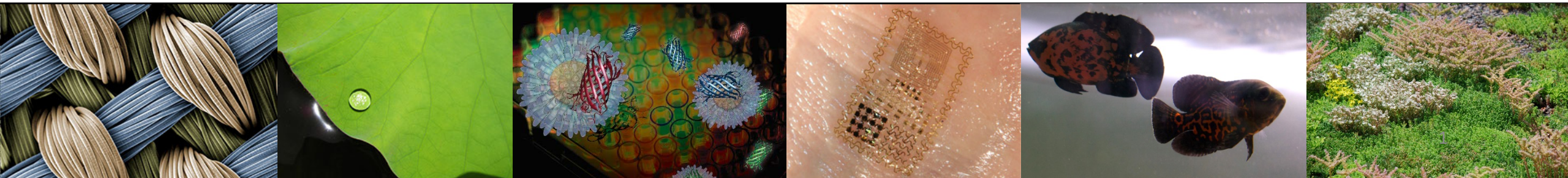


# An Overview of the CMMI Division

NSF Directorate for Engineering Advisory Committee Meeting,  
October 21, 2015

Deborah Goodings

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

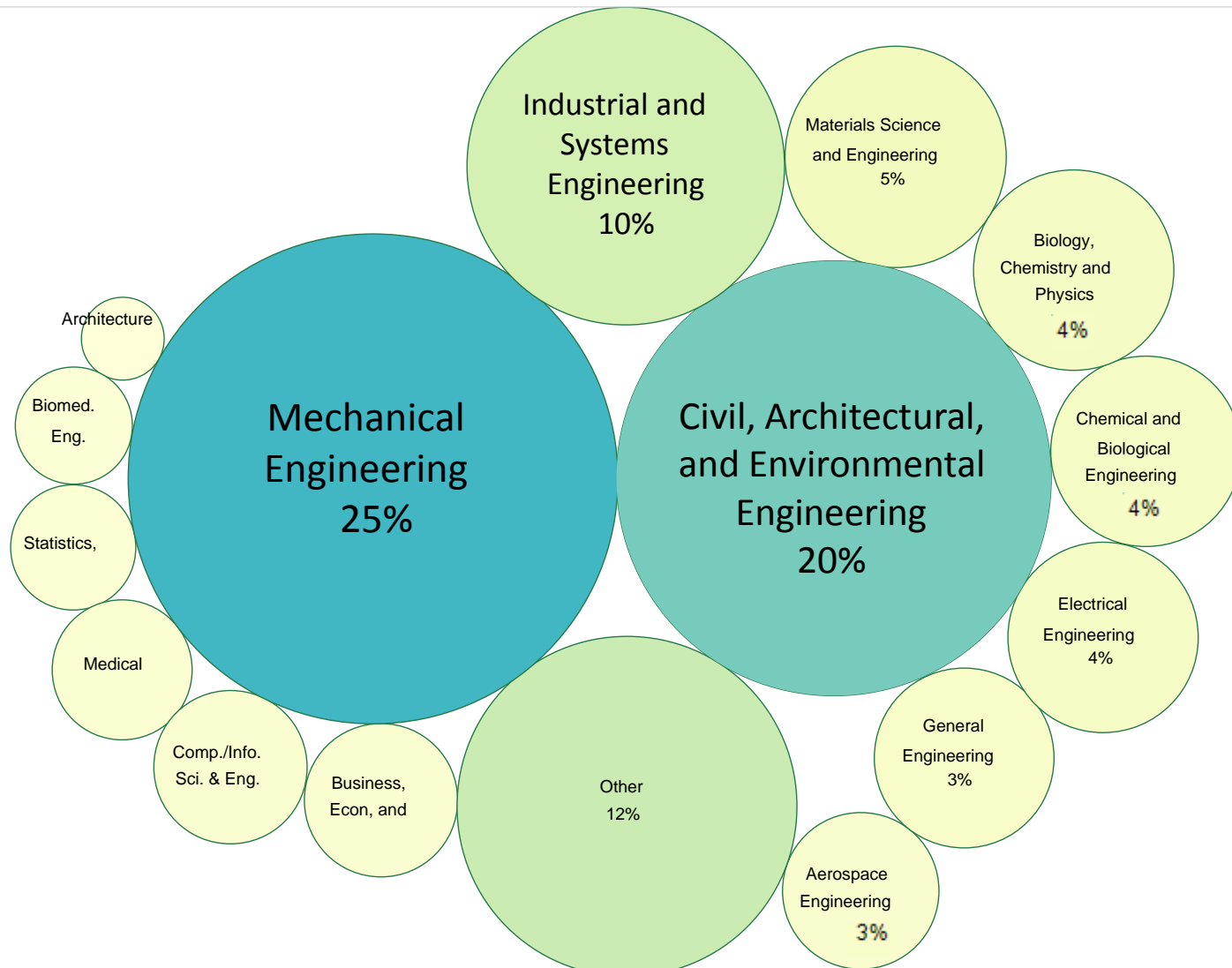


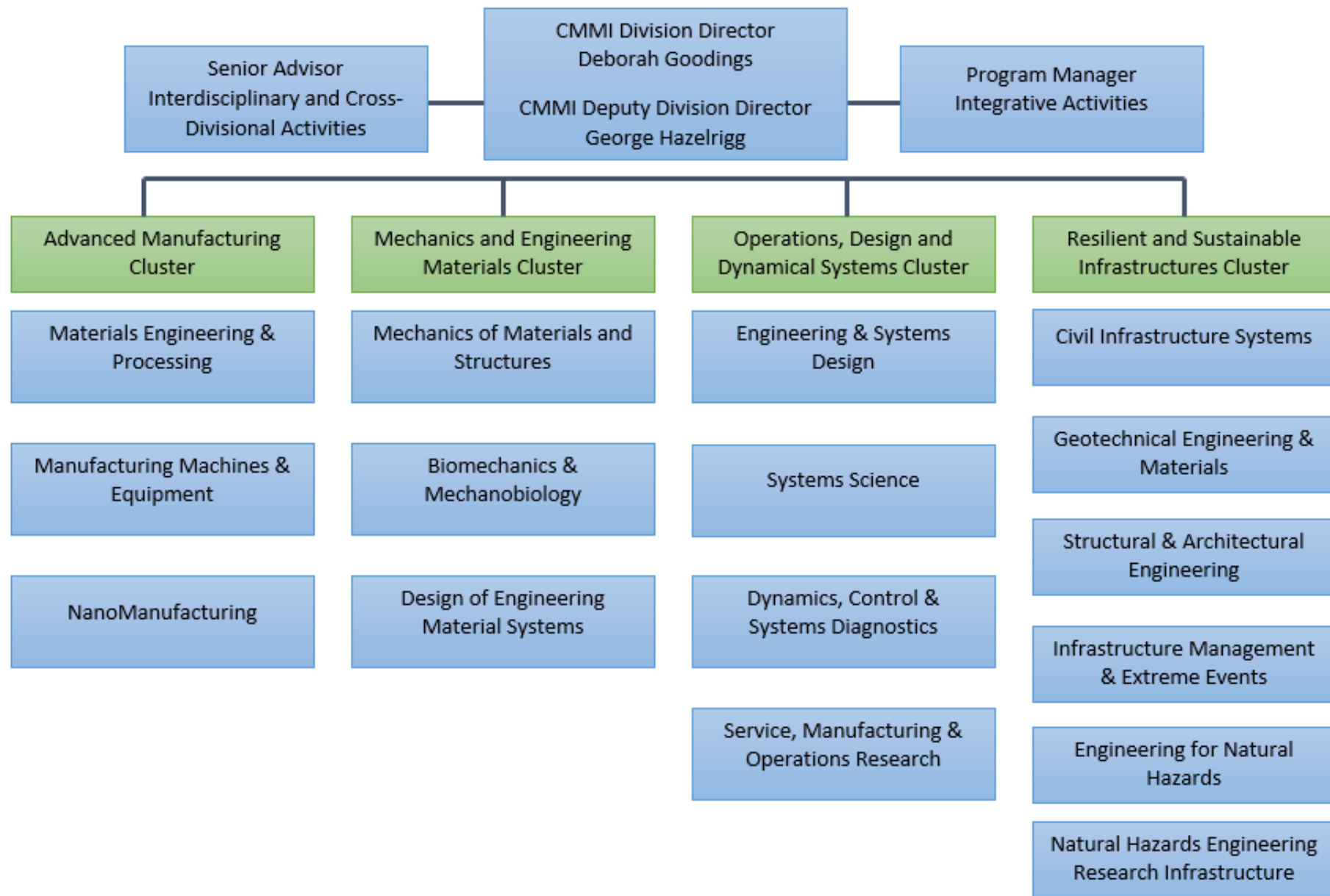
# CMMI Mission

*“To promote the progress of science; advance the national health, prosperity, and welfare; and to secure the national defense...” by supporting fundamental, transformative research and education in support of*

- Advances in manufacturing, design and use of engineering materials, and building technologies across scales from nanometers to kilometers,
- Advances that improve the resilience and sustainability of the nation’s civil infrastructure, including reduction of risk and damage from natural and human-induced disasters, and
- Advances in engineering mathematics, engineering decision-making, and systems control and engineering

# CMMI Awardee Community, FY2015





# CMMI By the Numbers, FY2015

- Total number of submitted proposals: 4,410
- Total number of awards made: 642
- FY15 budget (estimate): \$218M

# CMMI Cluster Research



- Manufacturing and building technologies, with emphasis on efficiency, economy, and sustainability
- Programs
  - Materials Engineering & Processing
  - Manufacturing Machines & Equipment
  - NanoManufacturing





# Example AM Awards

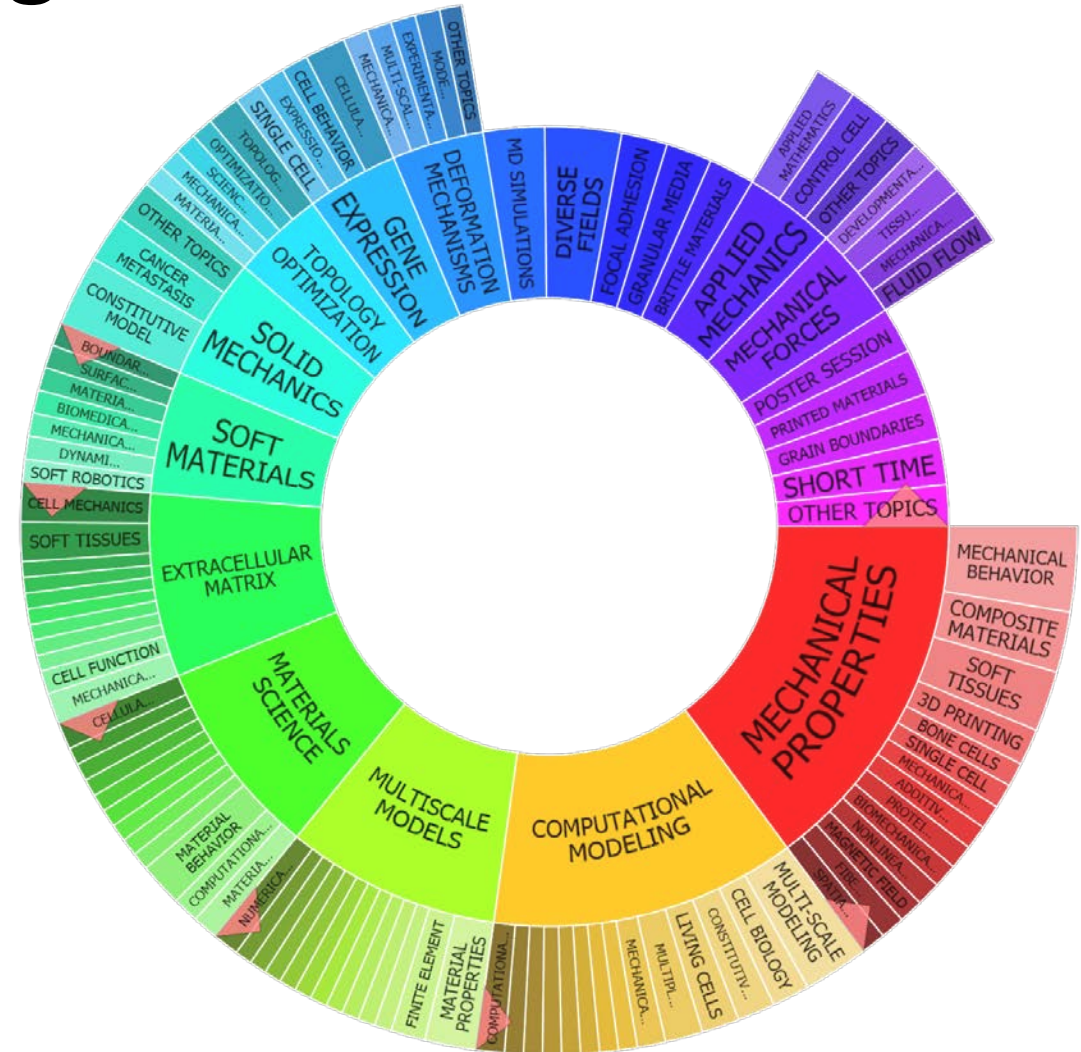


- MEP: Smart Manufacturing of Hybrid Materials with an Exceptional Combination of Strength and Toughness
- MME: Scalable Laser Printing of Three-Dimensional Living Tissue Constructs
- NM: Ambient Processing and Patterning of Graphene Oxide across Multiple Length Scales



# Mechanics and Engineering Materials

- Transformation and use of engineering materials efficiently, economically, and sustainably
- Programs
  - Biomechanics & Mechanobiology
  - Design of Engineering Material Systems
  - Mechanics of Materials & Structures



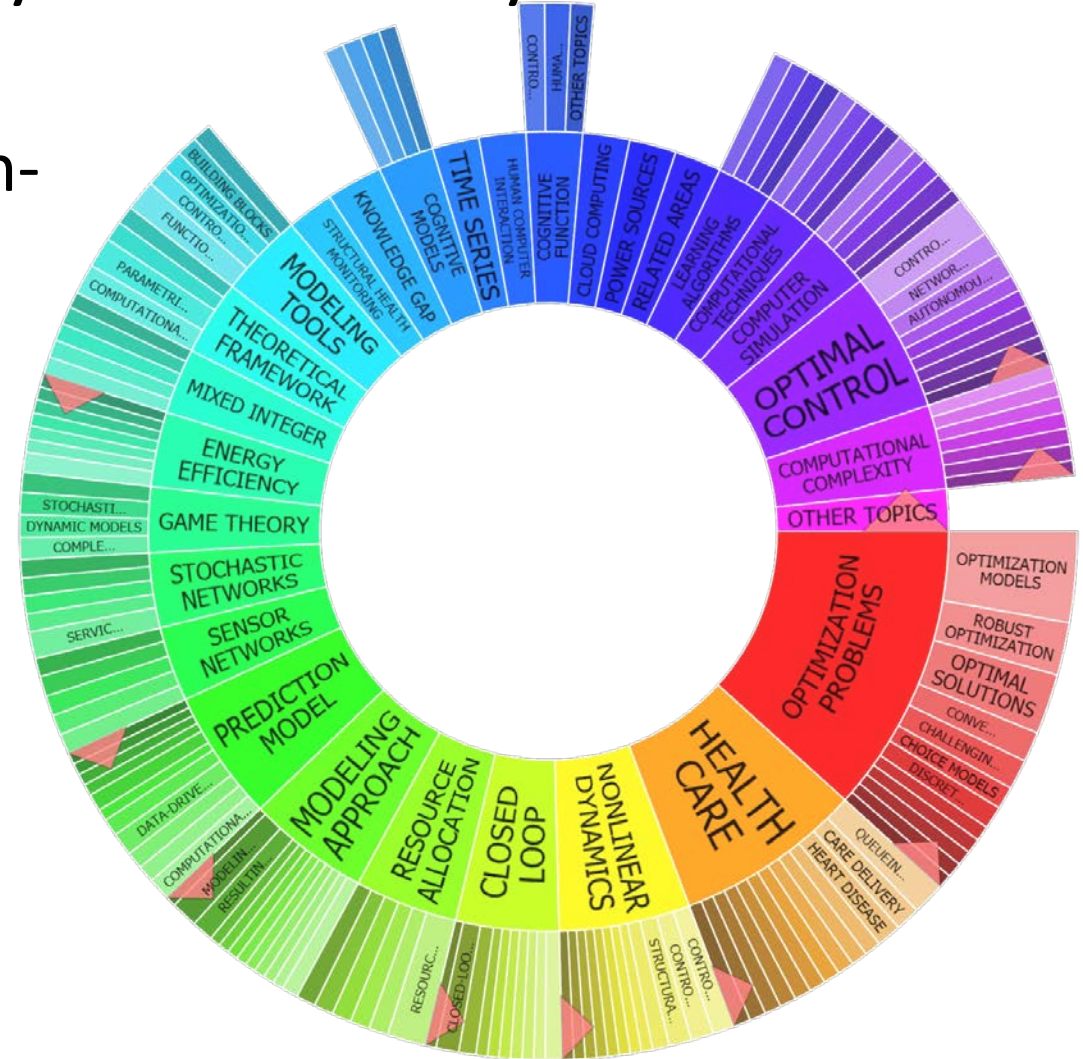
# Example MEM Awards



- BMMB: Investigating the Emission of Sounds by the Mammalian Ear Using a Computational Model
- DEMS: Designing Functional Materials with Optimal Learning
- MOMS: Nonlinear Fracture Mechanics of Hydrogel-Like Soft Materials

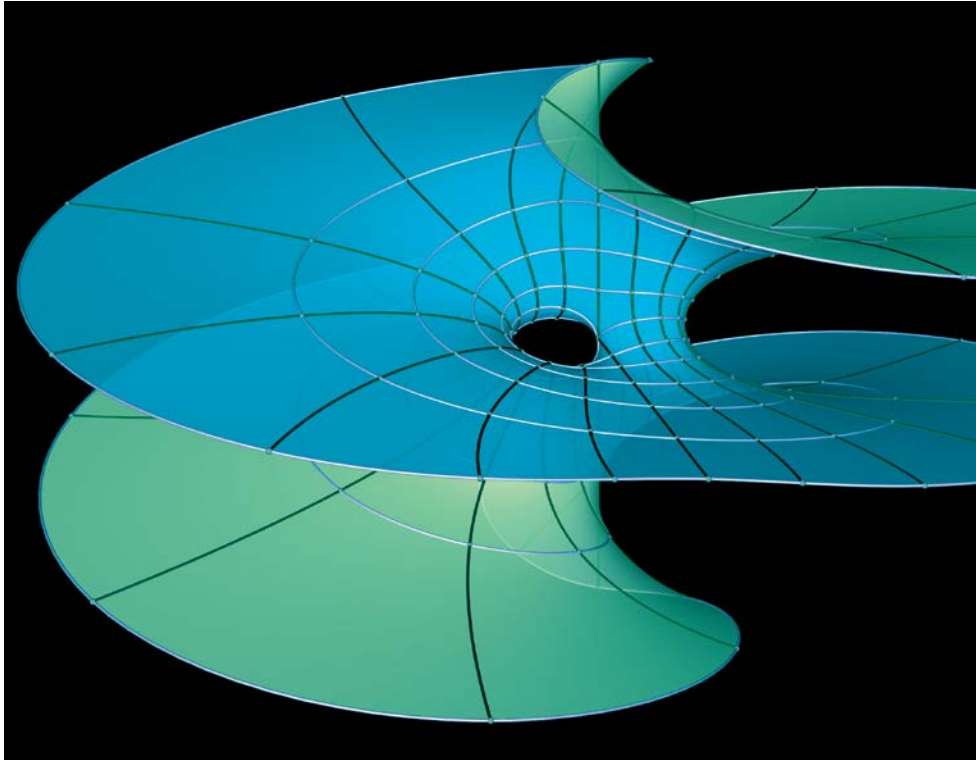
# Operations, Design, and Dynamical Systems

- Mathematical and engineering decision-making for design, control and optimization from component to enterprise systems
- Programs
  - Dynamics, Control & Systems Diagnostics
  - Engineering & Systems Design
  - Service, Manufacturing & Operations Research
  - Systems Science





# Example ODDS Awards



- DCSD: A Dynamical Systems Approach to Shepherding and Sorting Microparticles in Fluids
- ESD: Model-Based Multidisciplinary Dynamic Decisions in Design
- SMOR: Optimal Dose-Response Learning
- SYS: Expanding Open Innovation Methods to Complex Engineered Systems

# Resilient and Sustainable Infrastructures

- Resilient and sustainable infrastructure and distributed infrastructure networks
- Programs
  - Civil Infrastructure Systems
  - Engineering for Natural Hazards
  - Geotechnical Engineering & Materials
  - Infrastructure Management & Extreme Events
  - Structural & Architectural Engineering
  - Natural Hazards Engineering Research Infrastructure



# Example RSI Awards



- CIS: Transportation Network Identification: Information Fusion via Stochastic Optimization
- ENH: A Decision and Design Framework for Multi-Hazard Resilient and Sustainable Buildings
- GEM: Soil Improvement Through Bio-Cementation: Physical and Numerical Experiments
- IMEE: Learning Failure Propagation Patterns in Interdependent Network From Observed Post-Disaster Disruptions
- SAE: Life-cycle Assessment of Resiliency and Sustainability of Buildings
- NHERI: Experimental Facility with Large, High Performance, Outdoor Shake Table

# CMMI Funding Mechanisms

## CAREER

- FY2015 – 301 proposals; 49 awards; \$24.5M

## Unsolicited proposals

- Includes special category unsolicited proposals: GOALI, EAGER, RAPID, Workshops, Travel Support, Research Experiences for Undergraduates, Research Experiences for Teachers
- FY2015 – 3645 proposals; 585 awards; ~\$180M

## Solicited Proposals

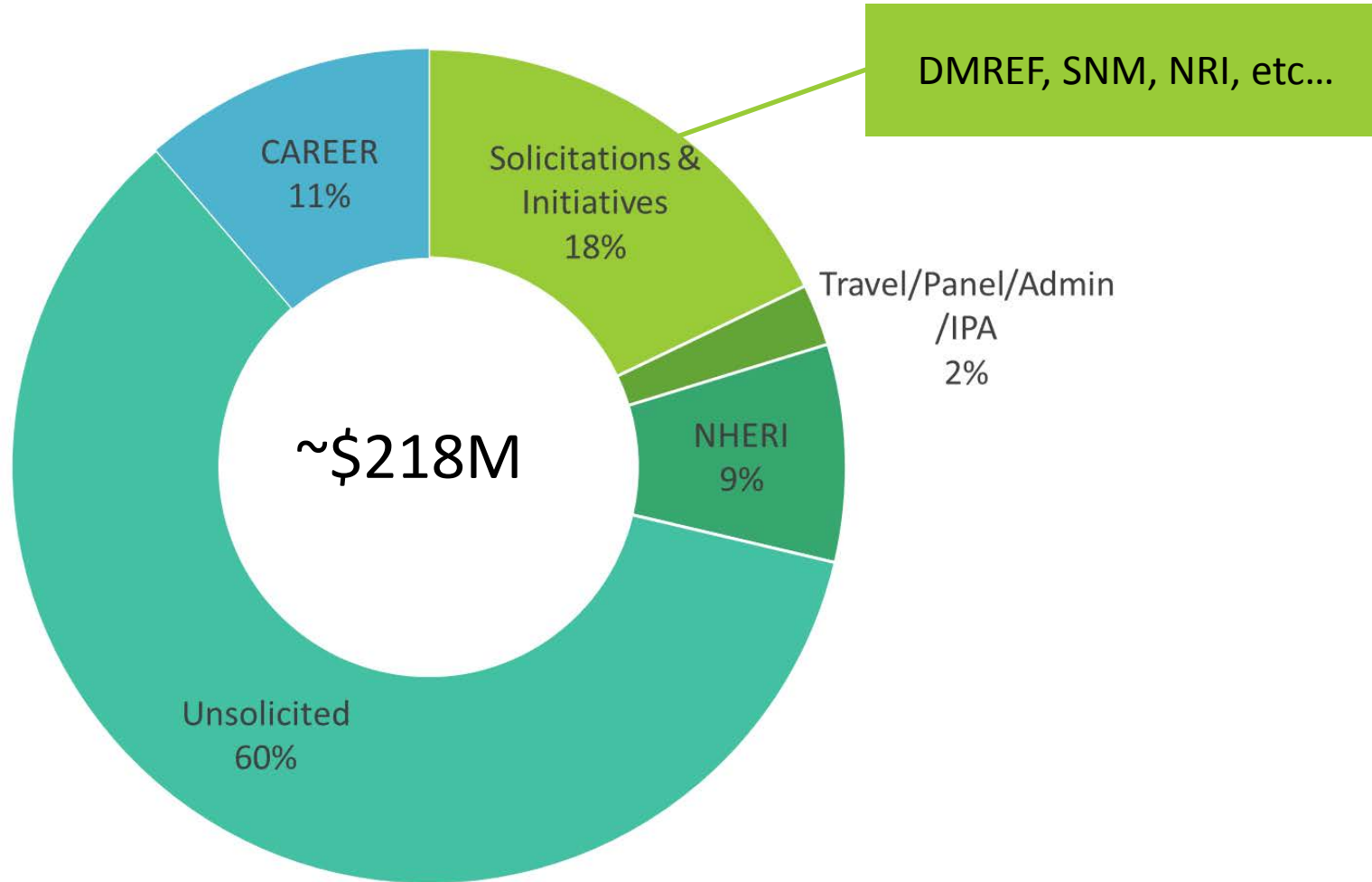




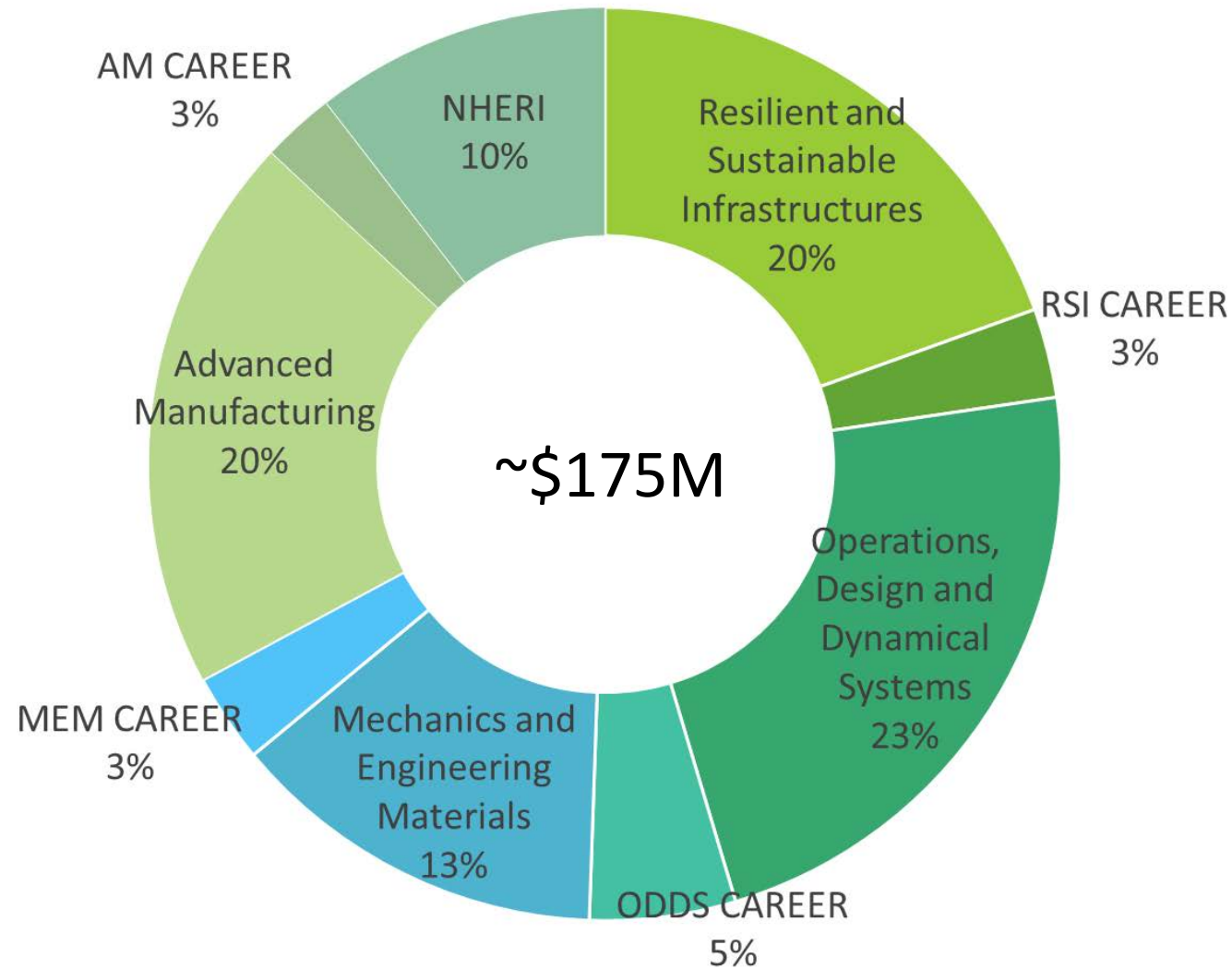
# Solicitations & Initiatives, FY2015

- Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP)
- Scalable Nanomanufacturing (SNM)
- Cybermanufacturing
- Designing Materials to Revolutionize and Engineer our Future (DMREF)
- National Robotics Initiative (NRI)
- Cyber-Physical Systems
- Computational & Data-Enabled Science and Engineering (CDS&E)
- Interdisciplinary Research in Hazards and Disasters (Hazard SEES)

# Overall Budget, FY2015



# Distribution of CMMI Funding, FY2015



# Distribution of CMMI Funds, FY2015

- ~23% supporting PIs with <7 years since PhD
- ~38% supporting Projects with New PIs or CoPIs
- ~27% supporting Projects with Female PIs or CoPIs
- ~11% supporting Projects with URM PIs or CoPIs

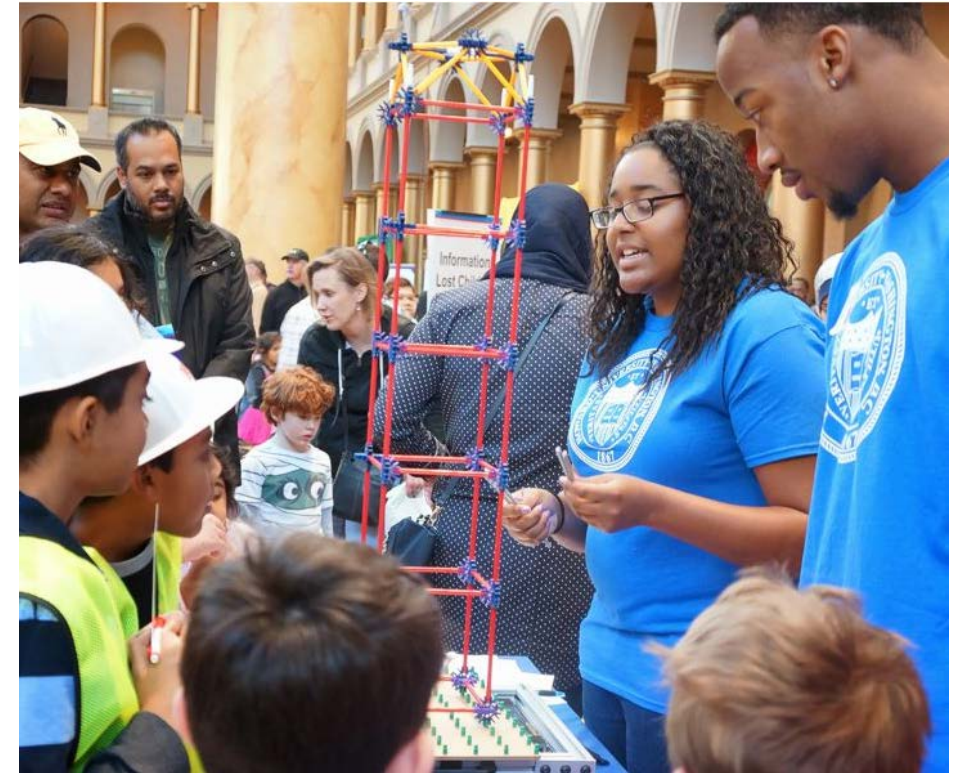


# Response to 2012 COV

- Balance of In-person and Virtual Panels
- Inclusion of Industry Reviewers
- Quality of Reviews
  - Relative emphasis placed on Intellectual Merit & Broader Impacts
- Consistency in Guidance for Evaluating Broader Impacts
- Accessibility of Workshop Reports

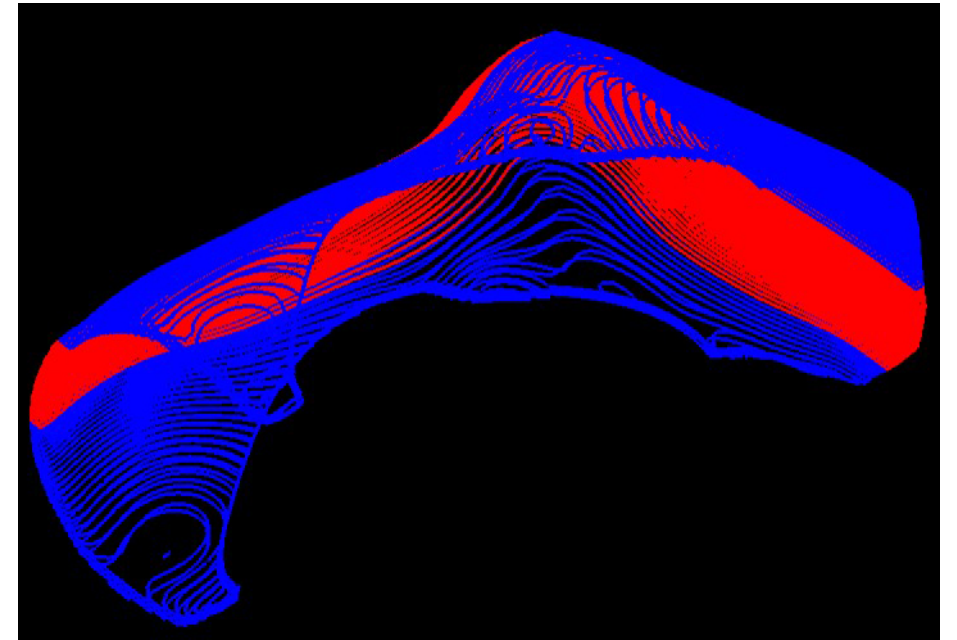
# Guiding Principles for CMMI Future Directions

- Inspire and position our research communities for high impact fundamental research
  - Through our programs and solicitations
    - National priorities and needs
    - Foundation-wide initiatives
    - Emerging research interests from community
- Broaden participation
  - Research team composition
  - outreach via education avenues, both formal and informal



# Cybermanufacturing

- Aligned with PCAST Advanced Manufacturing Partnership 2.0 (2014) recommendations
- DCL from ENG (CMMI, ECCS, CBET) and CISE; April, 2015
- New opportunities in CMMI
- Goals:
  - Complex, intelligent, precise products
  - Interoperable, reliable, secure systems
  - Decentralized and connected
  - Broadening participation





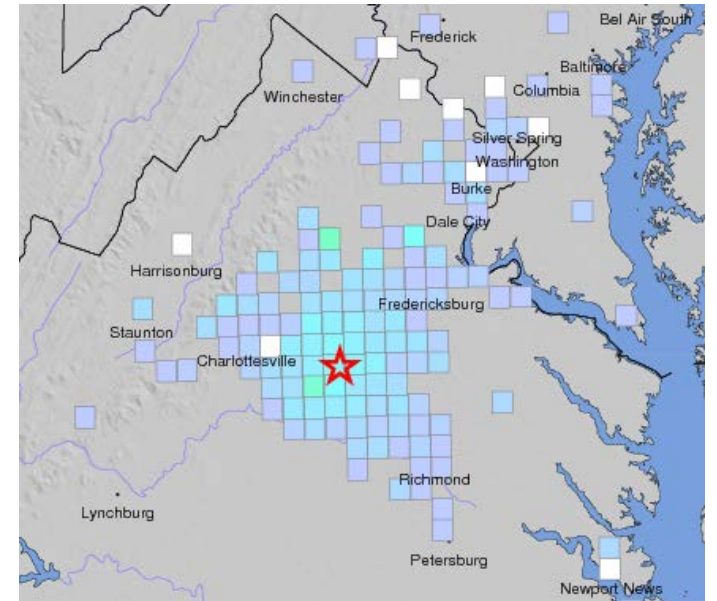
# Urban Engineering

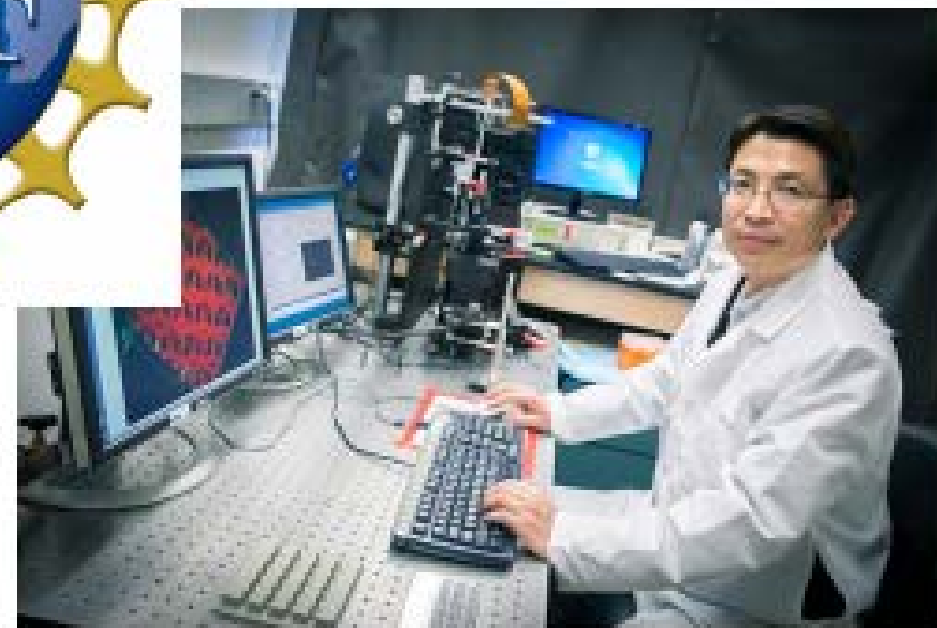
- Supporting the White House Smart Cities Initiative
- DCL from ENG, CISE, SBE, EHR, GEO; September, 2015
  - Smart and Connected Communities
  - New opportunities in CMMI
  - CMMI expanding scope and scale
- Goals:
  - Resource consumption
  - Economy
  - Efficiency
  - Livability



# Citizen Engineer

- OSTP Commitment to Citizen Science and Crowdsourcing, highlighted in September 30, 2015 announcement
- Engage citizenry in observations of and reporting on their surroundings
- New opportunities at intersection of ENG, GEO, CISE, SBE, EHR
- Goals:
  - Vastly expanded data collection for research and infrastructure decision-making
  - Broaden participation
    - Development of science and engineering observational methods
    - Sense of ownership of infrastructure and decision-making





## Image Credits

- *Title Slide*, Images Left to Right:
  - *BMMB*: Farshid Guilak of Duke and his team have developed a 3-D Fabric scaffold into which a strong, pliable hydrogel is integrated and infiltrated with stem cells, forming a framework for growing cartilage.
  - *MEP*: Tak Sing Wong of Penn State and his team have developed nano/micro-textured, highly slippery surfaces able to outperform naturally inspired coatings like lotus leaves, particularly when the water is a vapor or tiny droplets. Credit: *Xianming Dai, Chujun Zeng and Tak-Sing Wong/Penn State*
  - *NSEC*: Chemists at the University of Massachusetts Amherst have devised a multi-channel, signature-based approach to screening drugs using gold nanoparticles with red, green and blue outputs provided by fluorescent proteins. Credit: *Vincent Rotello, Department of Chemistry, University of Massachusetts-Amherst*
  - *MOMS*: Nanshu Lu of U Texas at Austin and her team have developed prototype wearable device of an electronic skin patch as thin as a temporary tattoo that can store and transmit data about a person's movements, receive diagnostic information and release drugs into skin. Credit: *Donghee Son and Jongha Lee*
  - *DCSD*: Maurizio Porfiri of NYU and his team have conducted the first study to show that in a side-by-side comparison, a robotic predator can spook zebrafish just as well as the real thing. These results may help advance understanding of fear and anxiety in animal populations, including humans. Image shows robotic and live predators. Credit: *NYU Polytechnic School of Engineering; picture by Simone Macrì*
  - *GEM*: Patricia Culligan of Columbia and her team are developing best strategies for the design and spatial distribution of urban green roofs Credit: *Stuart Gaffin and Shaily Kedia, Center for Climate Systems Research, Columbia University*

## *Image Credits (cont.)*

- Slide 8: 3D printed disk. Credit: *NSF*
- Slide 10: Hydrogels in a petri dish. Credit: *Joshua Knoff, UC San Diego Jacobs School of Engineering.*
- Slide 12: Illustration of a minimal surface from a mathematical optimization problem. Credit: *Matthias Weber, Indiana University*
- Slide 14: Durbar Square, Kathmandu, Nepal, before and after the April 2015 earthquake. Credit: *Wikimedia Commons*
- Slide 21: Howard University NEES student ambassadors engage in outreach at Discover Engineering Family Day. Credit: *Howard University*
- Slide 22: Albert Shih of the University of Michigan and his team are developing the capability for Internet-based design and rapid manufacturing of customized foot orthoses and ankle-foot orthoses with motion sensors. This image shows the path planning for 3-D printing an ankle-foot orthosis. Credit: *Albert Shih, University of Michigan*
- Slide 23: NSF recently announced nearly \$40M in funding commitments that continues to expand upon NSF's existing leadership in enabling smart and connected communities. Credit: *NSF*
- Slide 24: USGS Dig you feel it?, Community Internet Intensity map from Jan 30, 2012 earthquake in Virginia. Credit: *USGS*

## *Image Credits (cont.)*

- Closing slide, Images clockwise from top-left:
  - Ignacio Lamata Martinez, left, a researcher at the University of Oxford in England, and Gemez Marshall, senior software engineer for NEEScomm IT at Purdue, discuss efforts of the team at the George E. Brown Jr. Network for Earthquake Engineering Simulation to develop a system for integration of shared experimental data for global use. Credit: *Mark Simons, Purdue University*
  - Missouri S&T Additive Manufacturing Research Experience for Undergraduates. Credit: *Missouri S&T Photo Collection*
  - Nanoengineering professor Shaochen Chen led a team of nanoengineers at the University of California, San Diego, in developing a 3-D-printed device inspired by the liver to remove dangerous toxins from the blood. Credit: *University of California, San Diego, Jacobs School of Engineering*
  - Visitors at the Center for Ultra-wide-area Resilient Electrical Energy Transmission Networks' exhibit "Powering Today and Tomorrow" designed their own energy circuits at the 2014 USA Science and Engineering Festival. Credit: *Jackie Conciatore, National Science Foundation*