NSF Programs in Energy and Power Systems

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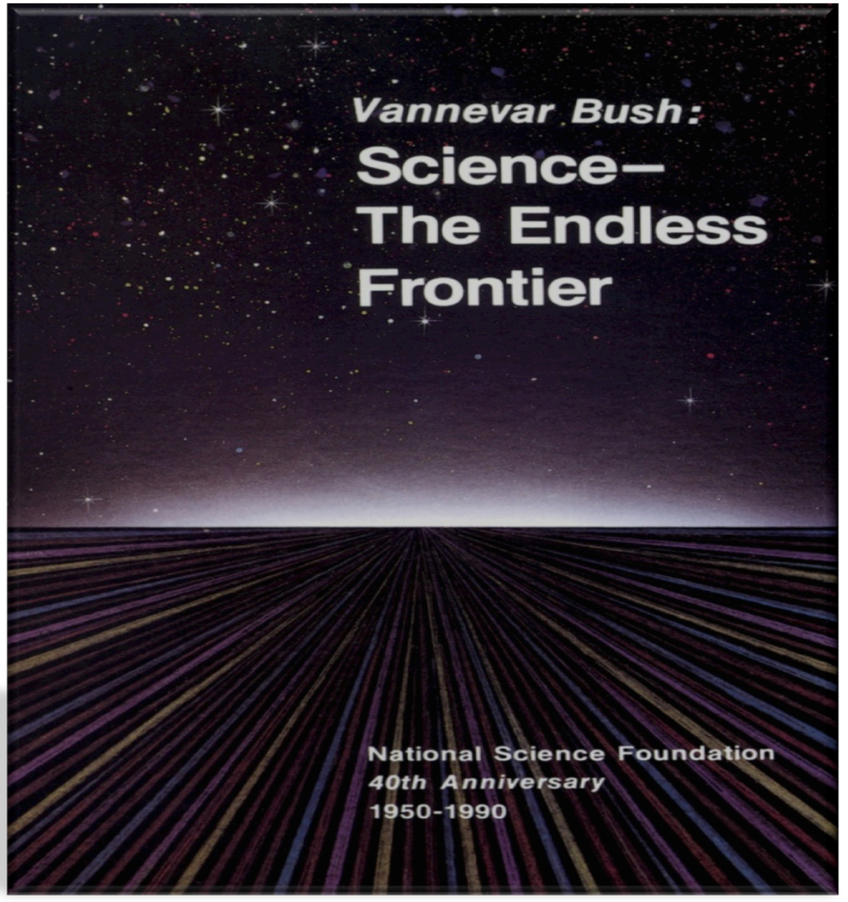
Virginia Tech, Blacksburg, VA
June 9, 2015

Outline

- Overview of NSF organization
- Energy, Power, Control and Networks (EPCN) Program
- The Evolving Electric Grid
- NSF Review Process
- NSF EAGER Mechanism
- Cyber Physical Systems (CPS)
  - Open/Remote Access Test Beds

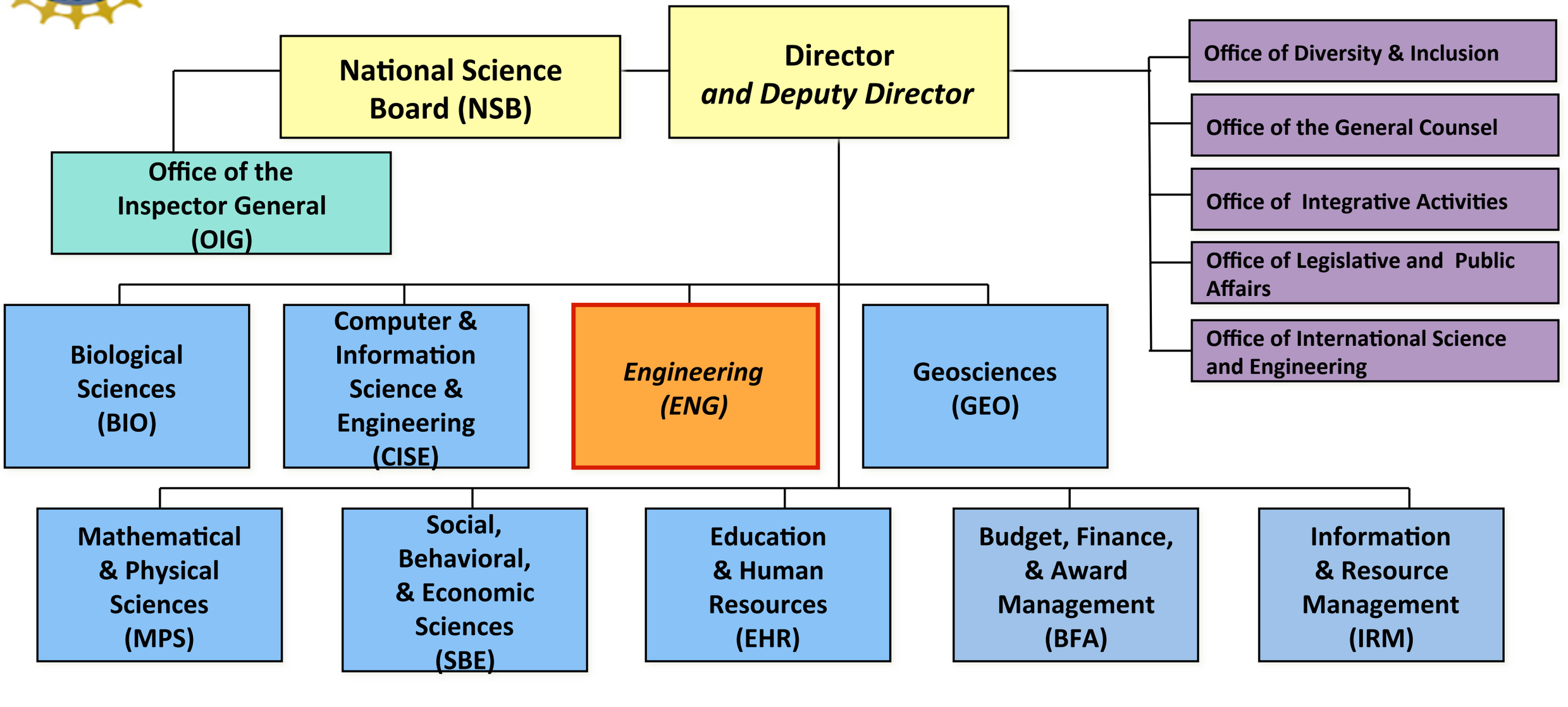


"to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…"
NSF Act, 1950

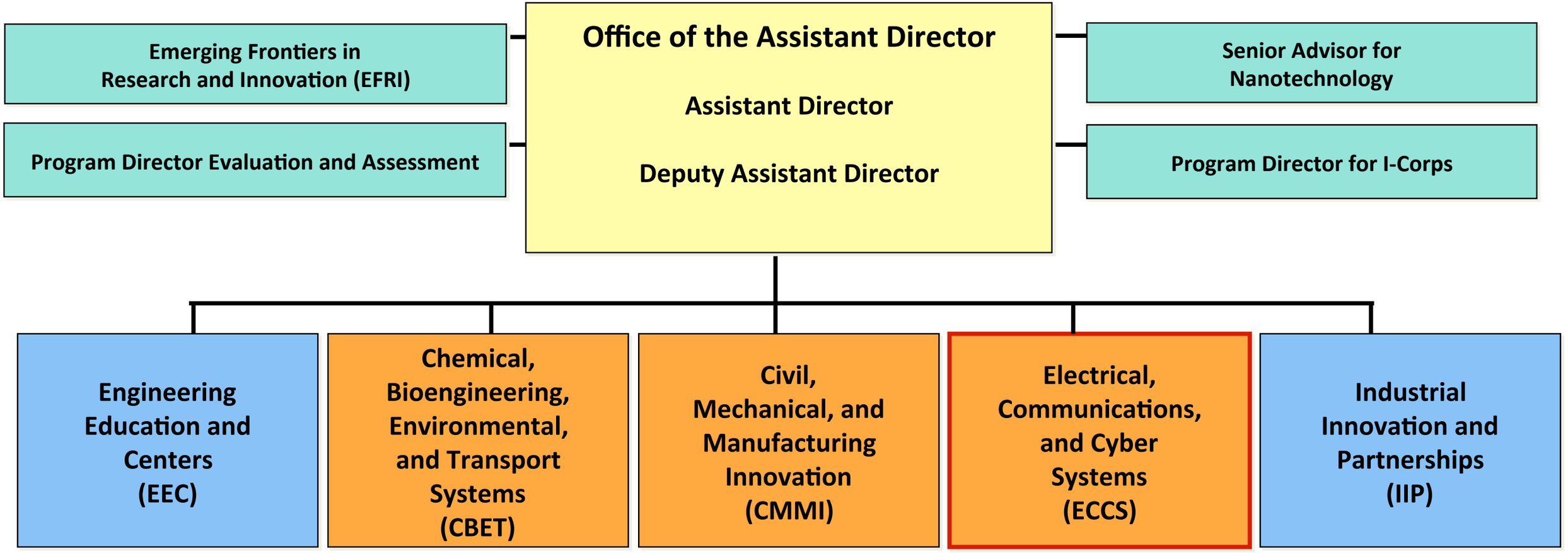
Unique Features of NSF

- Supports fundamental research and education across all fields of science and engineering
- Discipline-based structure with cross-disciplinary mechanisms
- Emphasis on integrating research and education
- Close interaction with Universities
- Rotator System: About 50% Program Directors are on loan from universities, labs, or industries
- FY2014 NSF Appropriation of $7.2 billion (total) – FY2015 Budget ~ $7.5 billion

National Science Foundation



NSF ENG Organization



Electrical, Communications and Cyber Systems (ECCS) Division

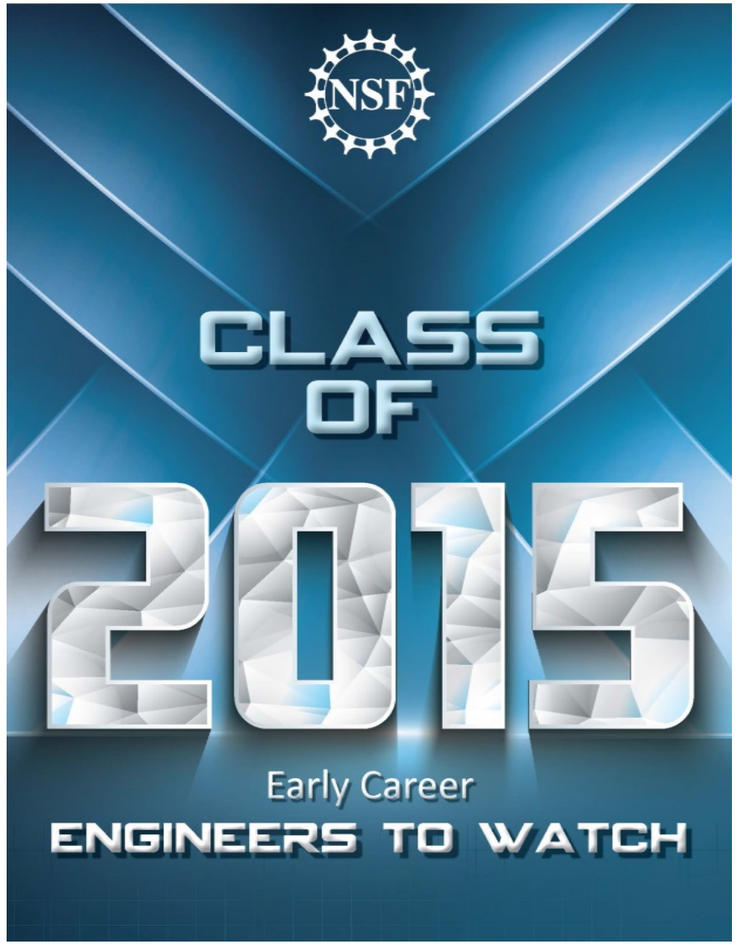
- Electronics, Photonics, and Magnetic Devices
- Communications, Circuits, and Sensing Systems
- Energy, Power, Control and Networks

Proposals Received by ECCS

- Faculty Early Career Development (CAREER)
- Single Investigator / Small Group
- Industry Collaborations (GOALI)
- Exploratory Research (EAGER)
- Workshops on emerging areas
- International collaborations
- Research experience for undergraduates (REU)
- Research experience for teachers (RET)

Engineering CAREER Awards for FY 2015

- $73M total investment in the next generation of engineering early-career faculty
- 146 grants at $500K each
  - 81 institutions in 36 states, including 16 EPSCoR states
  - 29% women and 9% under-represented minorities, according to available demographic data
  - 51% to new PIs



Announcement at
http://www.nsf.gov/news/news_summ.jsp?cntn_id=134554

Energy, Power, Control and Networks (EPCN) – A Core Program

- Design and analysis of complex systems including sensing, imaging, control and computational technologies
- Emphasis on electric power systems, especially with renewable energy integration
- Power electronics and drives
- Energy harvesting devices and systems
- Regulatory and economic structures for power and energy

A Partnership

We are committed to <u>working with the community</u> to discover and support innovation in electrical power and energy research and education ----

There is currently a great need for advancing such efforts

Electric Power Networks

- Critical infrastructure for society
- Large scale spatially distributed nonlinear dynamic systems with multiple time scales
- Hierarchical control and management system involving cyber-physical components, sensors, algorithms, and economic markets
- Techno-socio-economic system with multiple stakeholders
- Regulation and policy (and economics!)

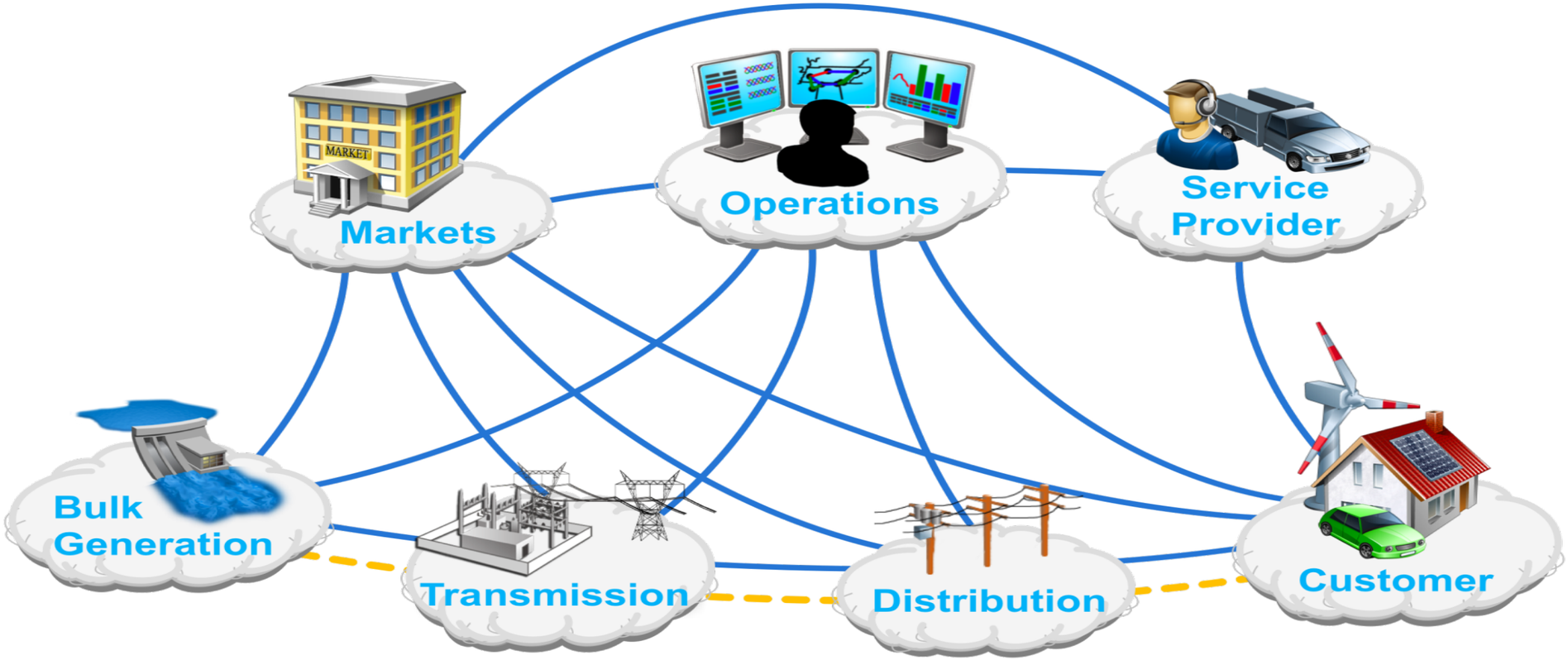
Major Trends and Drivers

- Aging infrastructure in developed world and new infrastructure in the developing world
- IHS Global Insight estimates $12 trillion to be spent on electric grid between 2014-2020
- The rise of distributed generation (DG) and microgrids
- Integration of renewable electric energy from wind and solar, including independent “prosumers”
- Changing demand profiles
- Increasing natural gas generation
- Need for greater resilience in the face of natural and man-made disasters
- Cybersecurity
- *All of these challenges require greater power system innovation and a new generation of power system engineers with broad and deep training.*

Power System Planning and Operations w/ DG

- Power systems with DG are different; new questions arise:
  - Stability criteria for traditional power networks do not carry over to systems with significant penetration of renewable sources.
  - Mandated feed-in tariffs (apply even if the power isn't needed).
  - Lack of storage means that the utility may have to pay for power it doesn't benefit from.
  - No economic policy to cover utility costs to support voltage at DG sources (newer DG sources add to the financial stress; should they pay more than earlier deployed DG?).
  - How to price high variability power sources (solar, wind)?
  - Demand response design ("demand dispatch").

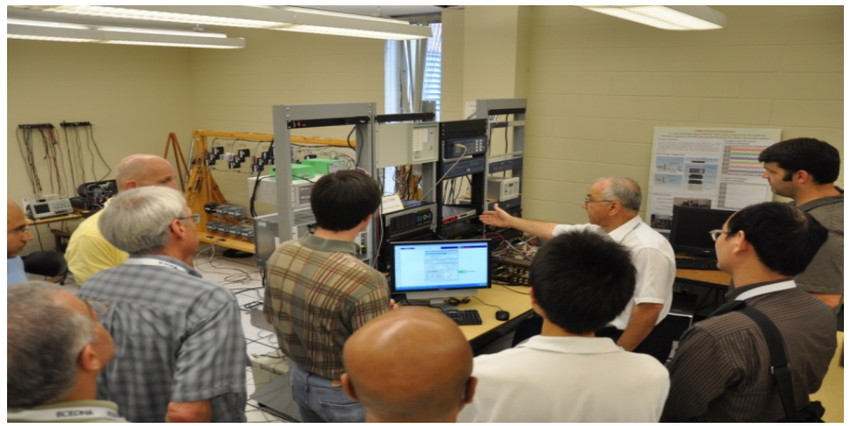
Smart Grid Framework



NIST Smart Grid Framework 1.0 Sept 2009

Shortage of Energy and Power Faculty in ECE Departments

- Electrical and Computer Engineering Departments Head Association (ECEDHA)
- NSF/ECEDHA faculty development workshop held at Georgia Tech on July 9-12, 2011



<u>Workshop Focus</u>:

Cyber Technologies for Electric Power Grid

Electrical Energy Systems Education with Emphasis on Sustainable Power *(ECCS-0901635/1028326, Mohan, University of Minnesota – Twin Cities)*

(Supported by NSF, NASA, ONR, DOE and EPRI)

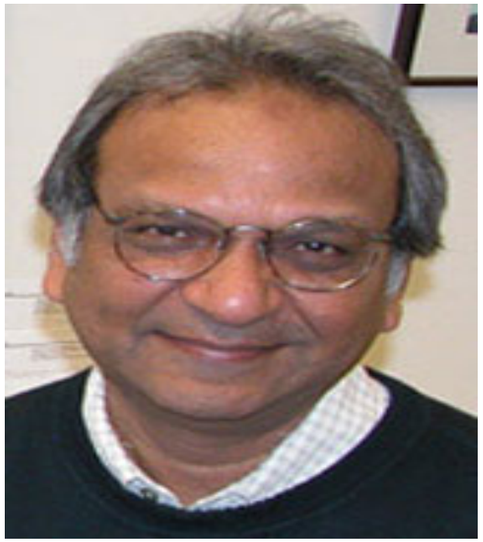
145 Universities

Consortium of Universities for Sustainable Power (CUSP) ™

Vision: Revitalizing Electric Energy Systems Education worldwide through proactive dissemination and the Internet using CUSP™

Outcomes:

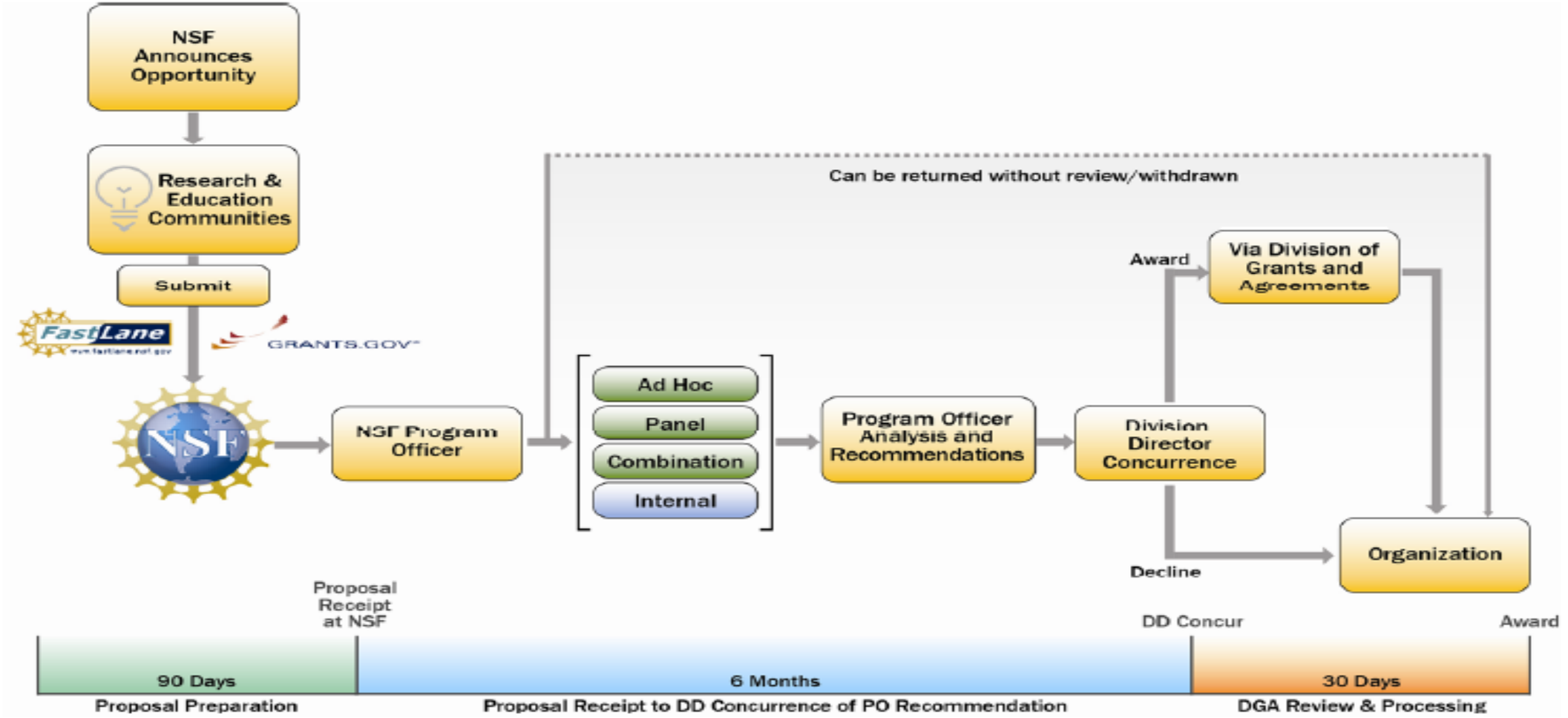
- Power & Energy Curriculum
- Undergraduate & Graduate Courses
- Workshops
- Laboratories
- Student Enrollment
- Published Textbooks



Professor Ned Mohan

University of Minnesota

NSF Proposal & Award Process

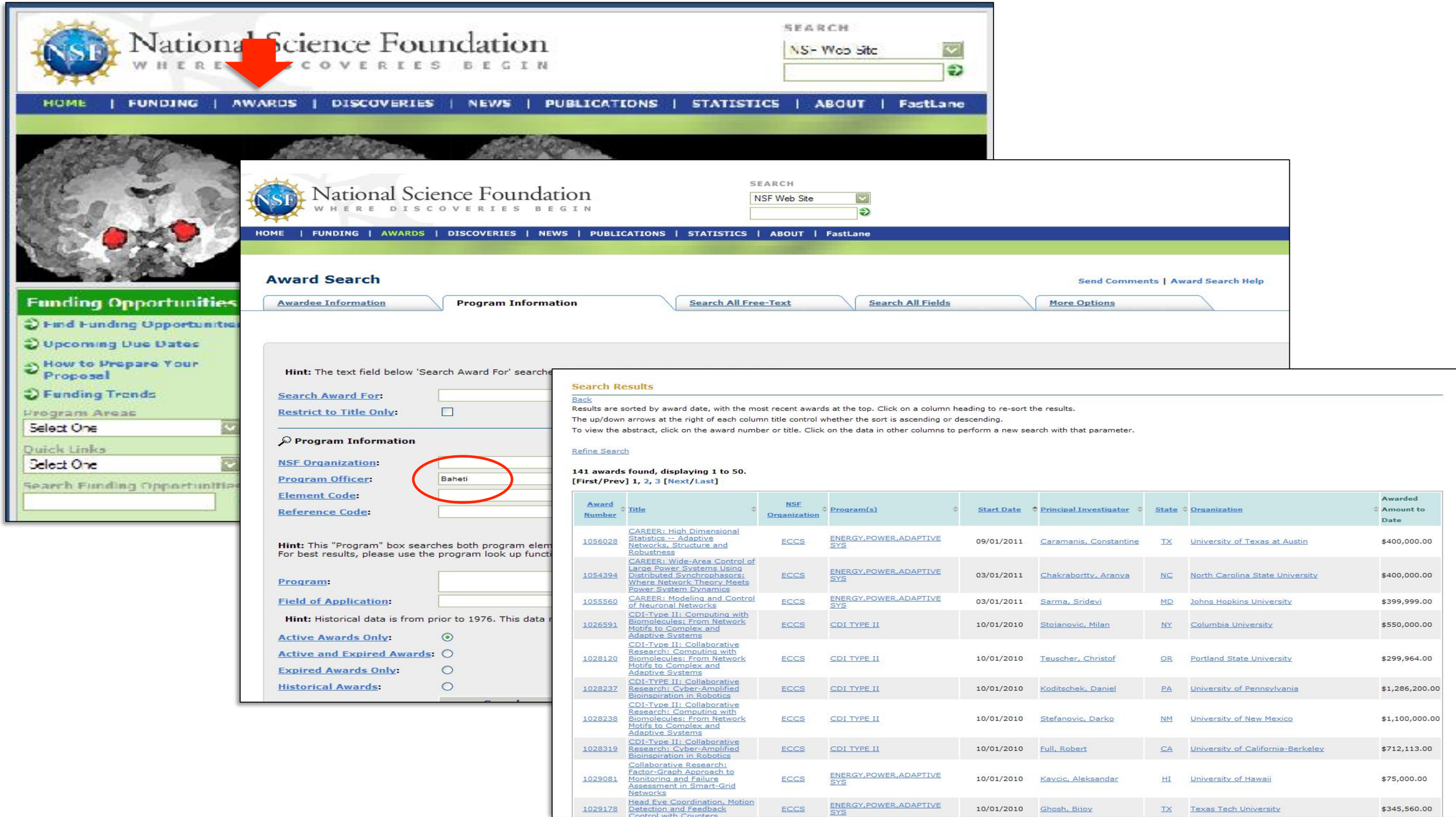


Merit Review Criteria

- **Intellectual Merit**
  - Advance knowledge and understanding within its own field or across different fields
  - Explore creative, original or potentially transformative concepts
- **Broader Impacts**
  - Benefit society or achieve specific desired societal outcomes

NSF AWARD SEARCH

- www.nsf.gov
  - Search awards
    - Advanced search
      - Program officer
- Many options available
  - Program Information
  - Keyword search, such as “Wind Energy” “Power Systems” “Power Electronics” “Energy Harvesting”…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Search All Fields
More Options
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NSF Organization:
Program Officer:
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Element Code:
Reference Code:
Hint: This "Program" box searches both program elem
For best results, please use the program look up functi
Program:
Field of Application:
Hint: Historical data is from prior to 1976. This data
Active Awards Only:
Active and Expired Awards:
Expired Awards Only:
Historical Awards:
Search Results
Back
Results are sorted by award date, with the most recent awards at the top. Click on a column heading to re-sort the results.
The up/down arrows at the right of each column title control whether the sort is ascending or descending.
To view the abstract, click on the award number or title. Click on the data in other columns to perform a new search with that parameter.
Refine Search
141 awards found, displaying 1 to 50.
[First/Prev] 1, 2, 3 [Next/Last]
Award Number
Title
NSF Organization
Program(s)
Start Date
Principal Investigator
State
Organization
Awarded Amount to Date
1056028
CAREER: High Dimensional Statistics -- Adaptive Networks, Structure and Robustness
ECCS
ENERGY,POWER,ADAPTIVE SYS
09/01/2011
Caramanis, Constantine
TX
University of Texas at Austin
$400,000.00
1054394
CAREER: Wide-Area Control of Large Power Systems Using Distributed Synchrophasors: Where Network Theory Meets Power System Dynamics
ECCS
ENERGY,POWER,ADAPTIVE SYS
03/01/2011
Chakrabortty, Aranya
NC
North Carolina State University
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MD
Johns Hopkins University
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CDI-Type II: Computing with Biomolecules: From Network Motifs to Complex and Adaptive Systems
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Stojanovic, Milan
NY
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CDI TYPE II
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University of Pennsylvania
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ECCS
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ECCS
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Full, Robert
CA
University of California-Berkeley
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Collaborative Research: Factor-Graph Approach to Monitoring and Failure Assessment in Smart-Grid Networks
ECCS
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Kavcic, Aleksandar
HI
University of Hawaii
$75,000.00
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Head Eye Coordination, Motion Detection and Feedback Control with Counters
ECCS
ENERGY,POWER,ADAPTIVE SYS
10/01/2010
Ghosh, Bijoy
TX
Texas Tech University
$345,560.00

NSF EAGER Mechanism

EAGER

- The EAGER funding mechanism can be used to support exploratory work in its early stages on untested, but potentially transformative, research ideas or approaches.
- This work could be considered especially "high risk-high payoff" in the sense that it, involves radically different approaches, applies new expertise, or engages novel disciplinary or interdisciplinary perspectives.
- Exploratory proposals may be submitted directly to an NSF program. Principal Investigators (PIs) must contact the NSF program officer(s) whose expertise is most germane to the proposal topic prior to submission of an EAGER proposal to determine the appropriateness of the work for consideration under the EAGER mechanism.
- The EAGER mechanism should not be used for projects that are appropriate for submission as “regular” (i.e., non-EAGER) NSF proposals.

EAGER

- Project Description should be brief (5-8 pages) and include clear statements as to why this project is appropriate for EAGER funding, including why it does not "fit" into existing programs and why it is a "good fit" for EAGER. Note this proposal preparation instruction deviates from the standard proposal preparation instructions contained in the Grant Proposal Guide (GPG); EAGER proposals must otherwise be compliant with the GPG.
- The box for "EAGER" must be checked on the Cover Sheet.
- Only internal merit review is required for EAGER proposals. However, if external review is to be obtained, then the PI will be so informed in the interest of maintaining the transparency of the review and recommendation process. The two standard NSB-approved merit review criteria will apply.
- Requests may be for up to $300K and of up to two years duration. The award size, however, will be consistent with the project scope and of a size comparable to grants in similar areas.

Watch for EAGER DCL's (Dear Colleague Letters)

For example there is one 15-082 with a June 19, 2015 due date on "Research on Theory and Analytical Tools for Power Networks with High Levels of Renewable Generation"
http://www.nsf.gov/pubs/2015/nsf15082/nsf15082.jsp

When a DCL is issued requesting EAGER proposals in a specific area, many proposals are expected, and therefore panel review may be used instead of internal review.

Cyber-Physical Systems

- Next generation of engineering systems in which computing, communications, and control technologies are tightly integrated
  - Enabler for “Internet of Things”

Cyber-Physical Systems

- Networked and controlled at multi- and extreme scales
- Dynamically reorganizing / reconfiguring
- High degrees of automation and potential human role
- Dependable operation with high assurance of reliability, safety, security and usability

Transportation

- Faster and safer aircraft
- Improved use of airspace
- Safer, more efficient cars

Energy and Industrial Automation

- Homes and offices that are more energy efficient and cheaper to operate
- Distributed micro-generation for the grid

Healthcare and Biomedical

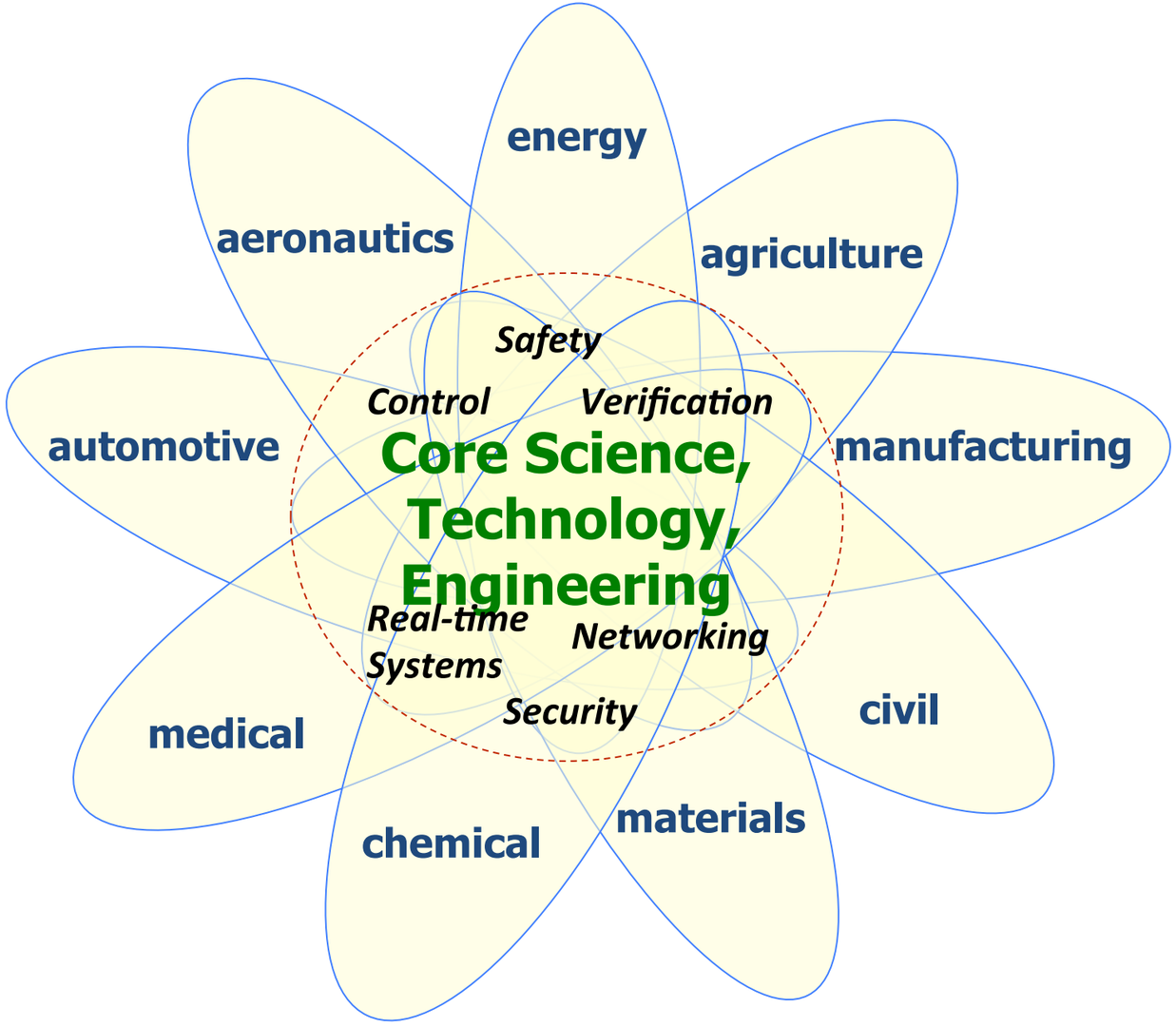
- Increased use of effective in-home care
- More capable devices for diagnosis
- New internal and external prosthetics

Critical Infrastructure

- More reliable power grid
- Highways that allow denser traffic with increased safety

CPS Approach

- Abstract from application sectors to more foundational principles
- Apply these principles to problems in new sectors
- Safe, secure, reliable, verification, real-time adaptation, …



Present - Some CPS Program Info

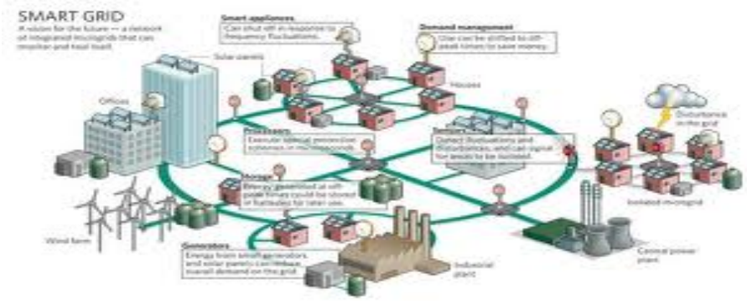
- Cross-cutting initiative including Directorate for Computer and Information Science and Engineering (CISE) and Directorate for Engineering (ENG)
- Since CPS Launch in 2009:
  - Well over $200M investment
  - More than 300 awards
  - 350+ PIs and Co-PIs in 35 states
  - Over $35M investment in FY13, over $40M in FY14
  - Mission Agency Partners since 2014 solicitation

Federal Government-Wide Effort

- Cyber-Physical Systems Working Group
  - under NITRD (The Networking and Information Technology Research and Development Program)
- Co-chaired by NIST and NSF and includes DOD, NIH, NTIA, DOT, FDA, …
- At NSF: CISE and ENG Directorates
  - ECCS Division plays a key role in CPS in ENG

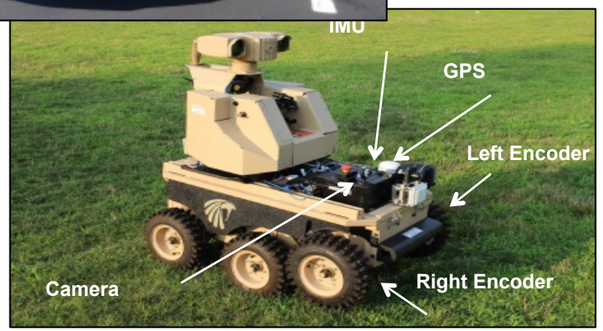
Open/Remote Access Test-beds

A new opportunity for the research community



Approach: Distributed laboratory space with open/remote access

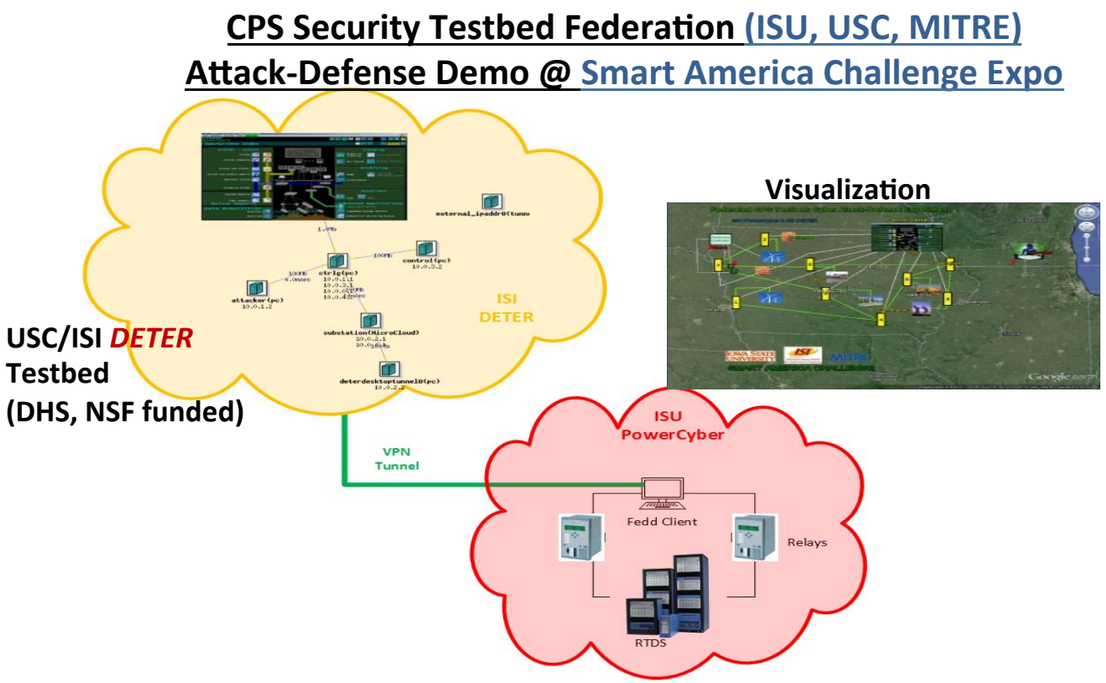
- Develop and use remote-access, online, shared engineering laboratory spaces
- Potential laboratories: robotics, power systems, drones, medical systems, etc.
- Shared cost and leveraging expertise



Images: Vehicle: I. Lee, KOCSEA Workshop 2014; Microgrid: https://der.lbl.gov/

Benefits: Improving research through better access to resources

- Significantly lower cost for access to expensive hardware/software
- Advance the participation of non-traditional and under-privileged students
- Encourage industry participation



Thank you

Questions?