



Challenges and Opportunities in Computational Science and Engineering

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Program Director, Mechanics of Materials (MoM-X)

Acting Program Director, Nano & Bio Mechanics (NBM)

*Division of Civil, Mechanical & Manufacturing Innovation
(CMMI)*

www.ghpaulino.com



Mechanics at the National Science Foundation (NSF) & Beyond

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CMMI Reorganization & Merger History*

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

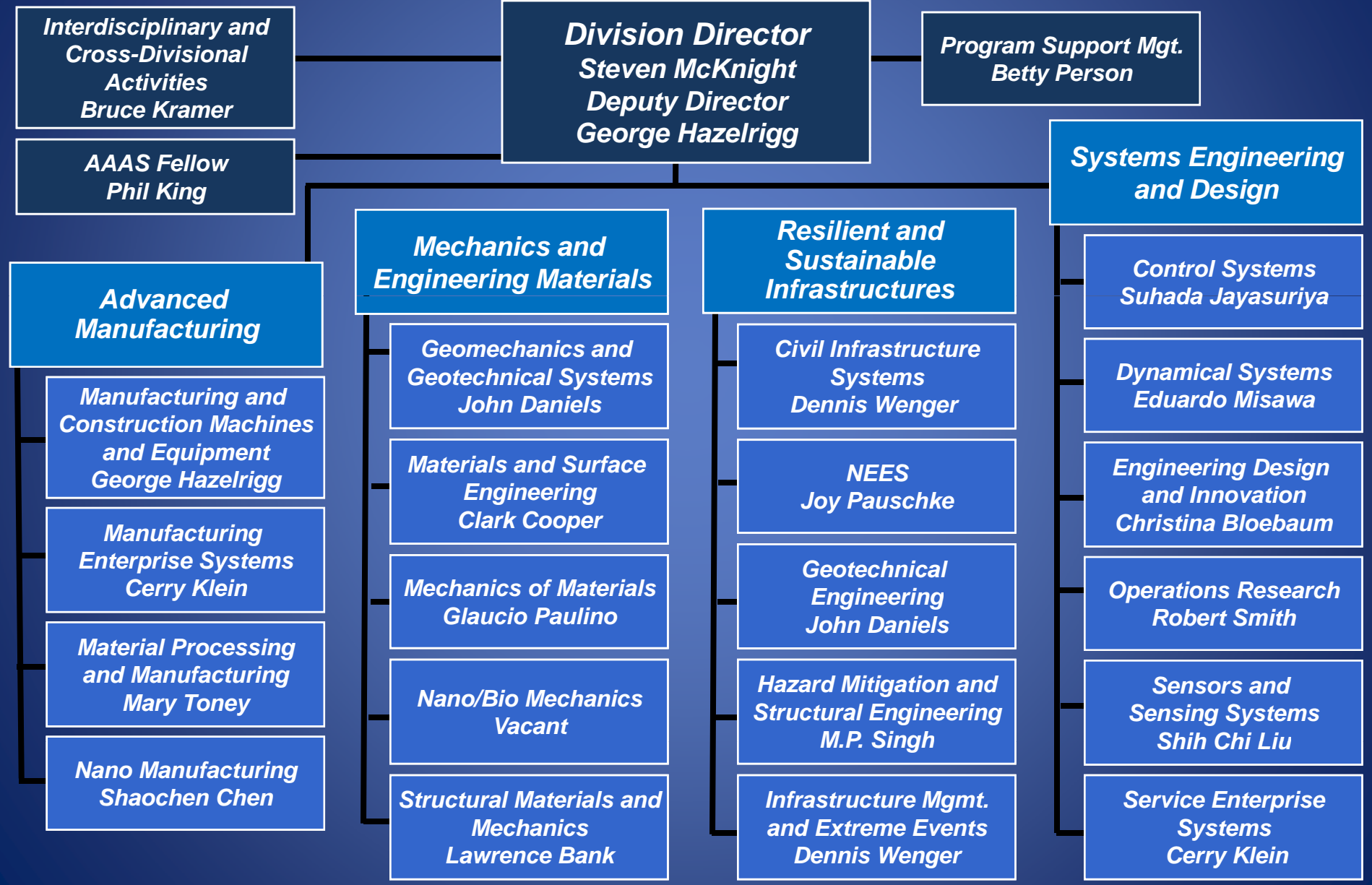
\$232.6 Million
4 Clusters
20 Programs
18 Program Directors
17 Staff Members
2,923 Proposals**

****Just completed third year***

*****Includes ARRA***



Current CMMI Organization

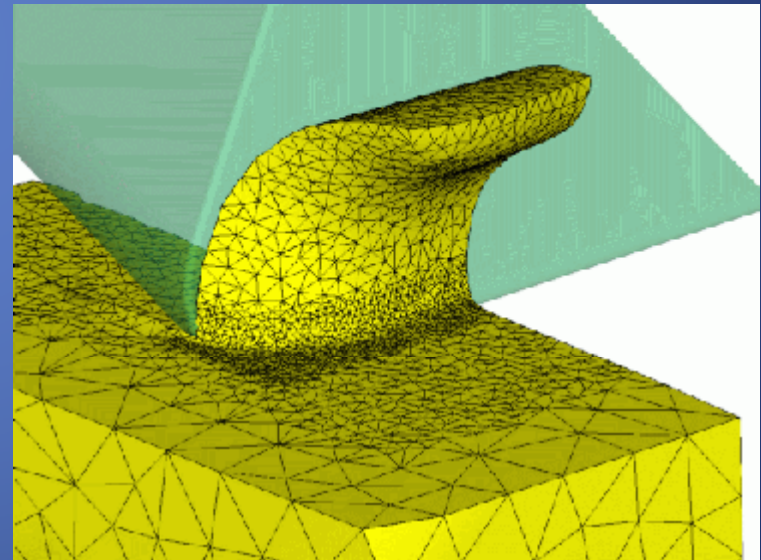




Current CMMI Research Clusters

Advanced Manufacturing

- *Research leading to transformative advances in manufacturing and building technologies, with emphases on efficiency, economy, and sustainability*
- *Supporting programs*
 - *Manufacturing and Construction Equipment*
 - *Manufacturing Enterprise Systems*
 - *Materials Processing and Engineering*
 - *Nanomanufacturing*





Current CMMI Research Clusters

Resilient and Sustainable Infrastructures

- *Research to advance fundamental knowledge and innovation for resilient and sustainable civil infrastructure and distributed infrastructure networks*
- *Supporting programs*
 - *Civil Infrastructure Systems*
 - *NEES – Ops and Research*
 - *Geotechnical Engineering*
 - *Hazard Mitigation and Structural Engineering*
 - *Infrastructure Mgt. and Extreme Events*





Current CMMI Research Clusters

Systems Engineering and Design

- *Research on the decision-making aspects of engineering, including design, control, and optimization*
- *Supporting programs*
 - *Control Systems*
 - *Dynamical Systems*
 - *Engineering Design and Innovation*
 - *Operations Research*
 - *Sensors and Sensing Systems*
 - *Service Enterprise Systems*

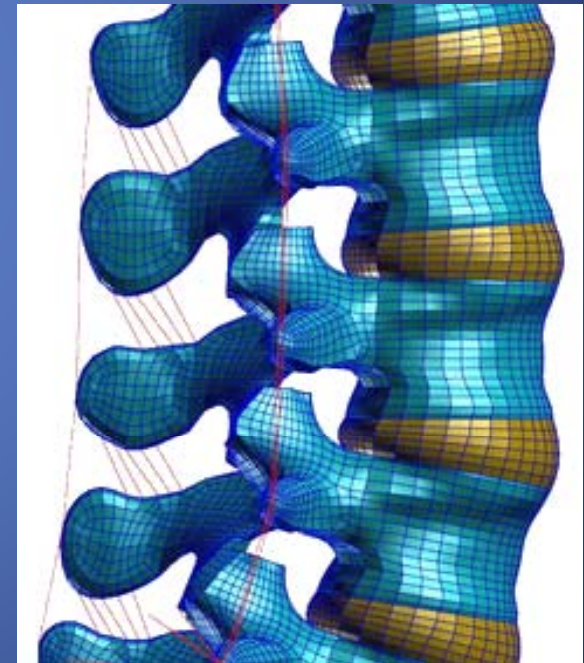




Current CMMI Research Clusters

Mechanics and Engineering Materials

- *Research aimed at advances in the transformation and use of engineering materials efficiently, economically, and sustainably*
- *Supporting programs*
 - *Geomechanics and Geomaterials*
 - *Materials and Surface Engineering*
 - *Mechanics of Materials*
 - *(Nano/) BioMechanics*
 - *Structural Materials and Mechanics*





Mechanics & Engineered Materials Grand Challenges

- Energy Efficient Materials
 - Efficient design/materials use
 - Novel materials for energy generation & conservation
- Energy Efficient Buildings
 - Building materials
 - Controls for energy use/demand
- Biologically inspired and enhanced materials
 - Biomimicry & bioinspired materials
 - Material improvement via biological systems



CMMI Participation in EFRI

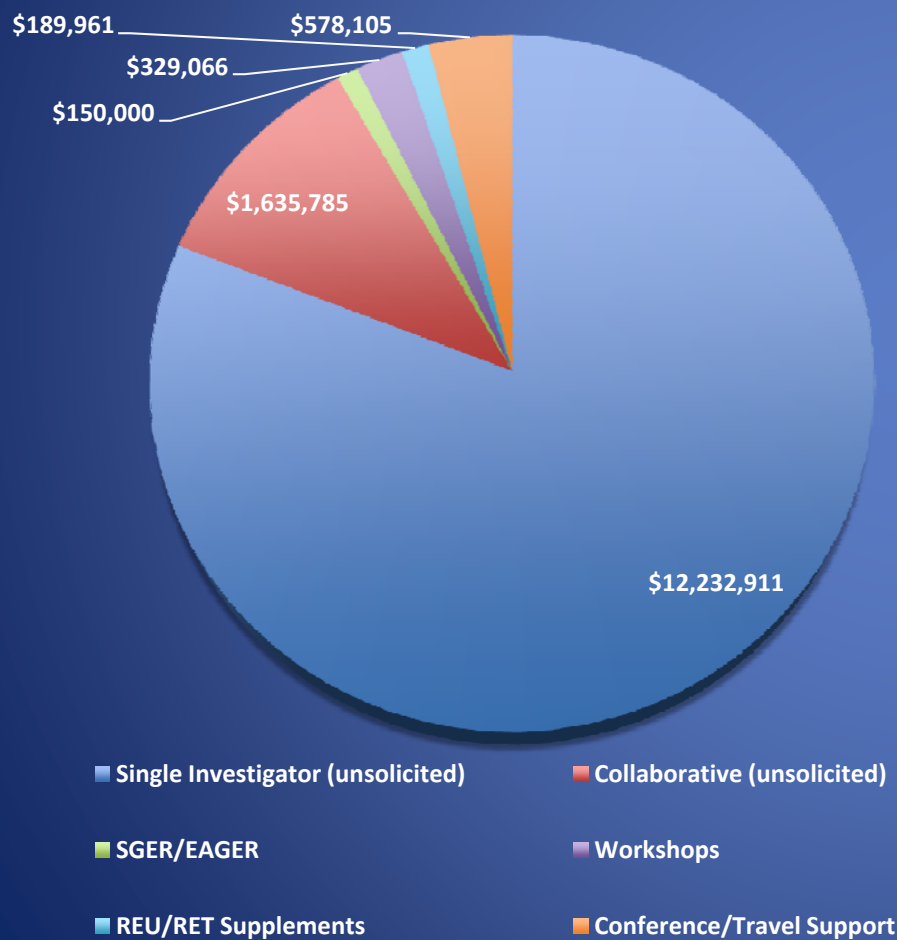
(CMMI Led in Red)

- *2006 Competition*
 - *Auto-Reconfigurable Engineered Systems (ARES)*
 - *Cellular and Biomolecular Engineering (CBE)*
- *2007 Competition*
 - *Cognitive Optimization and Prediction (COPN)*
 - *Resilient and Sustainable Infrastructures (RESIN)*
- *2008 Competition*
 - *BioSensing and BioActuation (BSBA)*
 - *Hydrocarbons from Biomass (HyBi)*
- *2009 Competition*
 - *Large-Scale Energy Storage*
 - *Science in Energy and Environmental Design (SEED)*

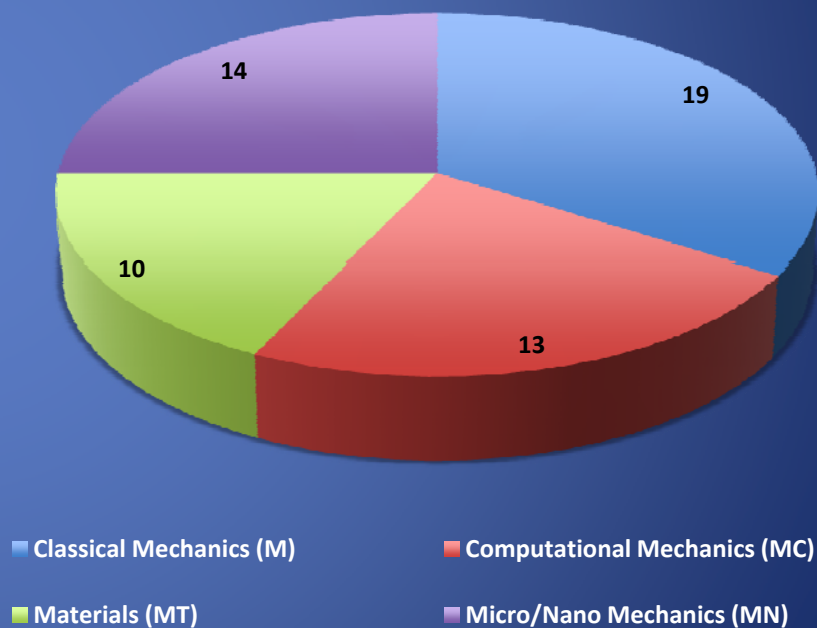


Mechanics of Materials - Research Portfolio, FY 2006 - FY 2008

Proposal Types



Number of Awards General Research Areas





Mechanics of Materials: MoM-X

- The MoM-X program supports fundamental research on solid mechanics including theoretical, experimental, and computational approaches, model-based simulation, and the development of constitutive models. Emphasis is placed on the fundamental understanding of existing and emerging material and structural systems behavior across time and length scales, including experimental and analytical research on deformation, fatigue, and fracture. *There is significant interest in techniques that address the theoretical basis of multiscale methods.*



Mechanics of Materials: MoM-X

- **Maturing Areas:**

Macro damage mechanics; Continuum linear mechanics; Bulk nondestructive testing techniques

- **Emerging Areas:**

Mesoscale Mechanics of Complex materials; Fundamentals of multiscale methods, influence of AGGREGATION on multilevel approaches (mathematics), “Divide-and-conquer” approach (mathematics), path dependency, parts versus whole, complex system



(Nano and) Bio Mechanics (N)BM

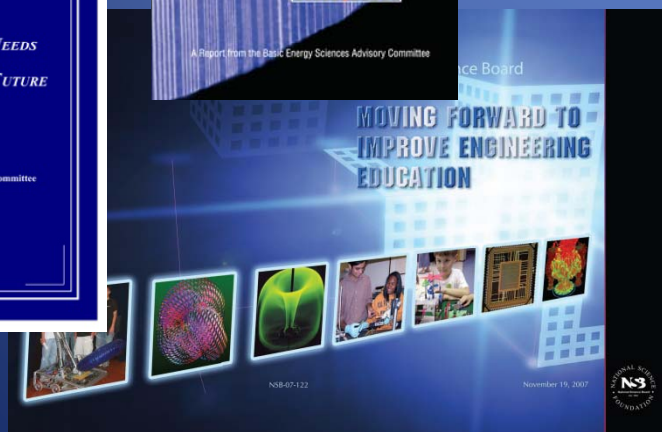
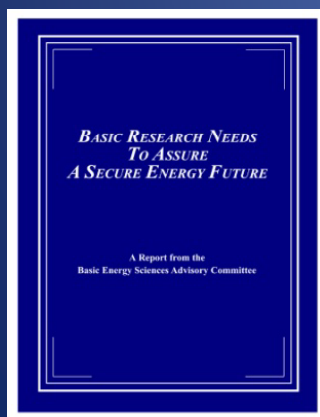
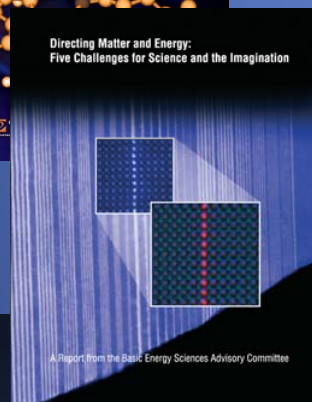
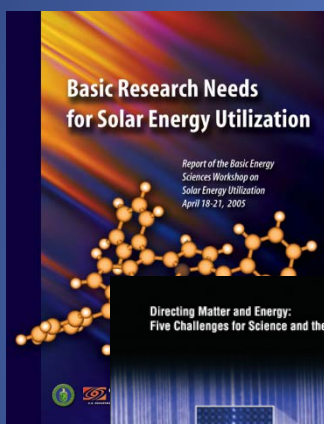
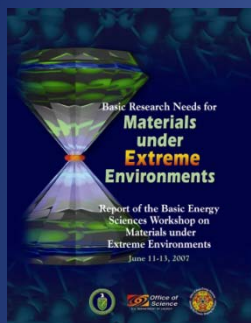
- The NBM program supports fundamental research in biomechanics. Research focuses on the mechanical properties and behavior of biological materials and structures at every length and time scale, including cells, tissue, muscles, bones, and prosthetic implants.



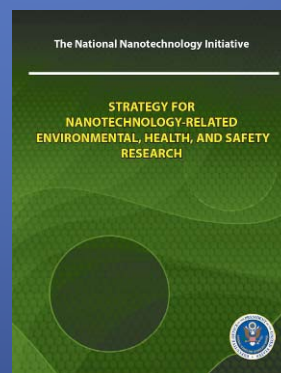
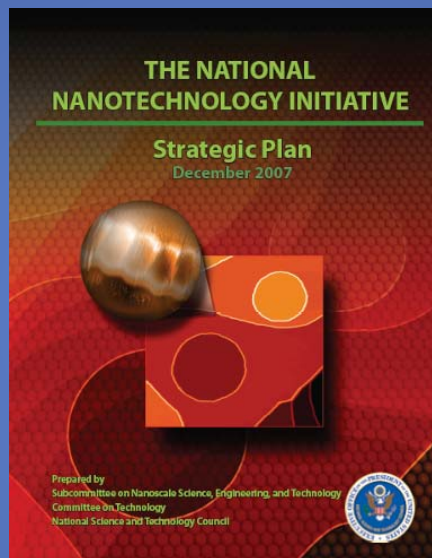
Future Directions for CMMI

Influence of Community and Context

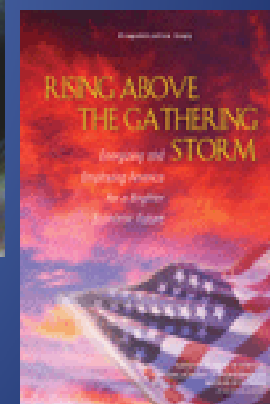
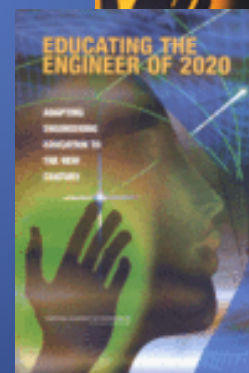
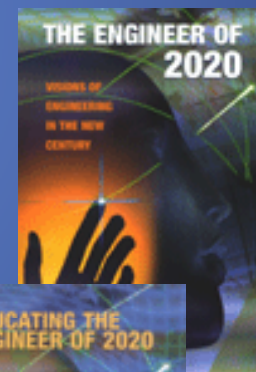
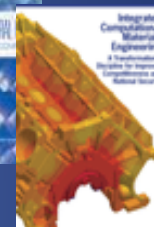
Interagency Studies, Workshops, And Coordination



National Initiatives



NRC / NAS / NAE



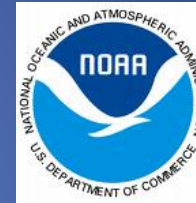


CMMI Collaborations

- *Internal collaborations within CMMI*
 - *Between programs and within clusters*
- *Collaborations within ENG and across NSF*
- *Interagency collaborative ventures*
 - *Create special initiatives*
 - *Co-fund research*
 - *Leverage unique capabilities for research use*
- *International collaborations*
 - *NEES Research & Japan's MEXT*
 - *Nanotechnology*
 - *International workshops with ESF*



AFOSR



*Collaborations with E-Defense
Miki, Japan*

Discovery, learning, research infrastructure, and stewardship



Future Directions for CMMI

Influence of Community and Context

*Interagency Studies, Workshops,
And Coordination*

National Initiatives

NRC / NAS / NAE

- ***Emerging areas of opportunity***
- ***Areas of critical need (big contributions possible)***
- ***Disciplinary research (core programs)***
- ***Cross-disciplinary advances (clear opportunities)***
- ***SBES (Clark Cooper)***



Workshop on the Emerging Applications and Future Directions of the Boundary Element Method

- BEM activity in the USA versus in other parts of the world
- Where is the new generation of researchers?
- Education: do students learn BEM in the USA?
- Segregation
- Grand challenges: Where can BEM play a role?
- What's next?



Thank You!