Welcome Address to CPS Community

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National Science Foundation

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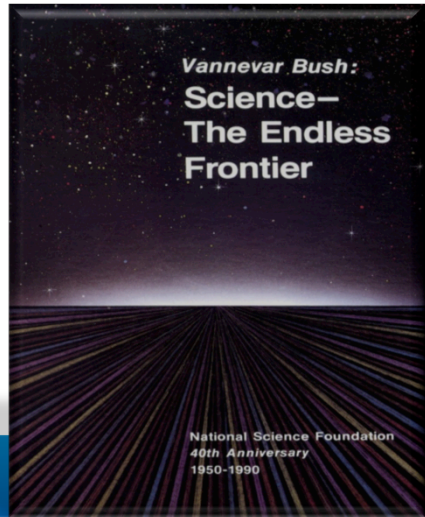
Opening Remarks

- Growing and thriving CPS community
- Remarkable accomplishment in creating an interdisciplinary community of researchers, practitioners with growing interest from policy makers
- Broad participation from academia and growing interest from industry and public sector
- Formation of CPSWeek and impact on standing professional conferences; CPS faculty positions
- Increased emphasis on integration of research and education, curriculum development and on human capital
- Impressive international momentum (US, European Community, S. Korea, Taiwan, Japan, …)
- Potential for highly engaged virtual communities

The Promise

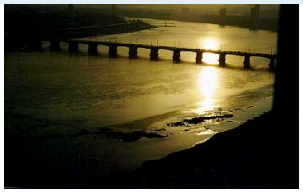
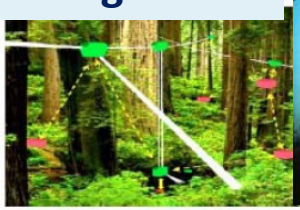
Advances in cyber physical system hold the potential to reshape our world with more responsive, precise, reliable and efficient systems that:

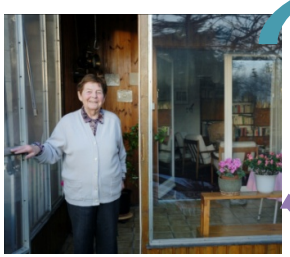
- augment human capabilities
- work in dangerous or inaccessible environments
- contribute to a sustainable future
- provide large-scale, distributed coordination
- enhance societal well-being



The Age of Observation: Smart Sensing, Reasoning and Decision

Environment Sensing



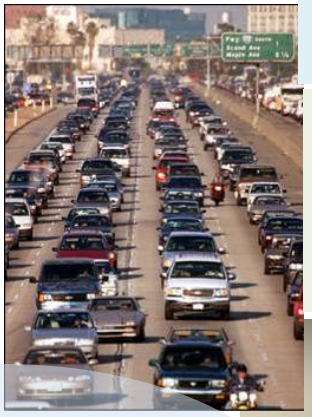

Percepts (sensors)

Agent (Reasoning)

Actions (controllers)

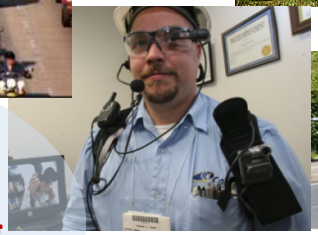
Pervasive Computing

Emergency Response



Credit: Photo by US Geological Survey

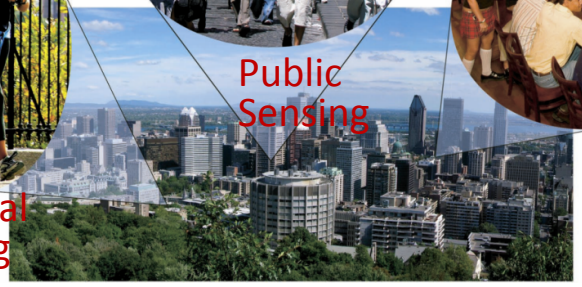
Situation Awareness: Humans as sensors feed multi-modal data streams


People-Centric Sensing

Social



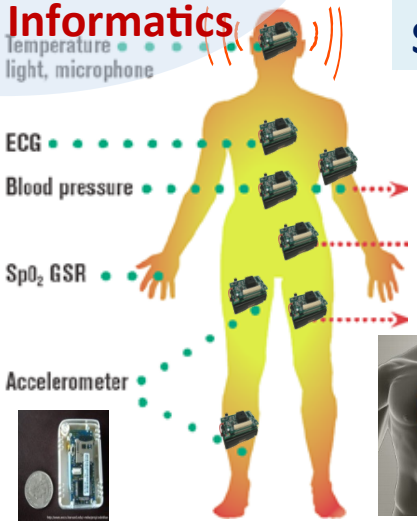



Public Sensing

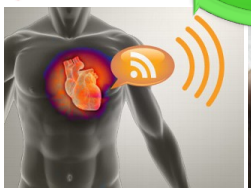
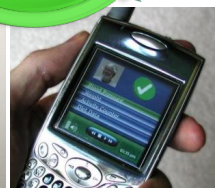
Social Sensing

Personal Sensing

Informatics



Smart Health Care

Source: Sajal Das, Keith Marzullo

Credit: Image courtesy of University of Florida

Infrastructure and Sustainability

Envision a day when…

- Static infrastructures such as buildings and factories are transformed into smart spaces that adapt to consumption, growth, and changing environmental needs through the use of networked instrumentation and software control.

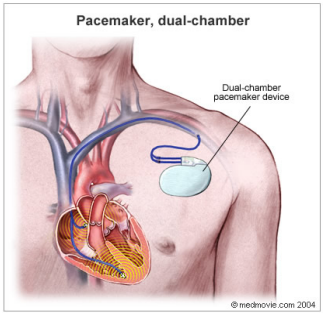
Kindly donated by Stewart Johnston

Credit: MO Dept. of Transportation

Smart Health

Envision a day when…

- We can improve quality of life through personalized healthcare and assistive technologies, enabled in part by robust, usable, and trustworthy wearable mobile devices integrated with instrumented environments.
- We can create a healthcare system that helps people prevent and manage chronic and acute diseases in their own every day context; robots extend independent living for seniors; and devices worn or embedded in the home can report adverse health events.



(courtesy of the Center for Integration of Medicine and Innovative Technology (CIMIT))

Emergency Response

Envision a day when…

- During the time of a natural disaster or a national emergency, ***unmanned*** search, rescue, and recovery is a reality through the use of autonomous, highly coordinated, and remotely operated robots in shared physical spaces – the promise of distributed, low-power sensing combined with communications and control.

Credit: Edwin Olsen, University of Michigan

Towards a Sustainable Human Future

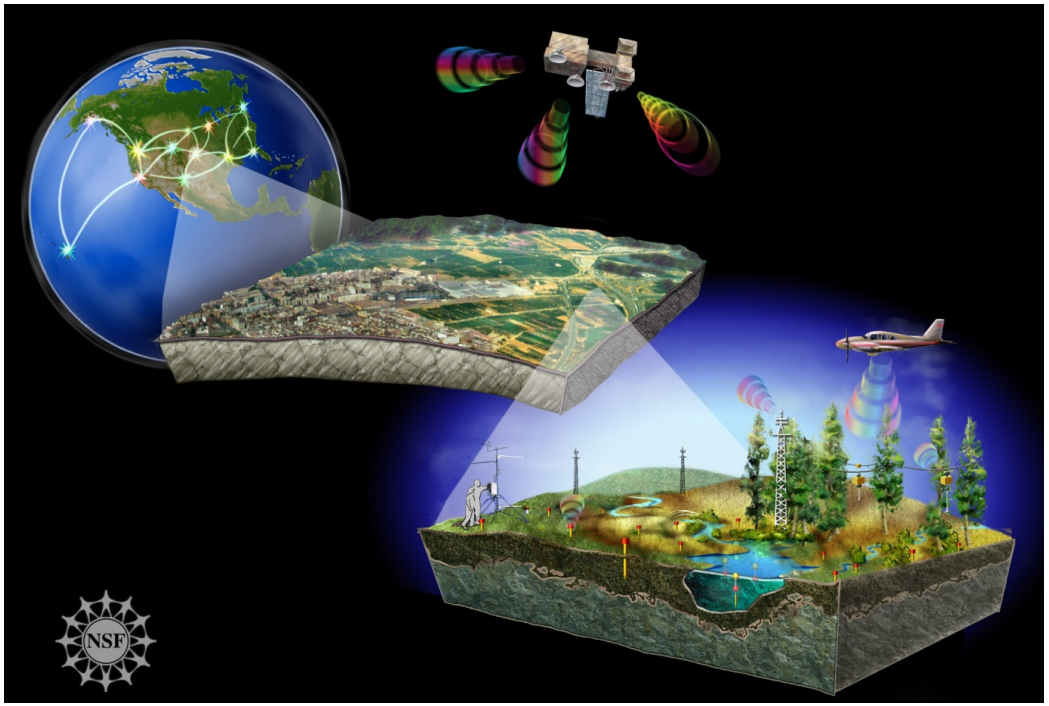
Of all the challenges we face as a nation and as a planet, none is as pressing as the three-pronged challenge of ***climate change, sustainable development*** *and the need to foster* ***new and cleaner sources of energy.***

(Office of Science and Technology Policy, Executive Office of the President)

Environment and Sustainability

Envision a day when…

- By developing rich ecological and environmental monitoring systems, we can create accurate models that support forecasting and management of increasingly stressed watersheds and ecosystems.

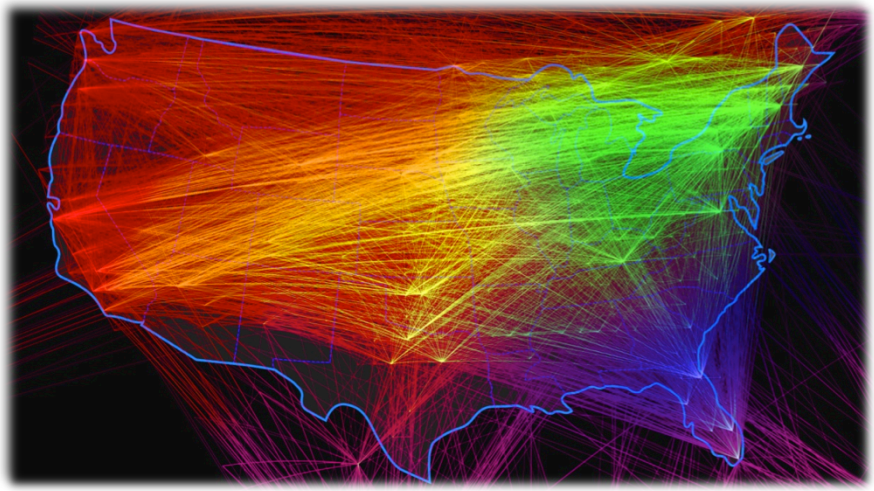


Credit: Nicolle Rager Fuller, National Science Foundation

Smart Grids

Envision a day when…

- Future power grids will be increasingly heterogeneous in energy sources and their locations, and will be efficiently managed through the deployment of intelligent sensor networks and distributed control and decision capabilities – improved quality of transmission, better resource utilization, reduced congestion, and real-time response and real-time pricing.



Credit: Map by Zina Deretsky, National Science Foundation, adapted from maps by Chris Harrison, Human-Computer Interaction Institute at Carnegie Mellon University (http://www.chrisharrison.net).

Transportation: Safety and Energy

Envision a day when…

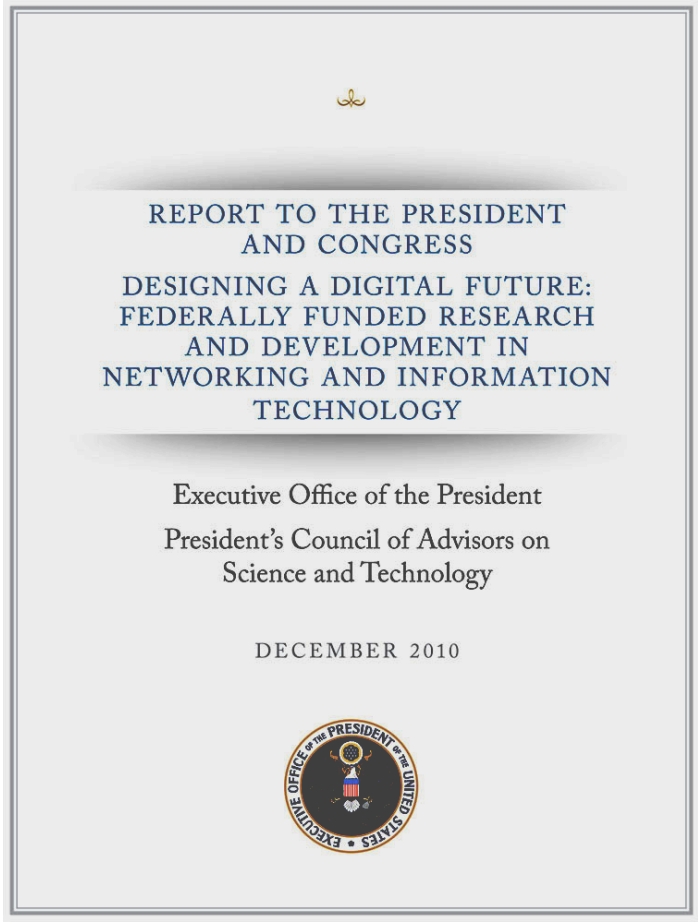
- Your car will be able to drive you safely and securely to your destination, where traffic fatalities are uncommon rather than daily events.
- Your home and car both consume energy from – and provide energy to – the electricity grid, and where advanced controls can provide substantial energy savings that can decouple the economic benefits of transportation from regional and global environmental impacts.

Credit: PaulStamatiou.com

A National Imperative

"Recent technological and societal trends place the further advancement and application of NIT squarely at the center of our Nation's ability to achieve essentially all of our priorities and to address essentially all of our challenges."[1] Advances in our discipline:

- are a key driver of economic competitiveness
- are crucial to achieving our major national and global priorities in energy and transportation, education and life-long learning, healthcare, and national and homeland security
- accelerate the pace of discovery in nearly all other science and engineering fields
- are essential to achieving the goals of open government



[1] "Designing a Digital Future" PCAST Report – a periodic congressionally-mandated review of the Federal Networking and Information Technology Research and Development (NITRD) Program.

National Priorities

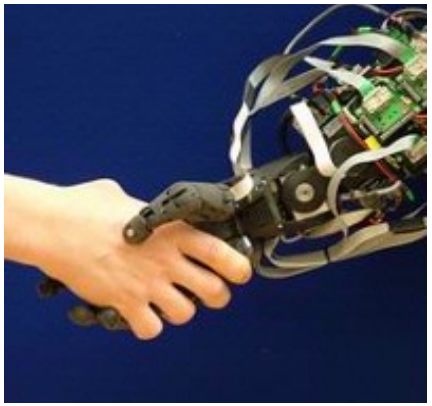
- Smart Systems & Robotics
- Environment and Sustainability
- Advanced Manufacturing
- Smart Health & Well Being
- Cyber Secure Society
- Education and Workforce Development

Credit: Nicolle Rager Fuller, National Science Foundation

National Robotics Initiative (NRI)

A concerted cross-agency program to provide U.S. leadership in science and engineering research and education aimed at the development of next generation robotics.

Conceived as robots that work beside, or cooperatively, with people in areas such as manufacturing, space and undersea exploration, healthcare and rehabilitation, emergency response, military and homeland security, education and training.



Credit: Photo Permission by Bristol Robotics Lab

Credit: 2011 Honda Motor Co., Ltd.

Credit: Edwin Olsen, University of Michigan

The National Robotics Initiative

- Definitive report on challenges and opportunities: *"A Roadmap for US Robotics- From Internet to Robotics," May 21, 2009*. http://www.us-robotics.us/reports/CCC Report.pdf

- A nationally coordinated robotics technology R&D program across multiple government agencies
  - Multi-agency commitment: initially NSF, NASA, NIH, USDA
  - $40M-$50M/year

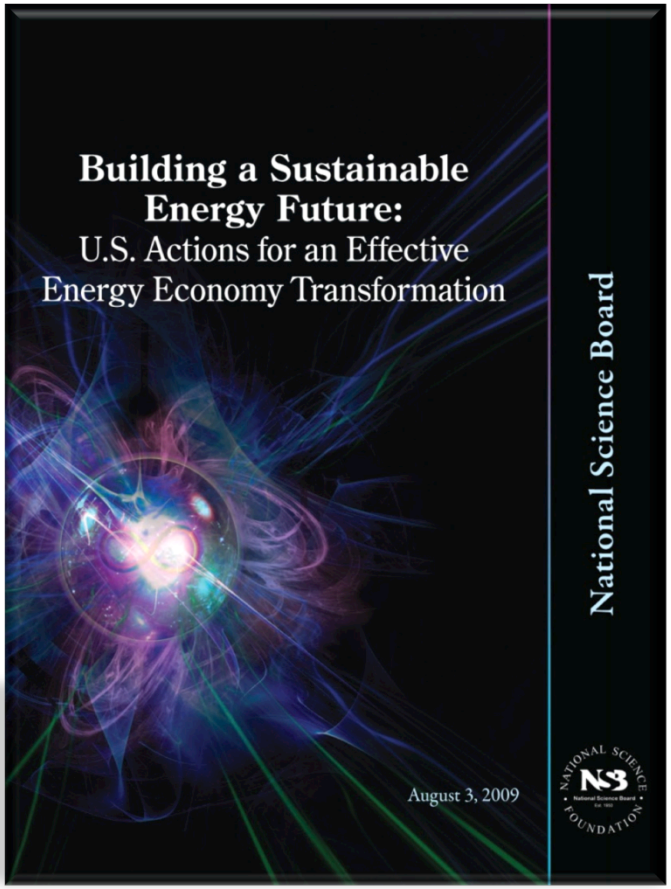
- Strong coupling with industry and startups, through SBIRs
- Emphasizes common platforms & standard interfaces
- Will sponsor national competitions, outreach & education

NSF Program on Science, Engineering, and Education for Sustainability (SEES)

Achieving a sustainable human future in the face of both gradual and abrupt environmental change is one of the most significant challenges facing humanity.

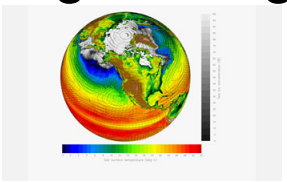
Generating discoveries and building capacity to achieve an environmentally and economically sustainable future.

Established FY10; Planned to continue thru FY15; Involves all NSF research and education directorates and offices.

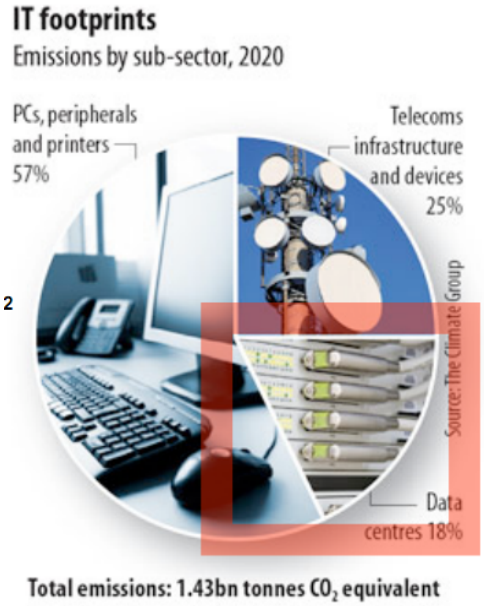


SEES

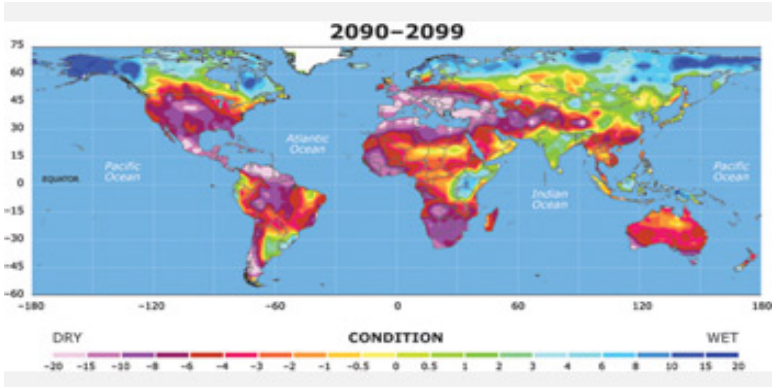
Interdisciplinary research in the areas of environmental & energy science and engineering



Credit: Gary Strand, NCAR



Credit: Climate Group and Molly Webb



Disciplinary research to develop the foundation of energy-efficient, energy-aware, and sustainable computing and communication

Credit: (c)UNEP

Charge to the CPS Community

- A **research pipeline** (portfolio) comprising of long-term foundational research, experimental prototyping and early deployment, and translation to spur innovative applications.

- Focus on **core science and engineering principles** for CPS
  - Break down area boundaries: computing, wired and wireless networking/ communication, sensing, control, formal methods, security
  - Pay special attention to foundational problems that bridge applications
  - Propose ideas for innovative technology substrates and run-time systems

- Foundations, models, and tools that enable:
  - Understanding cross-cutting interfaces between computing systems, control systems, sensor and communication networks
  - Synthesis and deep integration of **computation, communication, and control** into **physical** systems
  - Formal specification, verification and certification of systems

Charge to the CPS Community

- The need for networked systems that not only scale up, but also **scale down and scale out** (2010 PCAST Report):
  - Miniaturized, low-power, adaptive and self-calibrating instrumentation
  - Embedding sensors everywhere and connecting everything via networks leading to wide-scale sensors and control

- We swim in **a sea of sensors** and **drowning in data**:
  - Our smart phones, cars, increasingly instrumented homes and offices, health monitors, environmental monitors, …
  - Ability to analyze data in "real-time and retrospectively," create context for decisions, and offer meaningful actionable feedback
  - Data fusion and inference techniques over diverse potentially noisy data combined with contextual and location-aware data

- Take advantage of the **CPS Virtual Organization**
  - Role of CPS Virtual Organization? sector-based? cross-pollination?
  - Special Interest Groups and Open Source groups

Final Remarks

- Many of tomorrow's breakthroughs will occur at **the intersections of diverse disciplines.**
  - Long-term investments in multi-disciplinary interactions and collaborations
  - Increasingly important role for Industry partnerships

- The CPS community continues to have a transformative and durable impact on research and education

- Our commitment to foster this emerging, consolidating research community and to reinforce your sustained role in advancing frontiers of science and engineering innovation

- Beyond NSF
  - Engagement from mission agencies
  - Growing participation from the private sector
  - Coordination with other countries

Thanks!

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