# Structural and Architectural Engineering and Materials (SAEM) Program

Y. Grace Hsuan (Program Director)

[yhsuan@nsf.gov](mailto:yhsuan@nsf.gov)

---

***Engineering Mechanics Institute Conference 2017***

***June 4-7, San Diego***



# NSF Strategic Goals

---

## **Strategic Goal 1: Transform the Frontiers of Science and Engineering**

*“to promote the progress of science”*

## **Strategic Goal 2: Stimulate Innovation and Address Societal Needs through Research and Education**

*“to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes”*



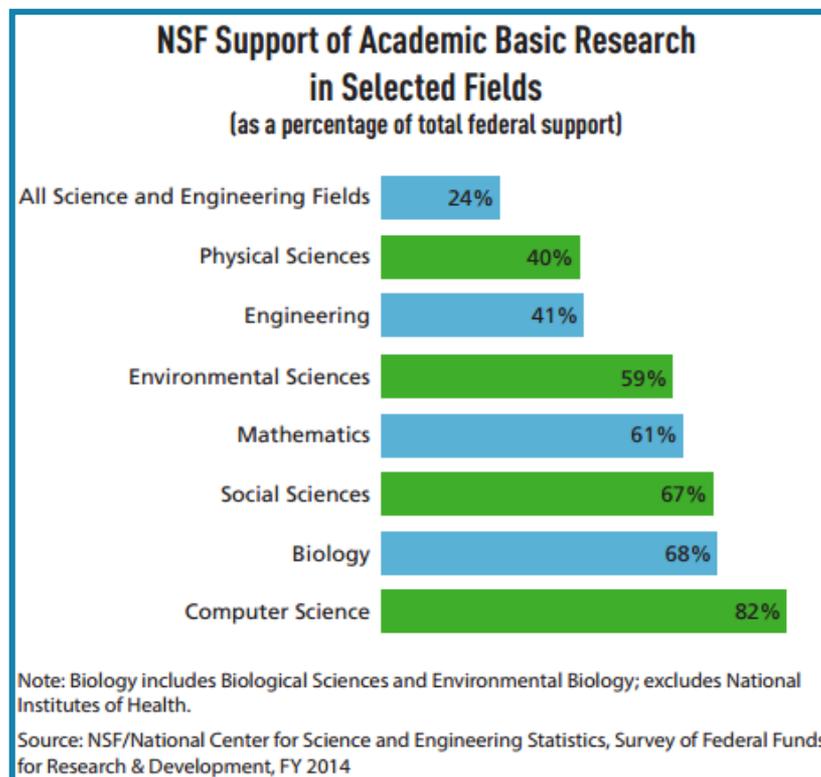
# What NSF Does

---

- **Supports all fields of fundamental science and engineering, except for medical sciences.**
- **Ensures that research is integrated with education so that today's revolutionary work will also be training tomorrow's top scientists and engineers.**

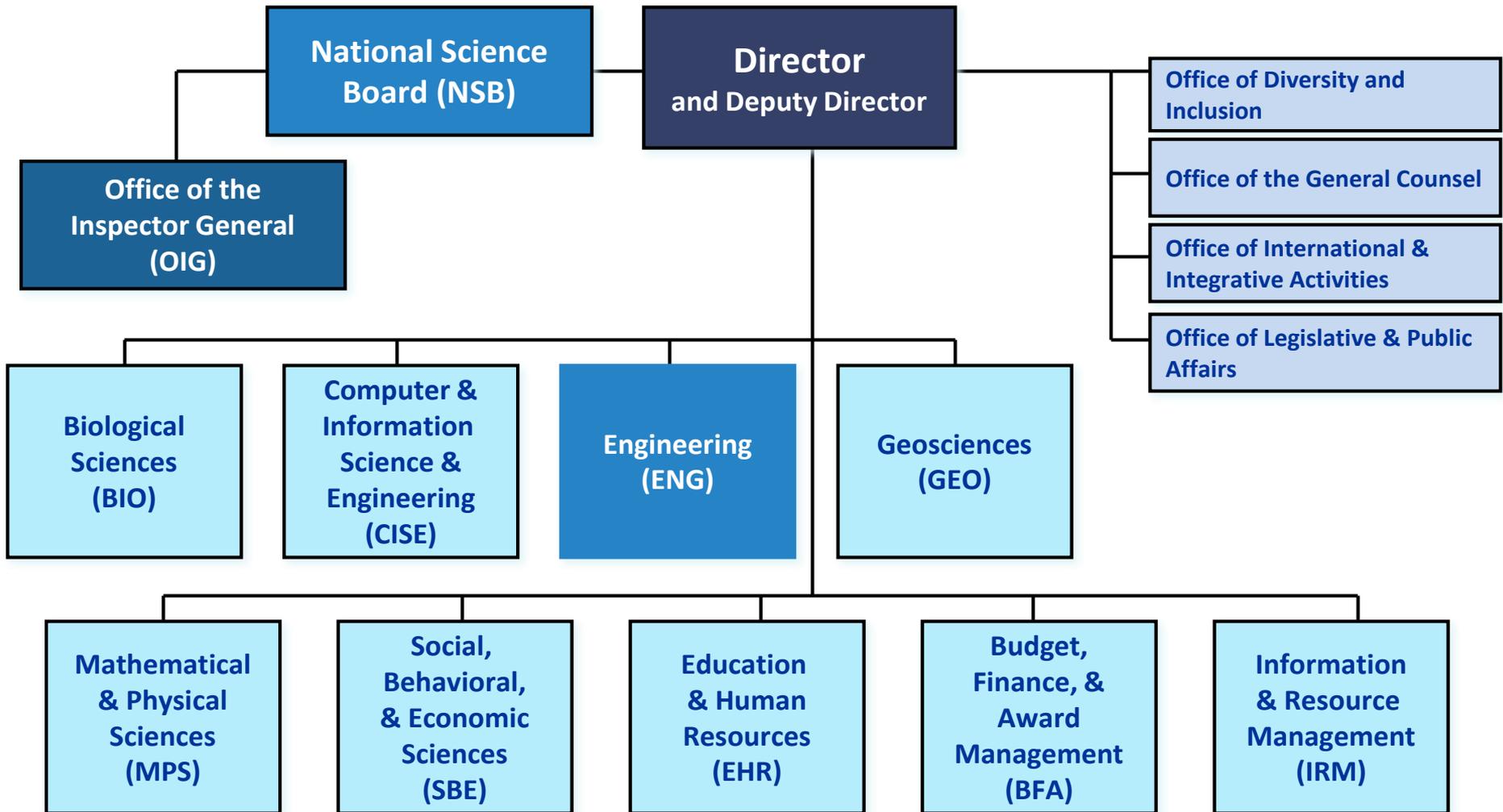


# NSF By the Numbers





# National Science Foundation



# Directorate for Engineering (ENG)



**Emerging Frontiers and  
Multidisciplinary Activities  
(EFMA)**  
Sohi Rastegar

**Program Director for  
Strategic Operations**  
Cheryl Albus

**Office of the Assistant Director**  
Barry Johnson, Assistant Director  
Clifford Gabriel, Deputy Assistant Director

**Senior Advisor for  
Nanotechnology**  
Mihail Roco

**Program Director for  
Evaluation & Assessment**  
Alexandra Medina-Borja

**Engineering  
Education and  
Centers  
(EEC)**  
Don Millard (acting)

**Chemical,  
Bioengineering,  
Environmental, and  
Transport Systems  
(CBET)**  
JoAnn Lighty

**Civil, Mechanical,  
and Manufacturing  
Innovation  
(CMMI)**  
Deborah Goodings

**Electrical,  
Communications,  
and Cyber Systems  
(ECCS)**  
Filbert Bartoli

**Industrial  
Innovation and  
Partnerships  
(IIP)**  
Graciela Narcho

# Division of Civil, Mechanical and Manufacturing Innovation (CMMI)



**Division Director**  
*Deborah Goodings*  
**Deputy Director**  
*George Hazelrigg*

**Interdisciplinary and Cross-Divisional Activities**  
*Bruce Kramer*

**Integrative Activities**  
*J. Culbertson*

**Advanced Manufacturing**

**Mechanics and Engineering Materials**

**Resilient and Sustainable Infrastructures**

**Operations, Design, & Dynamic Systems**

**Materials Engineering and Processing (MEP)**  
*T. Kuech, A. Lewis, M. Toney*

**Mechanics of Materials and Structures (MOMS)**  
*K. Peters, Siddiq Qidwai*

**Civil Infrastructure Systems (CIS)**  
*C. Chen*

**Engineering and Systems Design (ESD)**  
*R. Malak*

**Manufacturing Machines and Equipment (MME)**  
*Steve Schmid*

**Biomechanics and Mechanobiology (BMMB)**  
*D. Fyhrie*

**Engineering for Natural Hazards (ENH)**  
*J. Pauschke, R. Fragaszy*

**Systems Science**  
*R. Malak*

**Nano-Manufacturing (NM)**  
*K. Cooper*

**Design of Engineering Material Systems (DEMS)**  
*C. Paredis, K. Peters, M. Toney*

**Geotechnical Engineering and Materials (GEM)**  
*R. Fragaszy*

**Dynamics, Control and System Diagnostics (DCSD)**  
*J. Berg, A. Kelkar*

**Cybermanufacturing Systems**  
*B. Kramer*

**Infrastructure Mgmt. and Extreme Events (IMEE)**  
*D. Mendonca*

**Operations Engineering (OE)**  
*G. Klutke*

**Structural and Architectural Engineering and Materials (SAEM)**  
*Y. G. Hsuan*

**Mind, Machine, Motor Nexus (M3X)**  
*J. Berg*

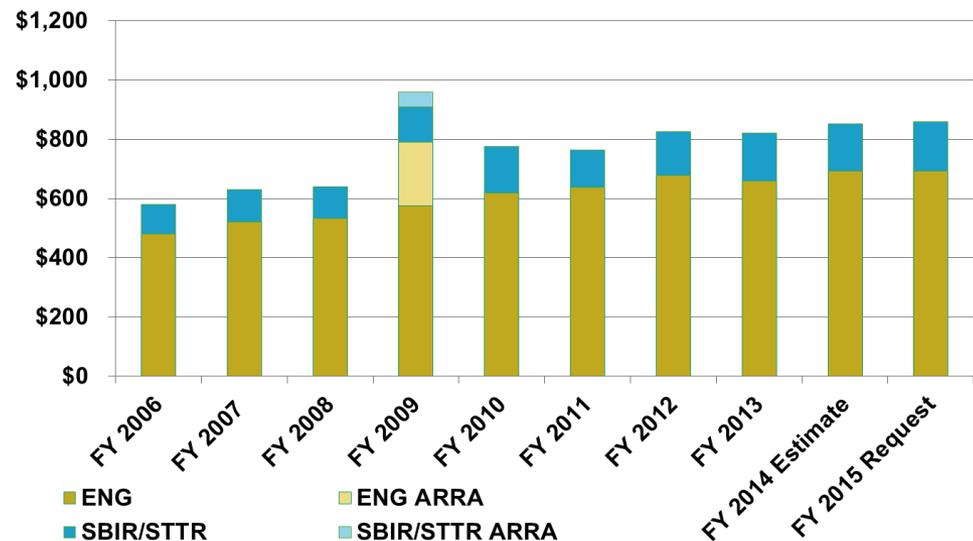
**Natural Hazards Engineering Research Infrastructure (NHERI)**  
*J. Pauschke, R. Fragaszy*



# CMMI by Numbers

In FY15, CMMI handled 4,214 proposals with an operating budget of ~\$218M and an overall success rate of 18%:

- **Unsolicited Proposals:** 2,945 competitive, 544 awards, ~\$180M
  - Includes GOALI, EAGER, RAPID, Travel Support and Workshops
- **CAREER Proposals:** 293 competitive, 49 awards, \$24.5M
- **Solicitations and Initiatives:** ~\$34M





# NSF Funds Fundamental Research

---

## **We look for proposals that**

- Are innovative and push the frontiers of knowledge
- Contribute to national needs and priorities
- Go beyond marginalia
- Integrate research and educational goals well
- Actually involve research, not development

## **We do not support (except as incidental to the research goals of the award)**

- Developmental efforts
- Computer programming
- Design of...
- Commercialization



# What is Research?

---

Research is the *process* of finding out something that we (everyone) don't already know

Scientific research builds upon the extant knowledge base and it is methodical, repeatable and verifiable

- Methodical - you can specify in advance of the research a method to accomplish your objective
- Repeatable - not a “strange” (random) event
- Verifiable - tangible evidence

Research results in knowledge



# What is Research?

---

**If your proposal focuses an artifact, it's probably development, if it focuses knowledge, it's likely to be research**

**Ref: Research 101 for Engineers**



# What is a Research Proposal?

---

**A research proposal is an offer to engage in an effort to obtain new knowledge for a given price**



# A Question?

---

Research is the *process* of finding out something that we (everyone) don't already know

Scientific research builds upon the extant knowledge base and it is methodical, repeatable and verifiable

**Question: Exactly what will your research contribute to the knowledge base?**



# The Five Elements of Merit Review

---

1. What is the potential for the proposed activity to:
  - advance knowledge and understanding within its own field or across different fields (**Intellectual Merit**); and
  - benefit society or advance desired societal outcomes (**Broader Impacts**)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?

# The Five Elements of Merit Review (Contd.)

---

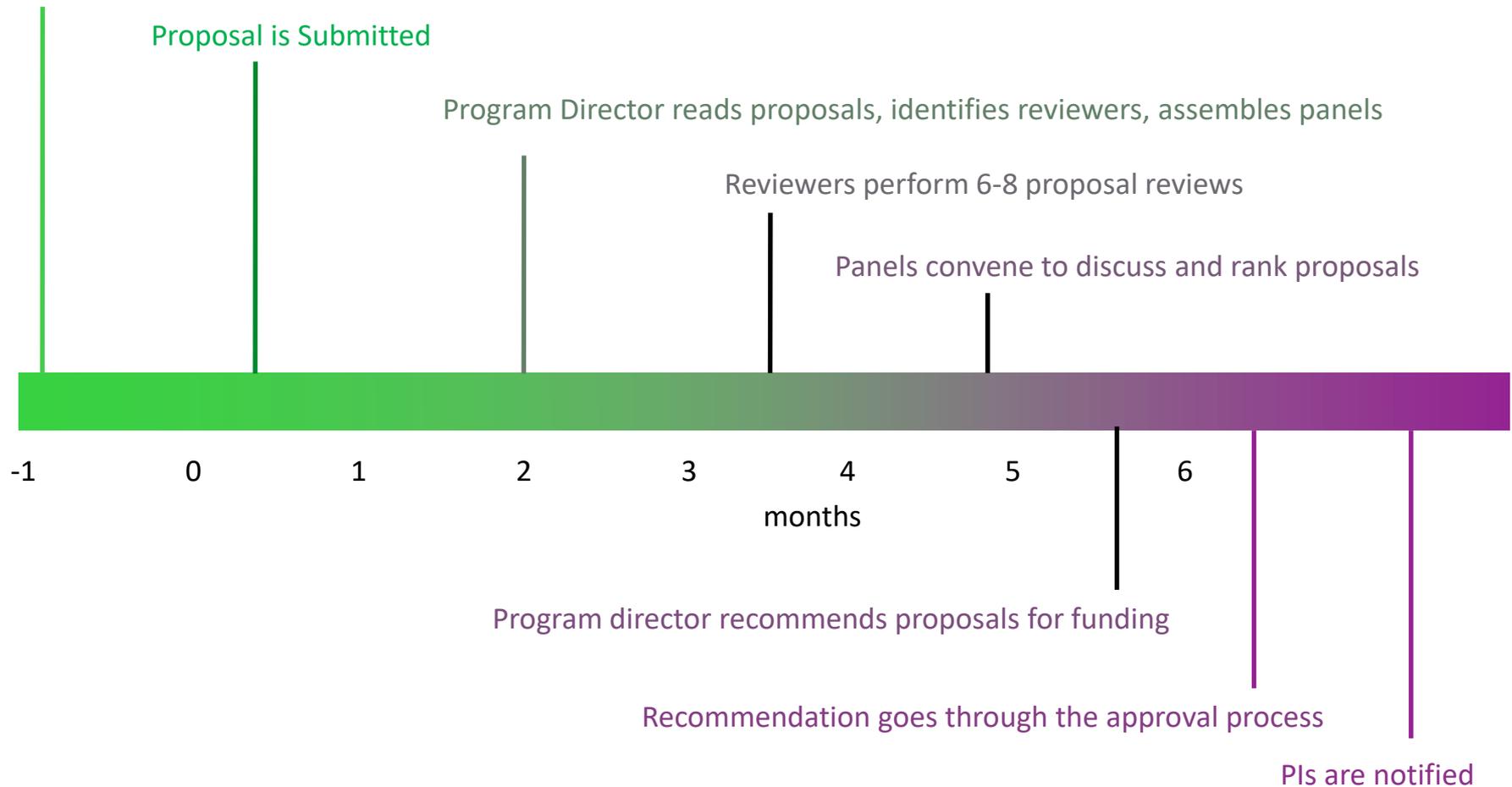


3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or institution to conduct the proposed activities?
5. Are there adequate resources available to the PI (either internally or through collaborations) to carry out the proposed activities?



# Review Timeline

PI communicates with Program Director to determine program fit





# IMPORTANT NOTICE

---

Starting Fiscal Year 2018, the CMMI winter proposal submission window will be from **January 10 to January 24, 2018.**

CMMI will continue to have **two annual windows** for unsolicited proposals.

The proposal submission deadline will be 5:00 PM submitter's local time.



# MoMS Synopsis

---

**Program Directors:** Kara Peters & Siddiq Qidwai

**Annual Budget:** ~\$12M

The Program supports fundamental research in mechanics as related to the behavior of deformable solid materials and structures under internal and external actions:

- Emphasis on **transformative advances** in experimental, theoretical, and computational methods
- Proposals should clearly emphasize the **contributions to the field of mechanics**

Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or engineering concept or educational practice or leads to the creation of a new paradigm or field of science, engineering, or education.

# MoMS Foci: Deformation & Failure Behaviors

---



- **Materials:** advances in fundamental understanding of deformation, fracture, and fatigue as well as contact and friction, etc.
- **Structures:** advances in the understanding of nonlinear deformation, instability and collapse, wave propagation, etc.
- **Intersection of materials and structures:** unique advances effectuated by metamaterials, and microarchitected, hierarchical, and low-dimensional materials
- Experimental and computational methods that address information across **multiple length and time scales**, potentially involving **multiphysics** considerations

# Recent MoMS Foci: Advanced Experimental & Computing Methods

---



- Experimental techniques to capture deformation and failure information for extreme ranges of loading or material behavior
- “Advanced Measurement Systems for Experimental Determination of Complex Biomaterial Properties” in collaboration with BMMB program
- Data analytics for deformation or damage response deduction from large experimental and computational data sets
- Reduced-order modeling, data-driven techniques, and/or stochastic methods with a strong emphasis on validation

# Dear Colleague Letter (MOMS – BMMB)



- **Advanced Measurement Systems for Experimental Determination of Complex Biomaterial Properties**
- Rapid advances in photonic, acoustic, imaging, electronic and manipulative technologies have led to the possibility to identify the material property distribution of perturbed living organisms.
- These technological advances have the potential to revolutionize our understanding of the mechanics of biological materials from the molecular scale to in vivo measurement.
- Goal of DCL is to advance developments at all levels for the experimental determination of complex biomaterial properties tested *in situ*.
- Collaborative research (experimental mechanics, mechanobiology) that specifically addresses determination of dynamic elastic and failure mechanical properties of: 1) the brain, 2) bone, 3) individual cells, 4) tissue, and 5) other biological material systems
- <https://www.nsf.gov/pubs/2016/nsf16142/nsf16142.pdf>



# DEMS Synopsis

---

**Program Directors:** Rich Malak, Mary Toney, Kara Peters

**Annual Budget:** ~\$3M

The Program supports fundamental research that leads to new paradigms of design, development and insertion of advanced engineering material systems:

- Emphasis on **transformative advances** in design methods for complex material systems
- Awarded proposals are generally a collaboration between researchers in design and researchers in mechanics/materials
- Proposals must clearly define the fundamental innovation to field of design
- The process of design is broader than simply optimization, also includes representation, propagation of uncertainties, etc.
- Proposals must include **validation** of design method.



# SAEM Synopsis

---

**Program Directors:** Grace Hsuan

**Annual Budget:** ~\$5M

- The Program supports Fundamental Research to Advance Knowledge and Innovation in structural and architectural engineering and materials.
- Promotes a holistic approach in Design, Construction, Operation, Maintenance, Repair.
- For buildings, all components including the foundation-structure-envelope and interior systems are of interest to the program.  
End-of-Life Disposal or Reusable (cradle-to-gate or cradle-to-cradle)

# SAEM Program



## Research Topics of Interest

Conduct *fundamental research* in innovative engineering concepts and design paradigms for buildings that are cost-effective and reduce dependence on energy.

Leverage *in understanding of basic mechanisms to* mitigate the material and structural deterioration.

Promote *fundamental research* in novel sustainable materials for structural and non-structural components.

Advance *in computational modeling and simulation* to aid in material and building design.

# Structural and Architectural Engineering Research Areas



- Research to *enhance sustainable structures*:
  - innovative building envelope to reduce energy/water dependence
  - novel concepts for retrofitting and repurposing existing structures
  - mitigation of deterioration due to *in-service* loadings
  - advances in physics-based computational simulation
  - *Structural health monitoring that focuses on decision-making systems for civil structures*

# Structural and Architectural Materials Research Areas



- Research to *enhance the integration of structural & architectural engineering with material design and innovation*:
  - encourage “*top-down/bottom-up*” approach in material design
  - innovative bioinspired materials and systems for building envelope to reduce energy dependence
  - understand and model material degradation mechanisms
  - incorporate life-cycle in the design of innovative sustainable materials (cradle-to-gate or cradle-to-cradle)



# CAREER Solicitation

---

- Foundation-wide activity that offers NSF's most prestigious awards for faculty members beginning their independent careers
- Provides stable support at a sufficient level and duration to enable awardees to develop careers as outstanding researchers and educators who effectively integrate teaching, learning, and discovery
- High priority for Engineering
- ENG award size now \$500,000 for 5 years
- ***Submission deadline is July 20, 2017***



# CAREER Proposals

---

The CAREER award is NOT  
a research award

The CAREER award is a career  
development award

**Your proposal must  
reflect this focus**



# The CAREER Research Topic

---

- The CAREER proposal is a proposal detailing how you will enhance your career development.
- Your career involves a research *path*, not a research project
- Determine your research path - your lifelong research goals - and then identify milestones toward your goals
- Detail the first one or two as the research projects for your CAREER proposal



# You

---

## Who are you?

- **Your expertise/interests**
- **Your career/life goals**
- **Your position/resources**

Your proposal should fit into your life plan

**What is your life plan?**

**Do you need to develop a strategic plan?**



# Your Strategic Plan

---

- A strategic plan has three parts:
  - Where are you today in your career path?
  - Where do you want to be in the future (5, 10, 20 years from now)?
  - How do you get from here to there?

- Questions:

What do you want to leave as your career legacy?

**A strategic plan is a roadmap for your life**



# Your Proposal

---

- Should advance you toward your life goals
- Should be a stepping stone to the next thing
- Should represent a contribution to society at large

**Test: If you accomplish your objectives, are you better off for the effort?**



# The Research Objective

---

- This is probably the hardest part of the proposal
- Examples of what not to write:
  - The research objective of this project is to create novel new transformational knowledge.
  - The objective of my research is to provide a quantum leap in the design of anti-gravity boots.
  - The objective of this project is to develop an integrated modeling tool for the hardening process.



# The Research Objective

---

- **How to do it right:**
  - The research objective of this project is to model the interfacial interaction from nano- to macro-scale.
  - The research objective of this proposal is to test the hypothesis that physical phenomena  $x$ ,  $y$ ,  $z$  dominate the chip formation process in the machining of brittle materials.
  - The research objective of this project is to account for uncertainty in engineering design decision making through the application of utility theory.



# Educational Plans

---

PIs work with:

- Underrepresented groups in STEM
- Undergraduate research
- Museums
- Industry
- Government labs
- Local K-12 school districts (identify a specific age range)
- Not for profit organizations (4H clubs, First-robotics, .....)
- Faculty in other colleges at their institution

Be creative! The education plans with the most potential impact are the ones that are motivated by your own life experiences.



# Finally, Dos and Don'ts

---

- Submit the proposal early (your SPO will have to submit a lot of proposals at the last minute, do you really want to play the lottery to see if yours is submitted on time?)!
- Ask for advice from other faculty members, NSF program director, department head, etc.!
- Ask for advice early!
- Read and follow the solicitation carefully (there is no flexibility)!
- Attend CMMI CAREER proposal workshop!
- Make educational plan realistic for the five-year effort!



# Funding Mechanisms

---

- Core/Unsolicited
  - Individual/small collaborative teams
- Solicitations
  - Special research call – DMREF, NRI, SNM
  - Early Career – CAREER
  - Instrumentation – MRI
  - Centers – ERC, STC
  - Small Business Innovation - SBIR, STTR
- Dear Colleague Letter (DCL)
- International Collaborations
- Workshops/Conferences



# CMMI Large Grants



CMMI is committed to supporting both single-investigator and team research, including **larger-scale unsolicited proposals that are not feasible through a series of smaller projects and are not achievable by a single principal investigator (PI)**. These larger-scale proposals may request longer time frames (up to five years) and larger budgets (typically not exceeding \$1,500,000) that reflect the scope of work. Larger-scale project descriptions must make a convincing case that collaborative contributions will be greater than the sum of each individual investigator's contribution, and are expected to include a Collaboration Plan. PIs are strongly encouraged to discuss the objectives, scope, research team, and budget of larger-scale proposals with the appropriate CMMI program director(s) prior to proposal preparation and submission.

# Crosscutting and NSF-wide Opportunities

---



- Faculty Early Career Development Program (CAREER)
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Data Infrastructure Building Blocks (DIBBs)—Ex: *Ontology-enabled Polymer Nanocomposite Open Community Data Resource*
- Computational and Data-Enabled Science and Engineering (CDS&E) —Ex: *The Integration of Data-Mining with Multiscale Engineering Computations*
- Software Infrastructure for Sustained Innovation (SI2: SSE & SSI) —Ex: *Multiscale Structure-Mechanical Property Investigation of Additive Manufactured Components for Development of a Reliable Qualification Method*
- National Strategic Computing Initiative (NSCI)
- Critical Techniques and Technologies for Advancing Big Data Science & Engineering (BIGDATA)
- Cyber-enabled Sustainability Science and Engineering (CyberSEES)
- Scalable Nanomanufacturing (SNM)
- Innovation Corps (I-Corps)
- National Robotics Initiative (NRI)
- Research Coordination Networks (RCN)



# Looking Ahead: Ten Big Ideas



**Navigating the New Arctic**

STATISTICAL COMPUTATIONAL FOUNDATIONS  
OPEN SCIENCE  
REPOSITORIES  
EDUCATION WORKFORCE  
ANALYTICS  
DISCOVER  
DATA MINING  
**DATA SCIENCE**  
FUNDAMENTAL RESEARCH  
MACHINE LEARNING

**Harnessing Data for 21st Century Science and Engineering**



**Work at the Human-Technology Frontier: Shaping the Future**

## RESEARCH IDEAS



**Understanding the Rules of Life: Predicting Phenotype**

**The Quantum Leap: Leading the Next Quantum Revolution**



**Windows on the Universe: The Era of Multi-messenger Astrophysics**

## PROCESS IDEAS



**Growing Convergent Research at NSF**



**NSF-Includes: Enhancing Science and Engineering through Diversity**



**Mid-scale Research Infrastructure**



**NSF 2050: Seeding Innovation**



# Dear Colleagues Letter (DCL)

---

DCL on [convergent research](#) by cultivating multi-disciplinary research communities. The convergence paradigm enhances a more traditional transdisciplinary approach to research by framing challenging research questions at inception, and fostering the collaborations needed for successful inquiry.

This DCL focuses on 4 of the 6 research-focused [NSF Big Ideas](#).

*Harnessing the Data Revolution for 21<sup>st</sup> Century Science and Engineering.*

*Navigating the New Arctic*

*The Quantum Leap: Leading the Next Quantum Revolution*

*Work at the Human-Technology Frontier: Shaping the Future*

**Submission deadline is either May 15, 2017 or June 1, 2017**



# Thank you

**NSF is Moving to a New Location  
CMMI will be moving in September 2017**



*Arlington, VA*



*Alexandra, VA*

# Questions?

---