National Science Foundation
Vermont EPSCOR Annual State Meeting
August 2012

Breakout Sessions on CISE and Innovation Funding

Dr. Anita J. La Salle
Program Director
Directorate for Computer and Information Science and Engineering

NSF Support for Innovation and
CISE Support of Computing:

- NSF's I-Corps Program
- NSF Innovation-centric Programs and Outcomes
- CISE's Support for Computing

NSF

I-CORPS

NSF Innovation Corps

- Background
- Program Details
  - Eligibility
  - Before Submitting a Proposal
  - Project Proposal
  - Budget
  - Curriculum
  - Demo
- Expectations
- Frequent Questions

I-Corps Program – Some Background

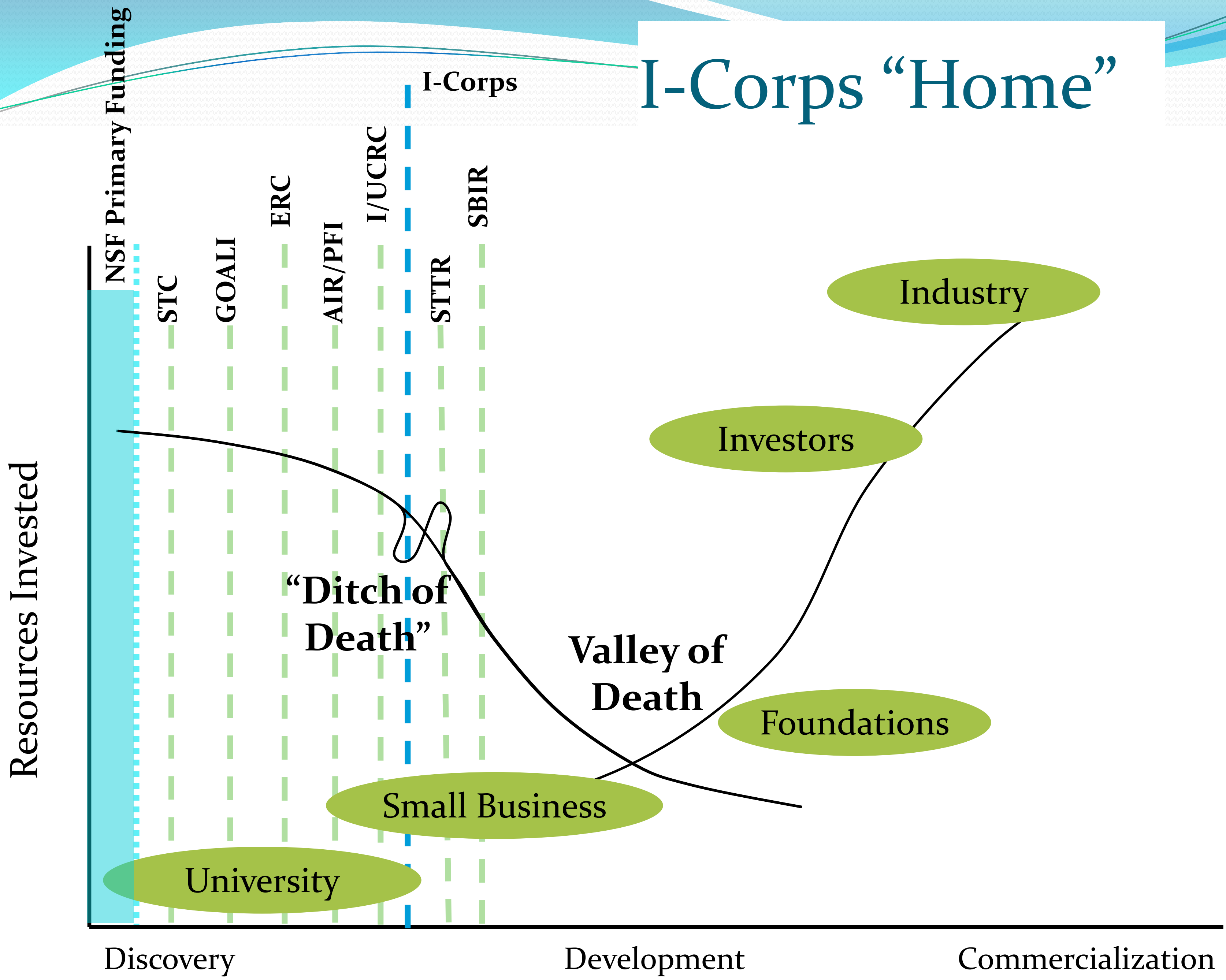
- Leverages NSF investments in research -- lineage of previous support
- Small grants to focus on creating a commercialization roadmap
  - Addresses the "Ditch of Death"
- Nimble funding -- Immediate assessment
- Projects are team-based -- commercialization is team effort
- Process-oriented -- Curriculum-focused

NSF | I-CORPS NSF Innovation Corps

I-Corps Program – Some Background

- NSF-Wide, Public-Private partnership to
  - support the development of technologies, products and processes
- Purpose: to provide access to resources to help determine the readiness to transition technology previously supported by NSF
- Creates a national network
  - Scientists, engineers, innovators, business leaders and entrepreneurs

I-Corps "Home"



Resources Invested
NSF Primary Funding
STC
GOALI
ERC
AIR/PFI
I/UCRC
I-Corps
STTR
SBIR
"Ditch of Death"
Valley of Death
Industry
Investors
Foundations
Small Business
University
Discovery
Development
Commercialization

I-Corps Program Details (Eligibility)

- PI: NSF award
  (current or expired no more than 5 years ago)
- Must have I-Corps team in place at initial contact
- Must be available for off-site Workshops and on-site Curriculum (entire team)
- Serious time commitment
  - Consistent with start-up mentality

NSF | CORPS NSF Innovation Corps

Credit: © 2011 JupiterImages Corp.

I-Corps Program Details:
First – Form your I-Corps Team

- Entrepreneurial Lead
  - Post-doc or Student to move project forward
- I-Corps Mentor
  - Domain-relevant volunteer guide
  - Proximity is better
- PI
  - Researcher with current or previous award

Credit: © 2011 JupiterImages Corp.

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I-Corps Program Details:
Second, prepare an Executive Summary

- Relate critical information in your Executive Summary (**1 page**)
  - Composition of the team proposing to undertake the commercialization feasibility research
  - Relevant current/previous NSF awards
  - Brief description of the potential commercial impact
  - Brief description of the *current* commercialization plan

I-Corps Program Details:
Third, Contact NSF

- Who within NSF can act as your advocate? Start with your advocate or Topic-specific PD or combination and send them your Executive Summary

Topic-Specific Program Directors

Steve Ellis – BIO
Anita La Salle – CISE
Don Millard – EHR
Babu DasGupta – ENG
Raffaella Montelli – GEO
Mary Galvin-Donoghue – MPS
Irene Qualters – OCI
David Croson – SBE

I-Corps Cognizant Program Officers

Errol Arkilic
Babu DasGupta
Anita La Salle

I-Corps Program Details: What will happen next?

- One of NSF's I-Corp Management Team members will contact you to set up a telephone conference call that includes your entire team and NSF-ers responsible for I-Corps. If this interview part of the process goes well, …
- Another conference call will be set up with your team, the NSF-ers, and a group of Instructors from the I-Corps Program. If this part goes well, you will be asked to submit a proposal.

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I-Corps Program Details
Your Project Proposal

- Read solicitation 11-560 – (but don't submit before completing the initial processes)
- Written authorization from Cognizant PD required to submit proposal – sent after phone interviews
- 5-page proposal
  - Team (2 pages)
  - NSF Lineage (1 Page)
  - Potential Commercial Impact (1 page)
  - Project Plan/Demo (1 page)
- Rolling process, Quarterly batches, FCFS
- 4-week turnaround to award, Internal Review

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Program Details (Budget)

- $50 K per award
  - Capped at 10% IDC ($5K)
  - $45K in direct costs (includes travel for three team members to two immersion sessions plus registration fee)
- 21 awards in Fall 2011, 24 in March 2012, 55 in July 2012.
- Approximately 250 awards in FY13

I-Corps Curriculum

- Based on hypothesis-driven business-model discovery
  - pioneered by Stanford and Steve Blank (see the E-245 blog for a preview)
- Focuses on addressing market risk
- Requires getting out of the lab
  - **AT LEAST 15 hours of prep per week**

- **Mandatory** for all I-Corps participants
  - Attend 3-day course

    (for Fall 2012 Cohort #1, dates are: **October 1-3, GA Tech**)

    (for Fall 2012 Cohort #2, dates are: **October 9-11, Univ. Mich**)

  - Participate in 5 follow-on webinars with team presentations/interactions

    (for Fall 2012 Cohort #1, Web dates are: **Tuesdays from noon until 3 p.m. Eastern, October 9, 16, 23, 30, and November 6**)

    (for Fall 2012 Cohort #2, Web dates are: **Mondays from 1 p.m. until 4 p.m. Eastern, October 15, 22, 29, November 5 and 12**)

  - Attend 2 days of demos/lessons learned

    (for Fall 2012 Cohort #1, dates are: **November 12-13**)

    (for Fall 2012 Cohort #2, dates are: **November 29-30**)

After I-Corps Curriculum comes the I-Corps Project Plan/Demo

- Must be within striking distance to product or process demonstration
  - remember it is $50 K and 3-6 months
- Demo description is up to your team
  - Proof of concept
  - Mockup
  - Working prototype

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I-Corps -- Expected Results

- Funded Project Deliverables
  - Technology demonstration
  - Technology disposition: Go/No Go
  - Commercialization Roadmap: Assuming Go
- Program Outcomes
  - Functioning network of Mentors/Advisors
  - Scientist and Engineers trained as Entrepreneurs (who pass on their knowledge to students)
  - Increased impact of NSF-funded basic research

I-Corps – Some Common Questions

- What can be included in direct costs?
  - ~$10K in travel and registration for two trips to course-site for entire team (depending on proximity)
  - Stipend for Entrepreneurial Lead
  - Travel costs to customers/partners/stakeholders
  - Machining, materials, software, licenses, etc for prototype or proof-of-concept, as appropriate
- Unallowable:
  - Stipend/consulting fees for I-Corps Mentor
  - Legal Fees (Startup, IP protection)

I-Corps – Some Common Questions

- Who makes a good mentor?
  - Someone with the right "rolodex" – contacts in your area of commercialization are critical for "getting out of the lab"
  - Someone who has entrepreneurial experience
  - Someone who has business expertise in your sector
  - Contact your Tech Transfer Office for ideas

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More Information

- I-Corps website:

  www.nsf.gov/i-corps

- Monthly webinars – first Tuesday of the month.
- View a video containing feedback from I-Corps veteran participants at:

  http://www.nsf.gov/news/special_reports/i-corps/program.jsp

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I-Corps Questions?

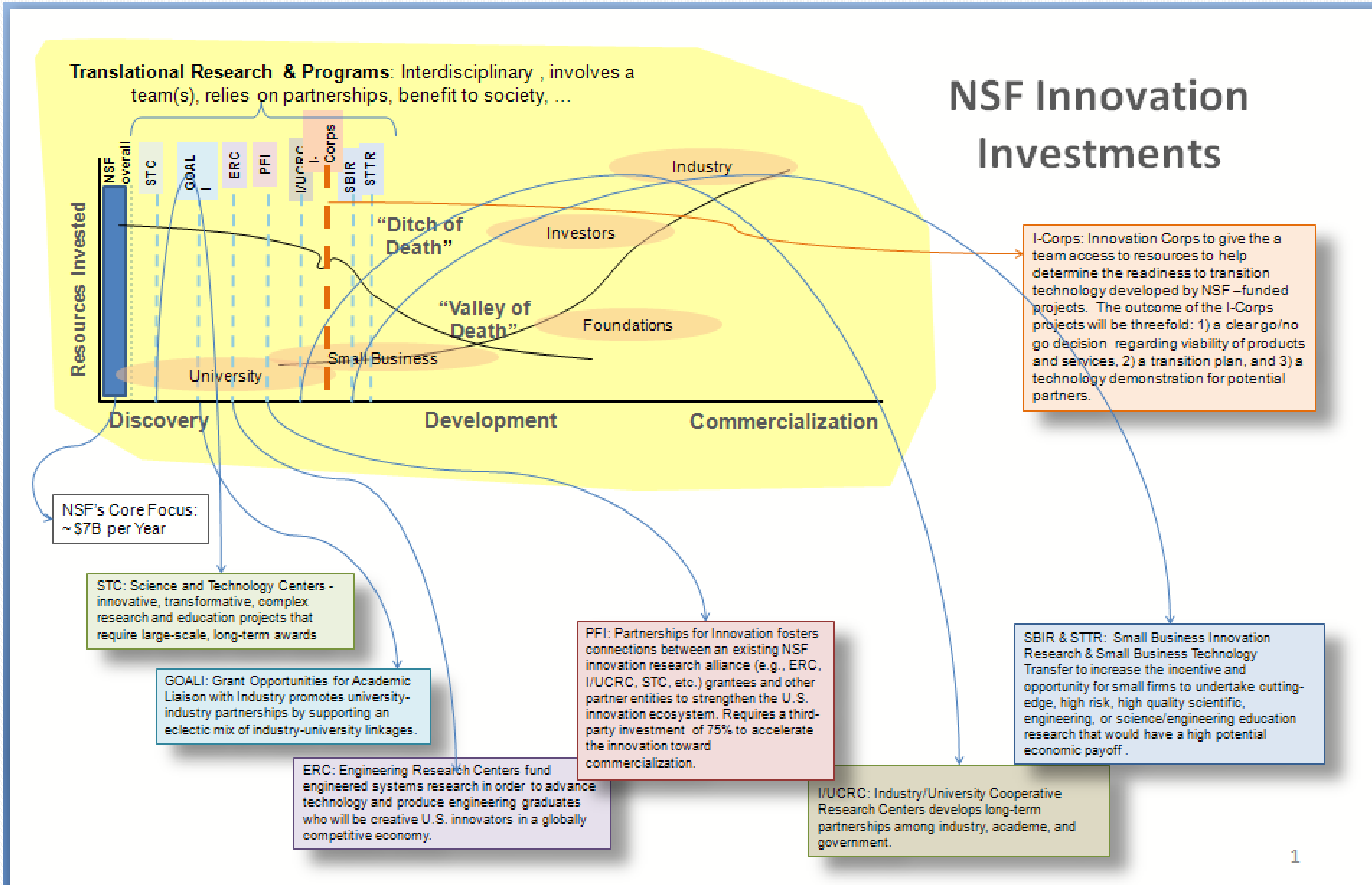
NSF

CORPS
NSF Innovation Corps

NSF Innovation-centric Programs and Outcomes:

Accelerating
Discovery to Innovation

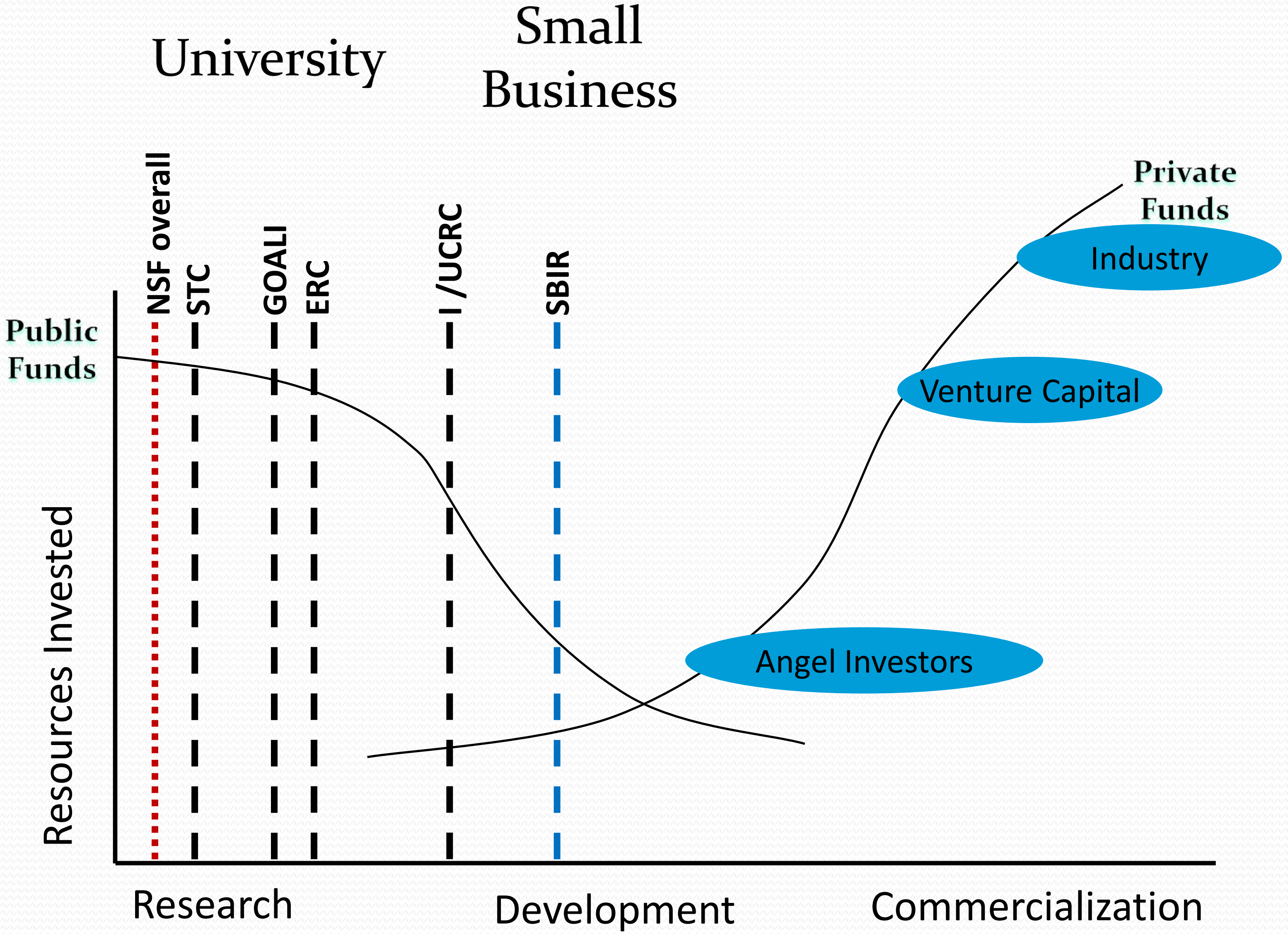
A few words about Innovation funding



NSF Programs for Translational Research

- Science and Technology Centers (STC)
- Engineering Research Centers (ERC)
- Grant Opportunities for Academic Liaison with Industry (GOALI)
- Industry/University Cooperative Research Centers (I/UCRC)
- Partnerships for Innovation (PFI)
- Small Business Technology Transfer (STTR)
- Small Business Innovation Research (SBIR)

NSF Innovation Investments



Some outcomes …
Disclaimer (of sorts)

- NSF doesn’t claim SOLE responsibility for these successes, but
- NSF played a clear and definable role in the intellectual evolution of all these innovations.

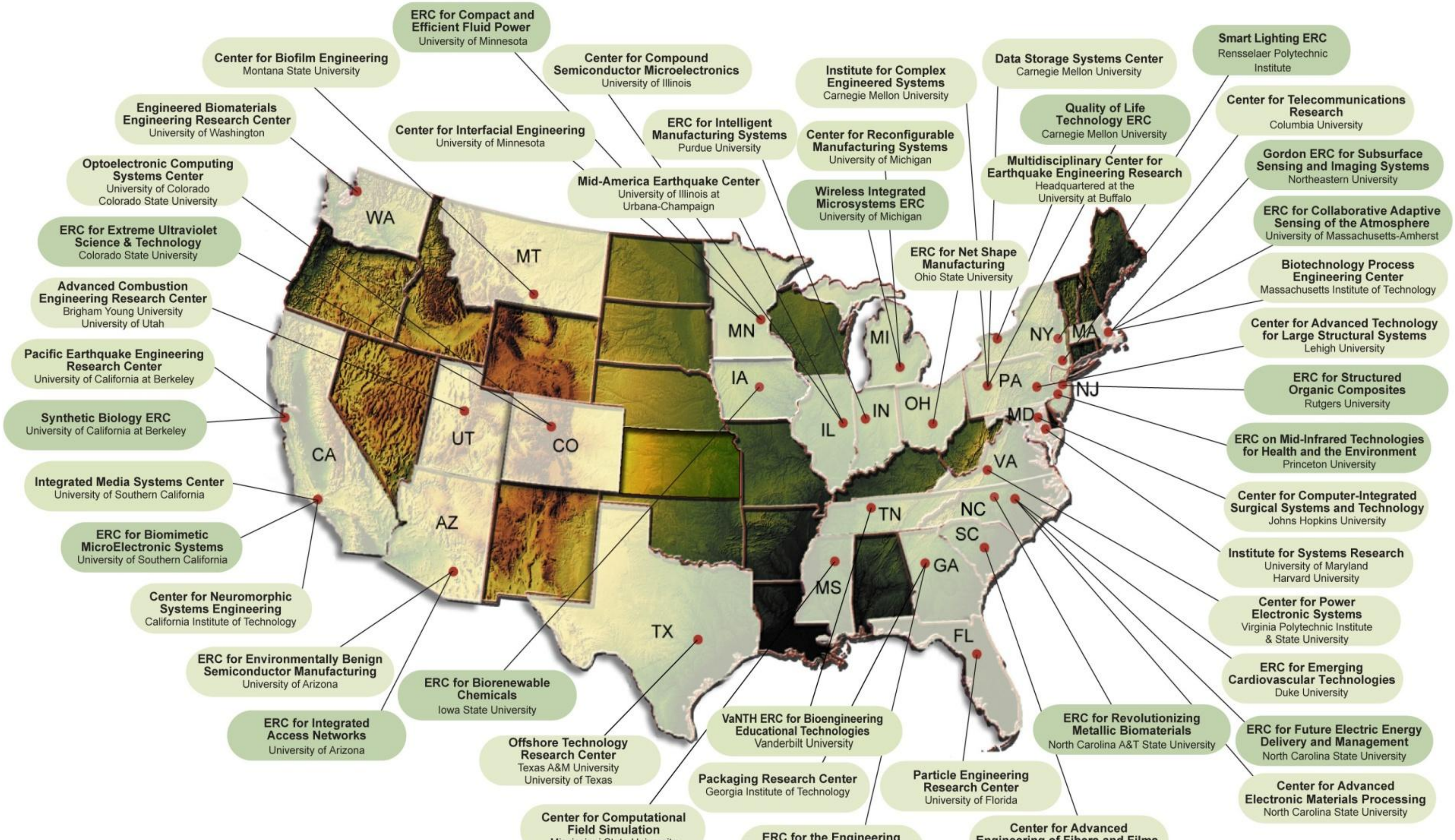
STC: Magnetic Resonance Imaging

- STC for Magnetic Resonance Technology for Basic Biological Research at UIUC established in 1991
- PI Paul Lauterbur discovered the possibility of creating a two-dimensional image by producing variations in a magnetic field

Lauterbur was awarded a **Nobel Prize** in 2003 for discoveries leading to magnetic resonance imaging.

Engineering Research Centers 1985-2009

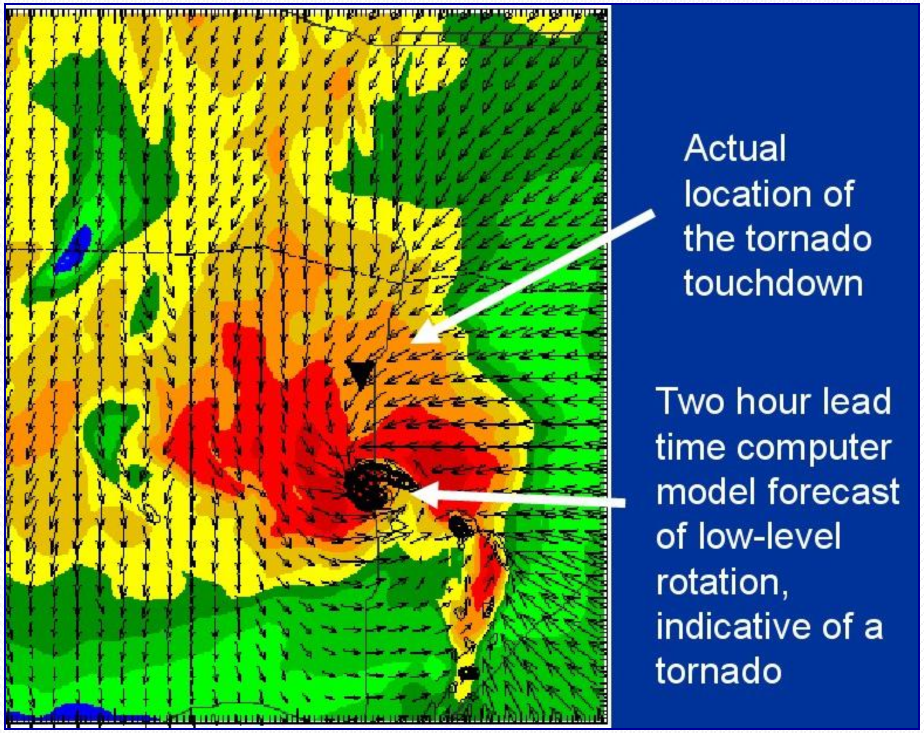
NSF Engineering Research Centers



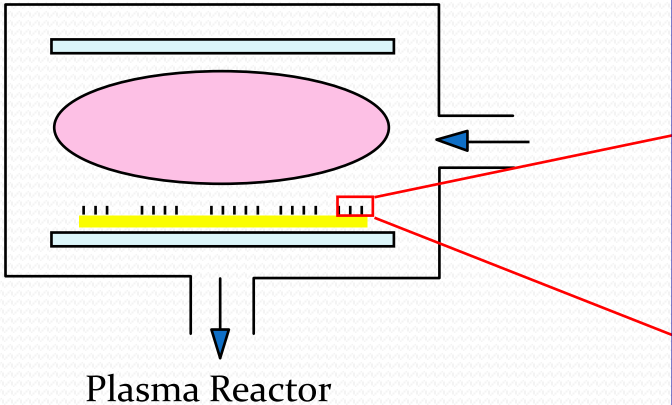
Notes: (1) Darker labels denote current ERCs. Lighter labels denote graduated centers.
(2) Most centers are multi-university partnerships. University shown is lead institution.

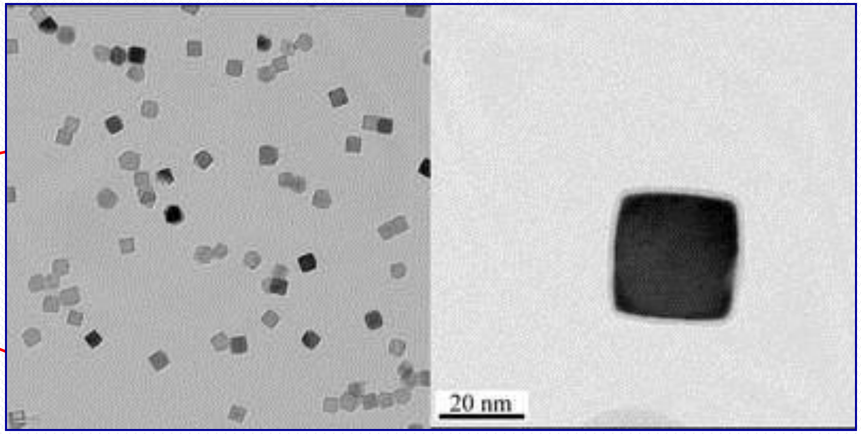
ERC: Radar Network Detects Low-Altitude Weather Phenomena

- ERC for Collaborative Adaptive Sensing of the Atmosphere, Univ. of Massachusetts, Amherst
- Improves on Doppler radar and NEXRAD



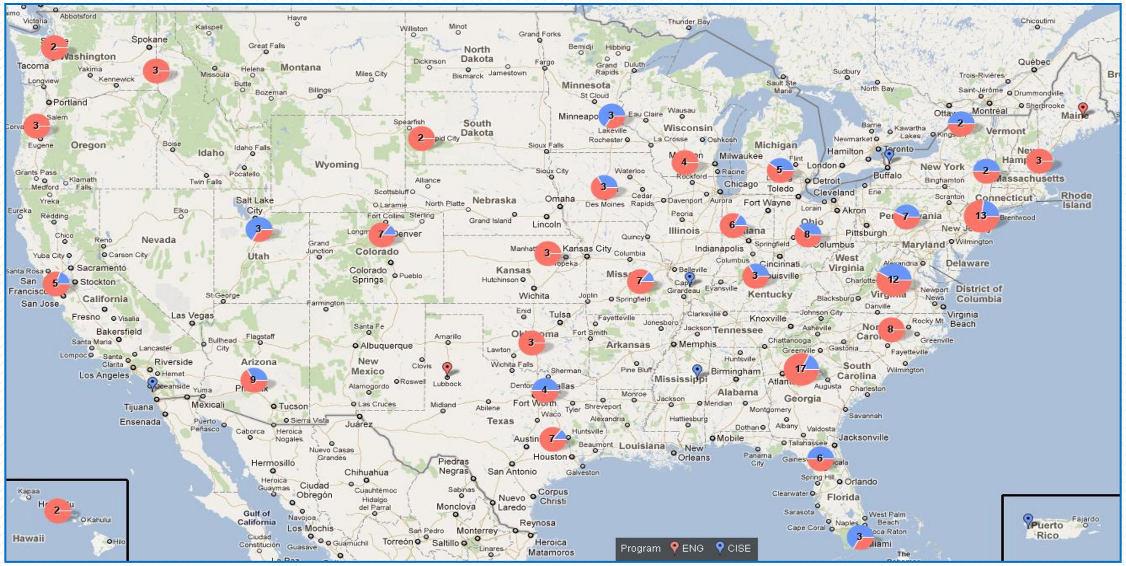
GOALI: Nanocrystal Formation and Morphology in Nonthermal Plasmas





- Uwe Kortshagen (Unvi. of Minnesota-Twin Cities) and Michael Zachariah (Univ. of Maryland College Park) have demonstrated the ability of plasmas to produce crystalline nanoparticles with specific geometries and beneficial properties.
- InnovaLight, Inc., licensed the approach to synthesize silicon nanocrystals for the use in low-cost, efficient solar cells based on silicon nanoparticle films.

I/UCRC Fast Facts – FY11 Snapshot



ENG – Engineering

CISE – Computer and Info. Sci and Eng.

Program Funding

- $15M in Program Funding (ENG, CISE)
- $118M in Total Center Funding,
- Nearly 8:1 Leveraging of NSF funds, over 13:1 leveraging of ENG Program Funds

Centers Nationally:

- 60 Centers with 175 Sites
- Over 500 distinct organizations holding over 1000 Memberships
- 55% Large Business, 23% SB, 15% Federal Members

Students

- 225 PhDs, 249 MS & 128 UGs graduated in 2010, trained in Center research
- Over 30% hired by members

Sustainability

- 44 Graduated I/UCRCs remain in operation in 2010 true to model

I/UCRC: Engineering Logistics and Distribution (CELDi)

Sam's Club

- Collaboration between Univ. of Arkansas and Sam's Club
- Created an Excel-based simulator to replicate the functionality of the Sam's Club inventory and logistics software
- Resulted in more than 4% reduction in inventory costs in categories where applied

Sam's Club: When complete, cost savings from inventory reductions could be very significant.

CELDi Provides Return on Investment

Odessa Medical Center Hospital and Texas Tech

Reducing the ER Backlog by Improving the Patient Discharge Process

mch
Medical Center Health System
Your One Source for Health

"We've seen a triple bottom line impact: Cost savings of over $250,000 per year, lower ER backlog, and increased customer satisfaction."

Alan Synder, Director of Industrial Engineering, MCH

SBIR: Support of Symantec

- In 1981, Gary Hendrix founds Symantec
- In 1982, NSF SBIR awards $30,000 for developing a framework for managing dissimilar data
- In 1984, Symantec was acquired by C&E Software
- Now, a leading anti-virus and PC-utilities software company valued at $12B

symantec. Confidence in a connected world.

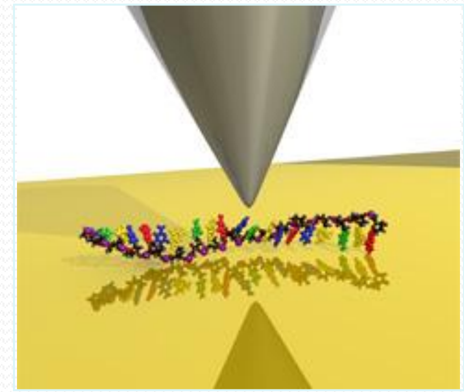
SBIR: Support of Qualcomm

- In 1985, Andrew Viterbi and 6 colleagues formed "QUALity COMMunications"
- In 1987–1988 SBIR provided $265,000 for single chip implementation of Viterbi decoder
  - Led to high-speed data transmission via wireless and satellite
- Now the $78B company holds more than 10,100 U.S. patents, licensed to more than 165 companies

Other SBIR Success Stories

Integrated electric and magnetic field sensor for subsurface mapping in field use. *Credit: QUASAR Federal Systems, Inc.*

Dr. Henry Liu invented the 100 percent fly ash brick. *Credit: Freight Pipeline Co.*



NNIN atomic force microscope for nanoscale characterization and fabrication. *Credit: John Lund and Babak Parviz, Univ. of Washington*

A flexible film photo display optically addressed with a high resolution image. *Credit: Kent Displays Inc. and Kent State Univ.*

Filling Gaps in the Innovation Ecosystem

•Spur Translation of Fundamental Research

•Encourage Collaboration between Academia and Industry

•Educate to Innovate

Pilot Programs

- **Translation Research in the Academic Community (TRAC)**
  - Resources for existing NSF grantee researchers aimed at translating fundamental research into commercial applications

- **Industry Inspired Fundamental Research (IFR)**
  - Small groups of industry identify innovation opportunity and fundamental research questions / needs

- **Industry Post Docs**
  - Corporate Research Postdoctoral Fellowship Program provides recent engineering PhD recipients the opportunity to conduct postdoctoral research in a corporate setting

NSFs Computing-Centric Programs

The Future of Computing

- Computer and Information Science and Engineering (CISE) is at the center of an ongoing **societal transformation** and will be for decades to come.
- The **explosive growth of scientific and social data**, wireless connectivity at broadband speeds for billions of endpoints – which are both people and environmental sensors – and seamless access to computational resources and applications in the "cloud" are transforming the way we work, learn, play and communicate.
- The impact of computing will go **deeper into the sciences and engineering** and will become more **pervasive** throughout society. Policy and privacy issues will loom larger as our reliance on technology and computationally-enabled collective intelligence grows.

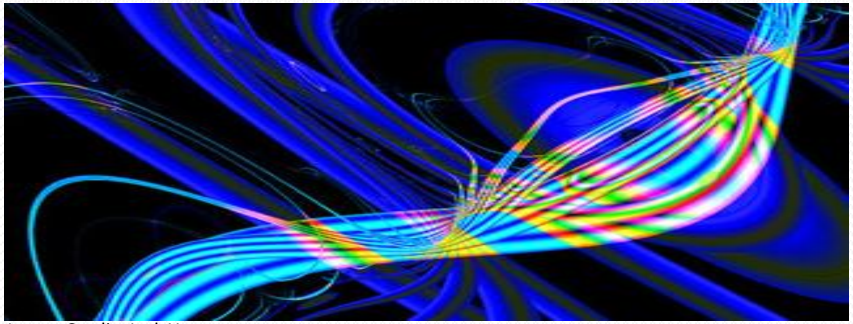
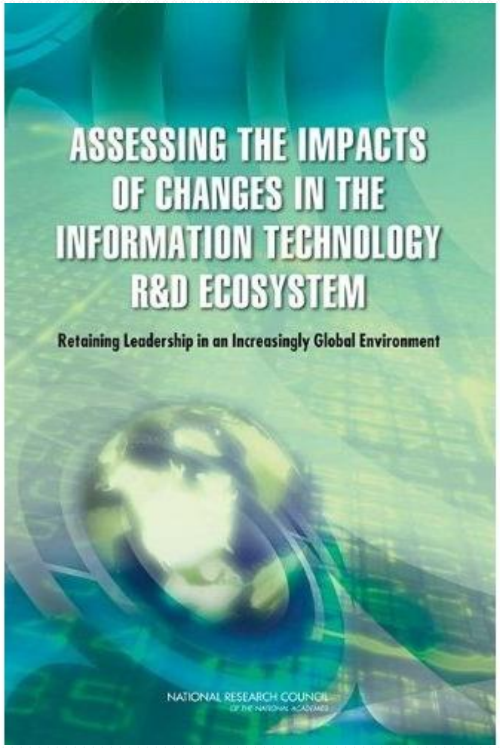


Image Credit: Jack Yaco

The Impact of Information Technology

- The enormous global economic impact is not only from the growth of IT industry itself, but to a greater extent from IT-enabled productivity gains from across the entire economy.
- Since 1995, Networking & IT industries accounted for 25% of US economic growth.
- The use and production of IT accounted for “roughly 2/3 of the post-1995 step-up in labor productivity growth.”
- Most investment in basic research comes from the federal government.

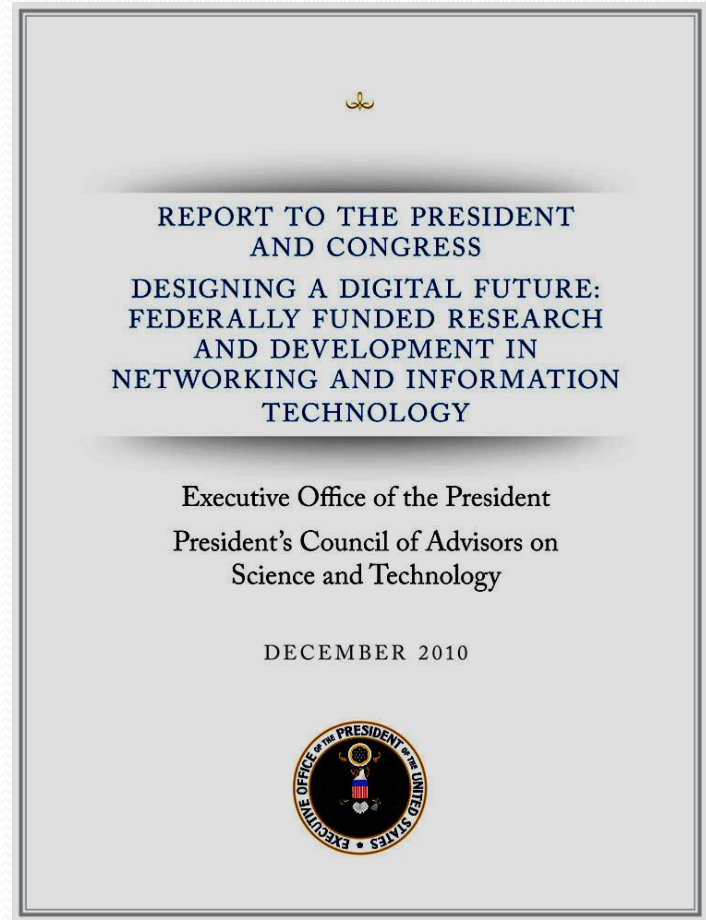


A National Imperative

"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


REPORT TO THE PRESIDENT AND CONGRESS

DESIGNING A DIGITAL FUTURE: FEDERALLY FUNDED RESEARCH AND DEVELOPMENT IN NETWORKING AND INFORMATION TECHNOLOGY

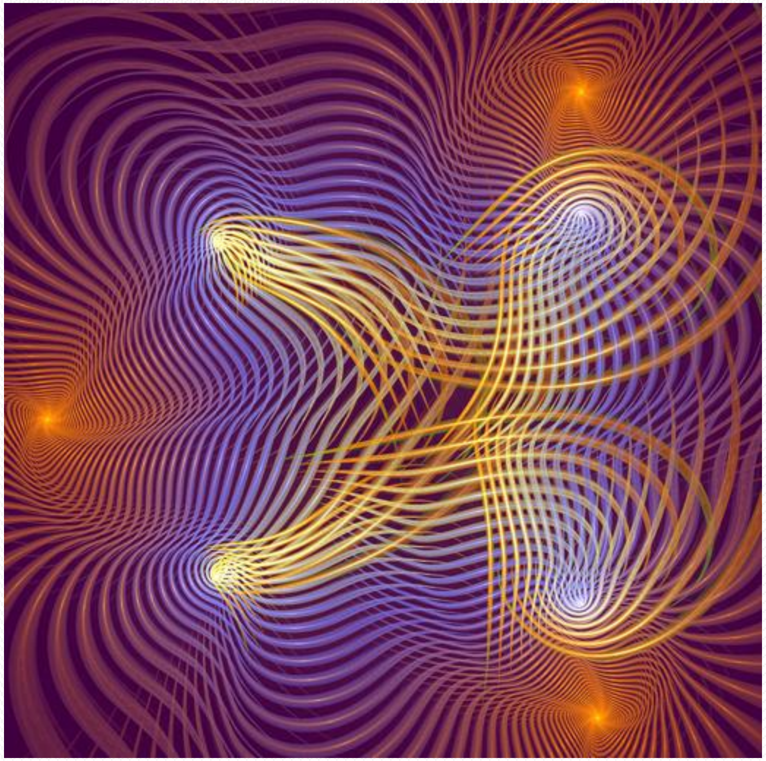
Executive Office of the President

President's Council of Advisors on Science and Technology

DECEMBER 2010

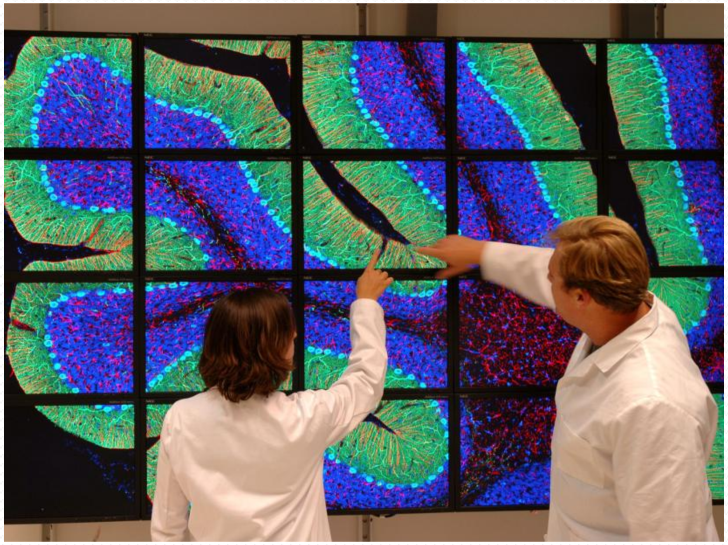
[1] *"Designing a Digital Future" PCAST Report – a periodic congressionally-mandated review of the Federal Networking and Information Technology Research and Development (NITRD) Program.*

Trends and Advances Shaping the Computing Discipline

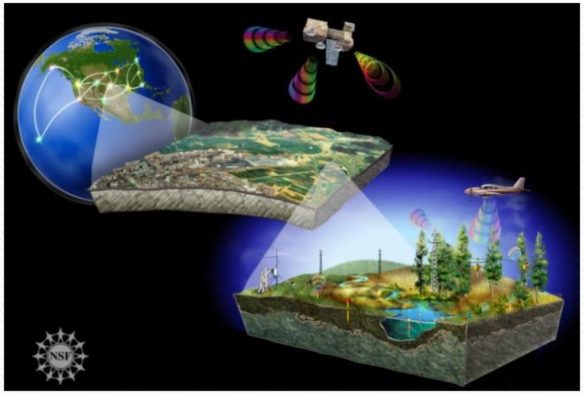


Explosive Growth in Size, Complexity and Data Rates

- **Enormous static or streaming data sets** generated by modern experimental and observational methods
- **Infusion of computation into science and engineering** is revolutionizing research
- Shift toward indirect, **automatic extraction of new knowledge** about the physical or biological world continues to accelerate
- **Enabled by data mining and machine learning**, discovery and visualization techniques together with the emergence of multi-core processing and advanced server architectures



Credit: Mark Ellisman and Tom Deerinck, NCMIR/UCSD



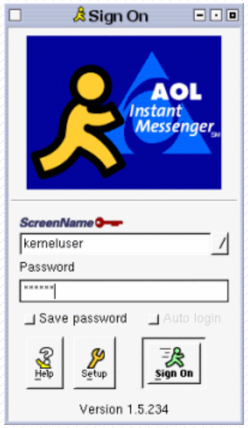
Credit: Nicolle Rager Fuller, National Science Foundation

New Breed of Communications

2010

1988

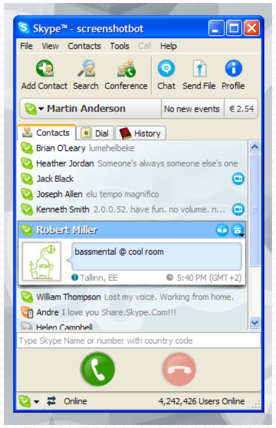
Remarkable
Pace of innovation



IM

BLOGS

EMAIL



VOIP

VIDEO

Explosive Growth in Volume & Traffic Diversity

VoIP → 663M registered Skype users in March 2011. Represents 20% of long distance minutes world-wide. If Skype were a carrier, it would be the 3rd largest in the world (behind China Mobile and Vodaphone). Largest provider of cross-border communication.

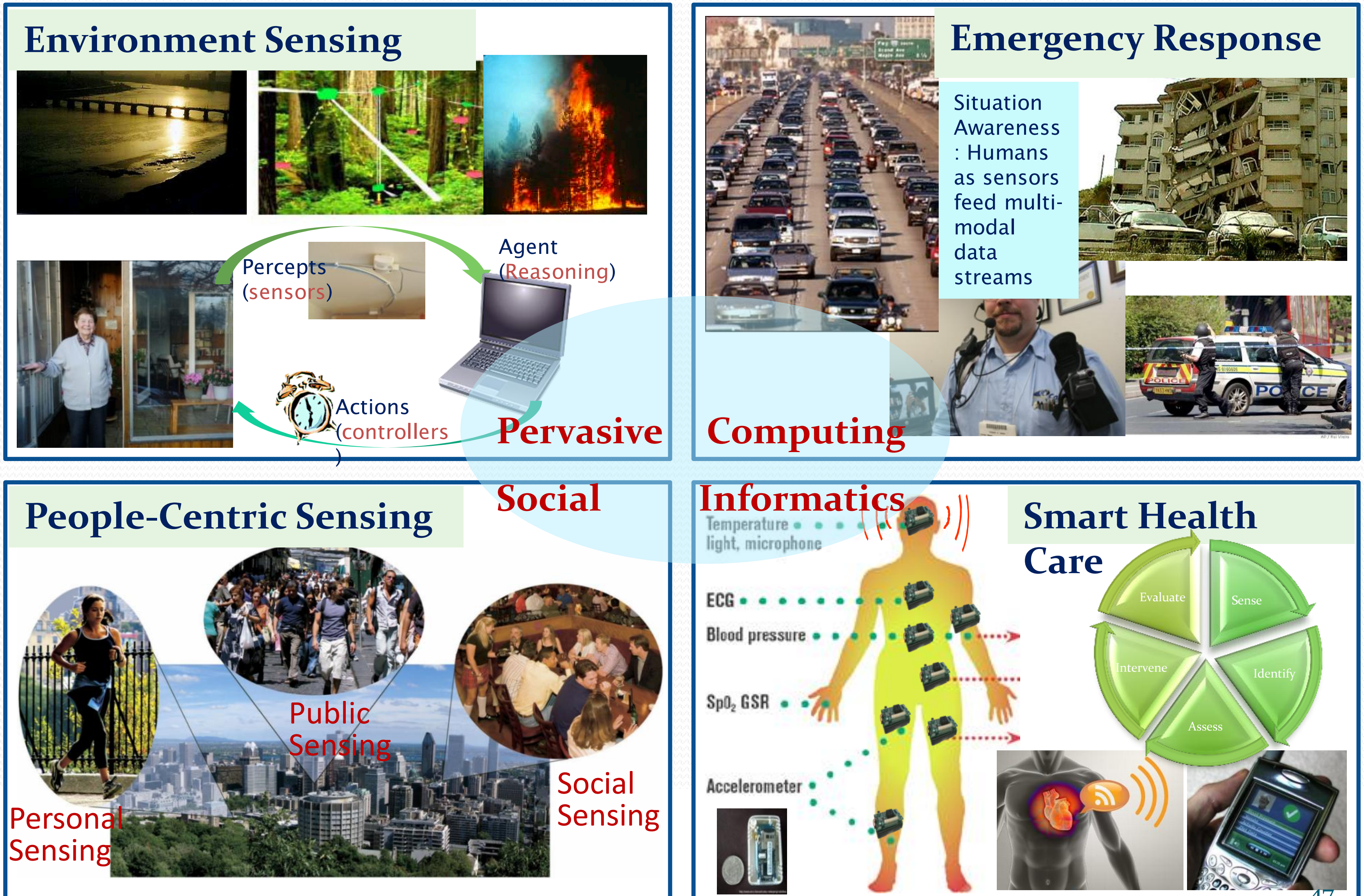
Video → Recent estimates as high as 60% of internet traffic is video and music sharing via P2P; 35 hours of new videos are uploaded every minute in 2011; 2 billion views per day.

Twitter → Currently 175 million registered users.

Broadband → 20% of global internet users have residential broadband; 68% in US subscribe to broadband.

Mobile → 5.3 billion mobile phone subscribers; 85% of new handsets will be able to access the mobile web; 1 in 5 has access to fast service, 3G or better; IM, MMS, SMS expected to exceed 10 trillion message by 2013; 300K new mobile applications in 3 years.

The Age of Observation: Smart Sensing, Reasoning and Decision



Source: Sajal Das, Keith Marzullo

The Era of Cloud Computing

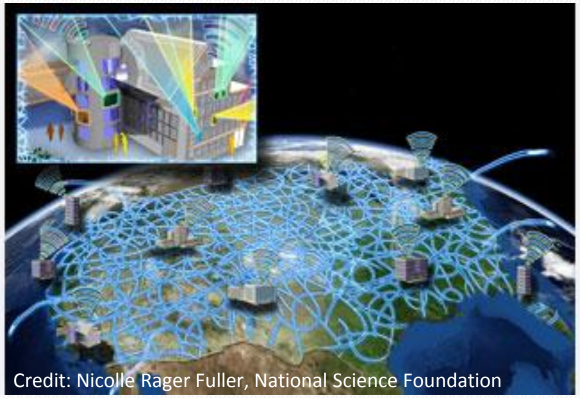
- Major public cloud service providers like Amazon are now able to provide vast computing resources to organizations … the interest in such services is staggering.
- Each day Amazon adds enough computing resources to power one whole Amazon.com circa 2000.
- Gartner Inc. believes the cloud computing market place will grow substantially from $60B in 2010 to $149 billion by 2014.
- A whole generation of Internet companies wouldn't be here today without the cloud: Netflix's video-on-demand service runs on it; Zynga uses it to handle spikes.
- The one constant in computing has been the explosion of data. The cloud is making data analytics available to small companies; a technology that was once available only to the largest companies in the world.
- Compelling New Business Models: Mindset shift from asset ownership to a utility-based model and economies of scale gained through multi-tenancy.

Credit: Wifinotes

Least expensive city for data centers = Sioux Falls, SD

Evolution of Cyber Threats

Future security challenges will follow Internet adoption patterns:



- Botnets will continue to dominate how attacks are launched; attribution and forensics is increasingly difficult.
- Distributed attacks increasing in size and sophistication, targeting specific applications.
- Proliferation of attacks spurred by financial gains and now political motives.
- Proliferation of wireless devices and social media platforms open new avenues for hackers.
- Protecting cloud infrastructure key to long-term adoption.
- The trend toward increasingly cyber-enabled systems expands the scope of attacks to physical infrastructure – manufacturing, energy production, healthcare, and transportation.

Networked Society

Clickworkers
Collaborative Filtering
Collaborative Intelligence
Collective Intelligence
Computer Assisted Proof
Crowdsourcing
eSociety
Genius in the Crowd
Human-Based Computation
Participatory Journalism
Pro-Am Collaboration
Recommender Systems
Reputation Systems
Social Commerce
Social Computing
Social Technology
Swarm Intelligence
Wikinomics
Wisdom of the Crowds

CISE Snapshot

CISE Organization and Core Research Programs

CISE
Office of the Assistant Director
Farnam Jahanian

~ 25-30% of CISE Budget in Cross-Cutting Programs

CISE Cross-Cutting Programs

~ 70-75% of CISE Budget in Core Programs

Computing and Communications Foundations (CCF)
Susanne Hambrusch

- Algorithmic Foundations
- Communication and Information Foundations
- Software and Hardware Foundations

Computer and Network Systems (CNS)
Keith Marzullo

- Computer Systems Research
- Networking Technology and Systems

Information and Intelligent Systems (IIS)
Howard Wactlar

- Human-Centered Computing
- Information Integration and Informatics
- Robust Intelligence

Computer & Computing Foundations (CCF)

http://www.nsf.gov/cise/ccf/about.jsp

Algorithmic Foundations (AF)

Algorithms
Complexity and Cryptography
Quantum Computing
Computational Geometry
Computational Biology
Computational Game Theory & Economics
Symbolic and Algebraic Computation
Parallel and Distributed Algorithms

Communications and Information Foundations (CIF)

Communication and Information Theory
Signal Processing
Network Coding and Information Theory
Sensor Networks
Wireless Communication and Signal Processing

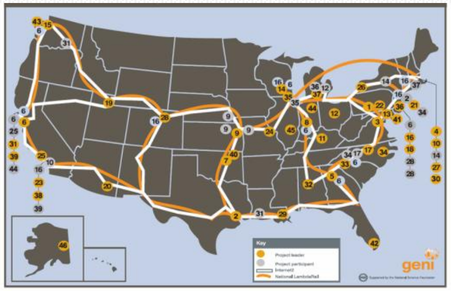
Software and Hardware Foundations (SHF)

Compilers
Computer Architecture
High Performance Computing
Programming Languages
Software Engineering & Formal Methods
Design Automation for Micro & Nano Systems
Bio Computing
Nano Computing

Computer and Network Systems Division (CNS)

Networking Technology and Systems (NeTS)

- Supports transformative research on fundamental scientific and technological advances leading to the development of future generation high performance networks.
- Enables research leading to new network architectures, algorithms and protocols that are responsive to the evolving requirements of current and emerging technologies, services and applications operating in dynamic environments.



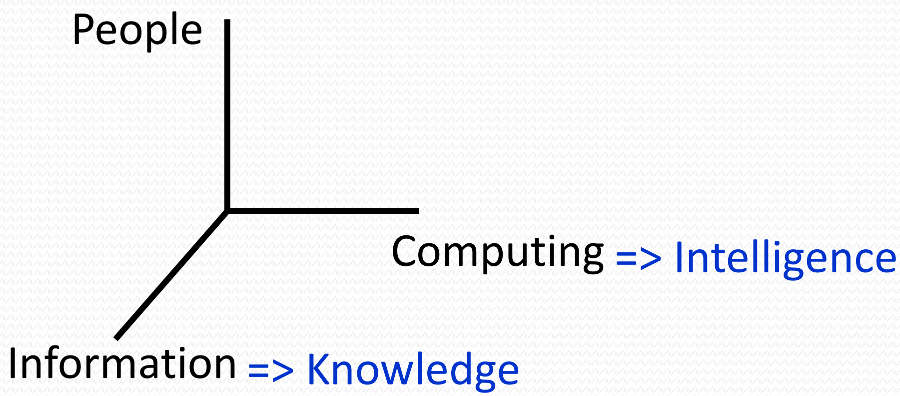
… plus infrastructure, GENI, and US Ignite

Computer Systems Research (CSR)

- Core program for new architectures; distributed real-time embedded control; handheld, wearable and implanted devices; pervasive, ubiquitous and mobile computing; file and storage systems; new programming models, abstraction, languages, compilers, and operating systems; reliable, fault-tolerant and secure hard/middle/software; …
- Is the *breeding ground for new ideas* that transcend traditional classification schemes.

Information and Intelligent Systems (IIS)

The People-Centered Division



All IIS Projects are Volumes in this Space

Robust Intelligence
robotics
computer vision
human language & commun.
artificial intelligence
machine learning
reasoning & representation
computational neuroscience

Information Integration & Informatics
data management
data mining
(bio) informatics
multimedia info. retrieval
semantic web

Human Centered Computing
human-computer interaction
social informatics
assistive technology
virtual human interaction
learning technology

Applying to Core Programs

- Program Solicitations:
  - CCF: NSF12-581
  - CNS: NSF12-582
  - IIS: NSF12-580

  } Coordinated Solicitations

- Project Types:

  Large: $1,200,001 to $3,000,000; up to 5 years duration
  collaborative team projects

  Medium: $500,001 to $1,200,000; up to 4 years duration
  multi-investigator collaborative projects

  Small: up to $500,000; up to 3 years duration
  one or two investigator projects

- CISE-wide Submission Windows:
  - Medium: September 15 - 30, annually
  - Large: November 1 - 28, annually
  - Small: December 1 – 19, annually

- PI Limit:
  - participate in no more than 2 “core” proposals/year

Cross-Cutting Programs

- Cross-Directorate
  - Computing Education for the 21st Century (CE21)
  - Cyber Infrastructure Framework for the 21st Century (CIF21)
  - Cyberlearning: Transforming Education (CTE)
  - Cyber-Physical Systems (CPS)
  - National Robotics Initiative (NRI)
  - Science, Engineering, and Education for Sustainability (SEES)
  - Secure and Trustworthy Cyberspace (SaTC)
  - Smart Health and Wellbeing

Smart Health & Wellbeing

To address fundamental technical and scientific issues that would support much needed transformation of healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, person-centered and focused on wellbeing rather than disease

- Cross-Directorate Program: CISE, ENG, SBE
- eHealth, mHealth, EHR datamining, distributed care, sensor technology, participating and empowered patient, etc.
- Must relate to a key health problem and must make a fundamental contribution to ENG, CISE, or SBE domains

Smart Health and the Healthcare Crisis

- Some troubling statistics:
  - The cost of healthcare in the U.S. is the highest in the world (per capita, % GDP)
  - The U.S. ranked 37th in the 2000 WHO study of healthcare system performance (8 underlying measures)
  - 50% Americans have 1 or more chronic diseases; age of onset getting younger
  - 98,000 deaths per year due to medical errors
  - 3 lifestyle behaviors (poor diet, lack of exercise, smoking) cause est. 1/3rd of US deaths
  - Current individual medical records have an error rate of 20%

Information and communication technologies are poised to transform healthcare …

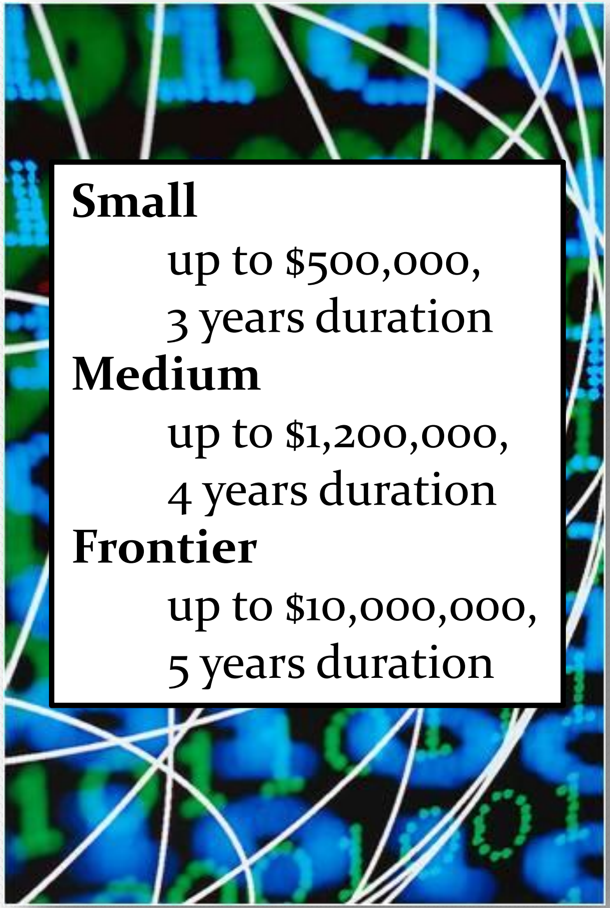
Smart Health and Wellbeing Research Thrusts

Digital Health Information Infrastructure ***Informatics and Infrastructure***	• Continuous collection, integration, fusion and exchange of EHR, biomedical and clinical research data in a distributed but federated system • A foundation for evidence-based, patient-centric practice & research
Data to Knowledge to Decision ***Reasoning under uncertainty***	• Cognitive support systems spanning clinical to lay decision making • Data mining, machine learning, discovery from massive longitudinal and individual data
Empowered Individuals ***Energized, enabled, educated***	• New models of distributed and home-centered healthcare provision • Technologies that aide in modifying self and group behavior
Sensors, Devices, and Robotics ***Sensor-based actuation***	• Assistive technologies embodying computational intelligence • Medical devices, co-robots, cognitive orthotics, rehab coaches

Secure and Trustworthy Cyberspace Program (SaTC)

To address cybersecurity from one or more of three perspectives:

- ***Trustworthy Computing Systems***
- ***Social, Behavioral and Economics***
- ***Transition to Practice***



- Cross-Directorate Program: CISE, SBE, OCI, MPS
  - Anticipated $50M for FY 2012
- We encourage both single perspective and multi-perspective proposals
- A successful multi-perspective proposal will most likely require a strong multi-disciplinary team.

SaTC: Research Principles

1. We need to aim at understanding *underlying cybersecurity deficiencies*
    - It is important to focus on *root causes* rather than just treating the symptoms.
    - Identifying these fundamental causes may require an iterative approach, taking theory and prototypes to practice (e.g., cybersecurity in cyber-physical systems)
    - Can also be the basis of curiosity driven research (e.g., return oriented programming)

SaTC: Research Principles

2. Cybersecurity is a *multi-dimensional problem*, involving both the strength of security technologies and variability of human behavior.
   - We need the expertise and resources from a wide range of disciplines: computer scientists, engineers, economists, mathematicians, behavioral scientists, …
   - This will take work: collaboration across mature fields requires effort (e.g., "*trust*" from a social science perspective versus "*trustworthy*" from a computer science perspective)

SaTC: Research Principles

3. We need *enduring cybersecurity principles* that will allow us to stay secure despite changes in technology and threat environment: a *science of security*

- Organize disparate areas of knowledge.
- Enable discovery of universal laws.
- Apply the rigors of the scientific method.
- Enhance capabilities to design, develop and evolve high assurance software and systems

SaTC Perspectives

Research Opportunities

Trustworthy Computing Systems

- Perspective aims to provide scientific basis for designing, building and operating cyber-infrastructure with improved resilience and resistance
- Support for both theoretical and experimental approaches
- Investigation of tradeoff among trustworthy properties

Social, Behavioral & Economic

- perspective includes research at individual, group, organizational, market and societal levels, identifying risks and exploring solution feasibility
- Understanding attack or defense behaviors to develop more effective strategies and solutions
- Cyber economic incentives including metrics and models

Transition to Practice

- perspective addresses the challenge of moving from research to practice
- focus on later stages of R&D activities including evaluation and experimental deployment
- Software required to be released under open software license

Cyber Physical Systems (CPS) Program

"Internet of [**controlled**] things"

NSF CISE and ENG Directorates

With involvement/cooperation/interest/support from:

Air Force Office of Scientific Research (AFOSR)
Air Force Research Laboratory (AFRL)
Advanced Research Projects Agency-Energy (ARPA-E)
FAA-Joint Planning and Development Office (JPDO)
Food and Drug Administration (FDA)
Department of Transportation (DOT)
National Institutes of Health (NIH)
National Institute of Standards and Technology (NIST)
National Aeronautics and Space Administration (NASA)
Nuclear Regulatory Commission (NRC)
National Security Agency (NSA)
National Transportation Safety Board (NTSB)
Director, Defense Research and Engineering (DDR&E)

Cyber-Physical Systems deeply integrate **computation, communication, and control** into **physical** systems

CPS Research Thrusts

National Priorities and Trends in Computing outlined in several reports[1] include: high-confidence critical infrastructures; safer transportation systems; collaborative intelligence; competitive economy and our manufacturing base; our aging population; ... networked information systems connected to our physical world.

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

[1] *See, for example, PCAST Reports: Leadership Under Challenge: Information Technology R&D in a Competitive World (August 2007) -- http://www.nitrd.gov/Pcast/reports/PCAST-NIT-FINAL.pdf; Federal Plan for Advanced Networking Research and Development (September 2008) -- http://www.nitrd.gov/pubs/ITFAN-FINAL.pdf; Grand Challenges: Science, Engineering, and Societal Advances, Requiring Networking and Information Technology Research and Development (Third Printing - November 2006) -- http://www.nitrd.gov/pubs/200311_grand_challenges.pdf*

The Promise of CPS

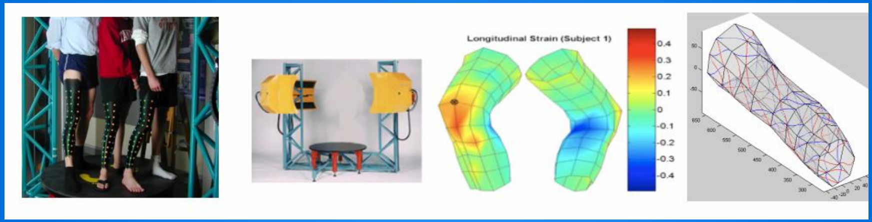
Advances in CPS hold the potential to reshape our world with more responsive, precise, and efficient systems that:

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

Examples of CPS Awards

Programmable Second Skin to Re-educate Injured Nervous Systems

Eugene C. Goldfield (Harvard Medical School, Children's Hospital Corp), Rob Wood and Radhika Nagpal (Harvard University), Dava Newman (MIT), Marc Weinberg (Draper), Kenneth Holt and Elliot Saltzman (BU)



Credit: Wyss Institute, Harvard University

Control of Surgical Robots: Network Layer to Tissue Contact

Blake Hannaford, Howard J Chizeck (U Washington)

Credit: Mitch Lum

Physical Modeling and Software Synthesis for Self-Reconfigurable Sensors in River Environments

Jonathan Sprinkle (U. Arizona), Sonia Martinez (UCSD), Alex Bayen (UC Berkeley)

Credit: Jonathan Beard

Science, Engineering, and Education for Sustainability (SEES)

To advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being

Support interdisciplinary research and education that can facilitate the move towards global sustainability

Build linkages among existing projects and partners and add new participants in the sustainability research enterprise

Develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues of sustainability

GOALS

Role of Computer Science in SEES

Monitoring

- **Scalable sensing & data collection for sustainability apps**
  - Ocean ice dynamics
  - Biodiversity tracking,
  - Water quality & availability
  - Disaster monitoring
  - Human well being (e.g., healthcare for masses)
- **Sensing in difficult environments (e.g., arctic, wild-fires, animals)**
- **Working with citizen science data**

Big Data

- **Data analytics for sustainability apps**
  - Integrating multimodal data
  - Dealing with unreliable, partial & indirect data
  - Data storage, retrieval, and provenance.
  - Analysis, visualization, and understanding

Scalability

- Application specific architectures
- Massive parallelization & cloud computing
- Multi-level modeling
- Software engineering

Addressing Complexity

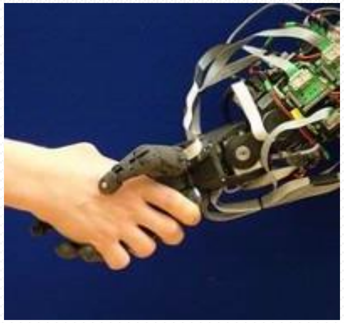
- **Rich set of techniques**
  - Separation of concerns
  - Symbolic modeling
  - Reasoning in uncertain environments
  - Machine learning
  - Autonomous & human assisted control

Behavior Modeling & Change

- Theory of complex systems
- Game theory / econometrics
- Data driven behavior change
- Social networking and sustainability

National Robotics Initiative (NRI)

To develop the next generation of robotic companions that work seamlessly with humans as co-workers, co-protectors, co-drivers, co-explorers, and co-inhabitants to enhance personal safety, health, and productivity



Credit: Bristol Robotics Lab

- A nationally coordinated robotics technology R&D program across multiple government agencies
  - Multi-agency commitment: NSF, NASA, NIH, USDA
  - NSF: CISE, ENG, SBE, EHR
  - Up to $50M for FY2012
- Serves multiple key national priorities: increased personal productivity in manufacturing, healthcare and security
- Strong coupling with industry and startups, through SBIRs
- Emphasizes common platforms & standard interfaces
- Will sponsor national competitions, outreach, & education

Credit: 2011 Honda Motor Co., Ltd.

NRI Research Thrusts

Fundamental research in robotics science & engineering

- Machine perception & cognition
- Controls & planning
- Learning & adaptability
- Natural language understanding and sensing
- Robust human-robot interaction

Understanding the long term social, behavioral, and economic implications across all areas of human activity

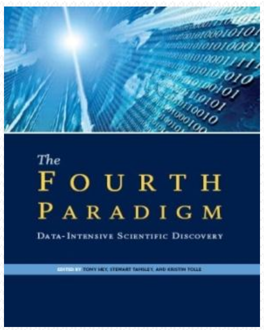
- Models of uptake, diffusion, and use among different demographics
- Incentives, disparities and ethical implications; workforce participation
- Models of human-robot collaboration

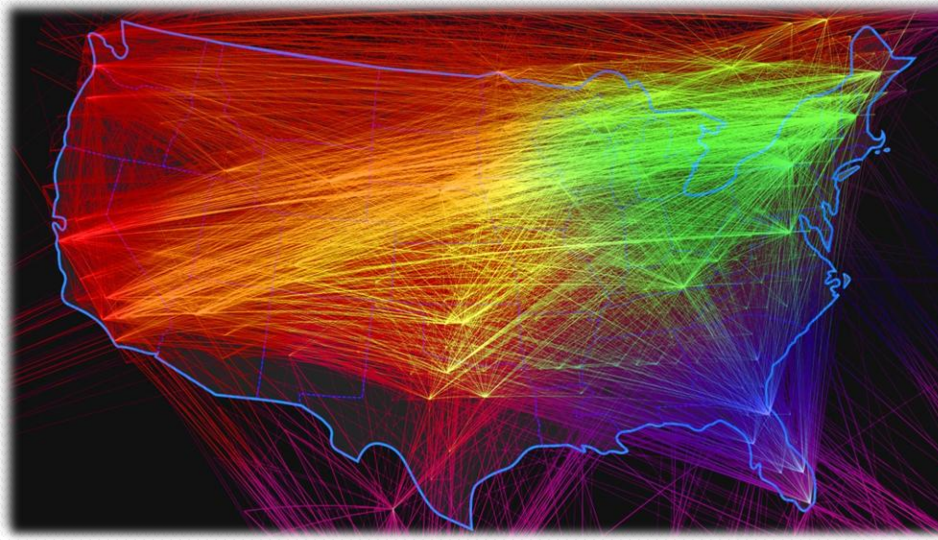
Use of robotics to facilitate and motivate STEM learning across the K-16 continuum

- Learning across all disciplines
- Engaging learners
- Evolving robotics-centric pedagogy and outreach

The Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)

A new, cross-directorate initiative to enable new ways of doing science and education





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).

- Data-enabled science & engineering
- New computational infrastructures including software and tools
- Community research networks
- Access and connections to cyber infrastructure facilities

FY 2012 request: $117 million; CISE $16M

CISE Investments in CIF21

- Data-enabled science through advances in e-science tools such as data mining, machine learning, and data visualization
- New experimental architectures and approaches to emerging computation infrastructure, e.g.. clouds and data centers
- Distributed collaborative software and tools

Wireless Innovation and Infrastructure Initiative (Wi3)

Spurring novel applications and services that will affect the vast sector of the U.S. economy driven by wireless technology

Credit: Nicolle Rager Fuller, National Science Foundation

Computing Education for the 21st Century (CE21)

AIM

Increase number and diversity of

- K-12 students and teachers with computational competencies
- Early college students with engagement and background to major in computing and computationally-intensive fields
- BPC and CPATH combined into CE21 (engagement and capacity building)

NOTEWORTHY FEATURES

- Spans K-14
- Intertwines broadening participation and education
- Adds educational, research component
- Assess with an appropriately rigorous evaluation process
- Partnership with EHR and OCI
- Encourages alignment with CS 10K Project

CE21 investment in FY10 and FY11: $25M NSF, $19M CISE

Cyberlearning: Transforming Education (CTE)

AIM

- Designing and using technologies to aid and understand learning
- Partnership with EHR, SBE and OCI
  - Using technology to amplify, expand, and transform learning for all
    - Access to Anytime, Anywhere Learning
    - Personalize Learning Experiences
  - Cyber learning research on new modalities of learning; better understand how people learn with technology and how technology can help people learn

CTE potential investment in FY11: $41M NSF, $15M CISE

"There is a need to inspire as well as promote proficiency and understanding to achieve society's most pressing learning goals." (2011 PCAST)

Expeditions-in-Computing

Inspire bold, transformative research that explores new scientific frontiers that promise disruptive innovations in computing and catalyze far-reaching research

10 awards made so far ($2M/year per award for 5 years)

Year	Pre-proposals	PI, Co-PI & SP	Institutions	Full Proposals	Awards
2008	75	1000	166	20	4
2009	48	650	161	20	3
2010	23	232	76	16	3
2011	36	328	69	15	?

Expeditions Awards – Overview

Beyond Moore's Law

Variability-aware Software for Efficient Computing with Nanoscale Devices – UCSD, UCLA, UIUC, Stanford, Michigan, 2010

Customizable Domain-Specific Computing – UCLA, UCSB, Rice, Ohio State, 2009

The Molecular Programming Project – CalTech, U Washington, 2008

Sustainability & Environment

Understanding Climate Change: A Data Driven Approach – Minnesota, Northwestern, NC State, NC A&T State, 2010

Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, and Society – Cornell, Oregon State, Bowdoin, 2008

Wireless & Internet

Open Programmable Mobile Internet 2020 – Stanford, 2008

Healthcare & Wellbeing

Computational Behavioral Science: Modeling, Analysis, and Visualization of Social and Communicative Behavior – Georgia Tech, MIT, Boston U, UIUC, USC, Carnegie Mellon, 2010

Next-Generation Model Checking and Abstract Interpretation with a Focus on Embedded Control and Systems Biology – Carnegie Mellon, Stony Brook, NYU, UMD, Pitt, Lehman College, JPL, 2009

Robotics

RoboBees: A Convergence of Body, Brain and Colony – Harvard, Northeastern, 2009

Complexity theory, Quantum Computing & Cryptography

Understanding, Coping with, and Benefiting from Intractability – Princeton, Rutgers, NYU, Institute for Advanced Study, 2008

Overwhelming?

- Helpful hints:
- Subscribe to NSF Updates by Email
- Subscribe to CISE Updates by Email
- Subscribe to receive special CISE announcements
- Visit CISE Web site often
- Use Award Search to find relevant programs
- Talk to program directors

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