NSF Networking Of Sensor Systems (NOSS) and Its Connection to NASA Sensor Webs

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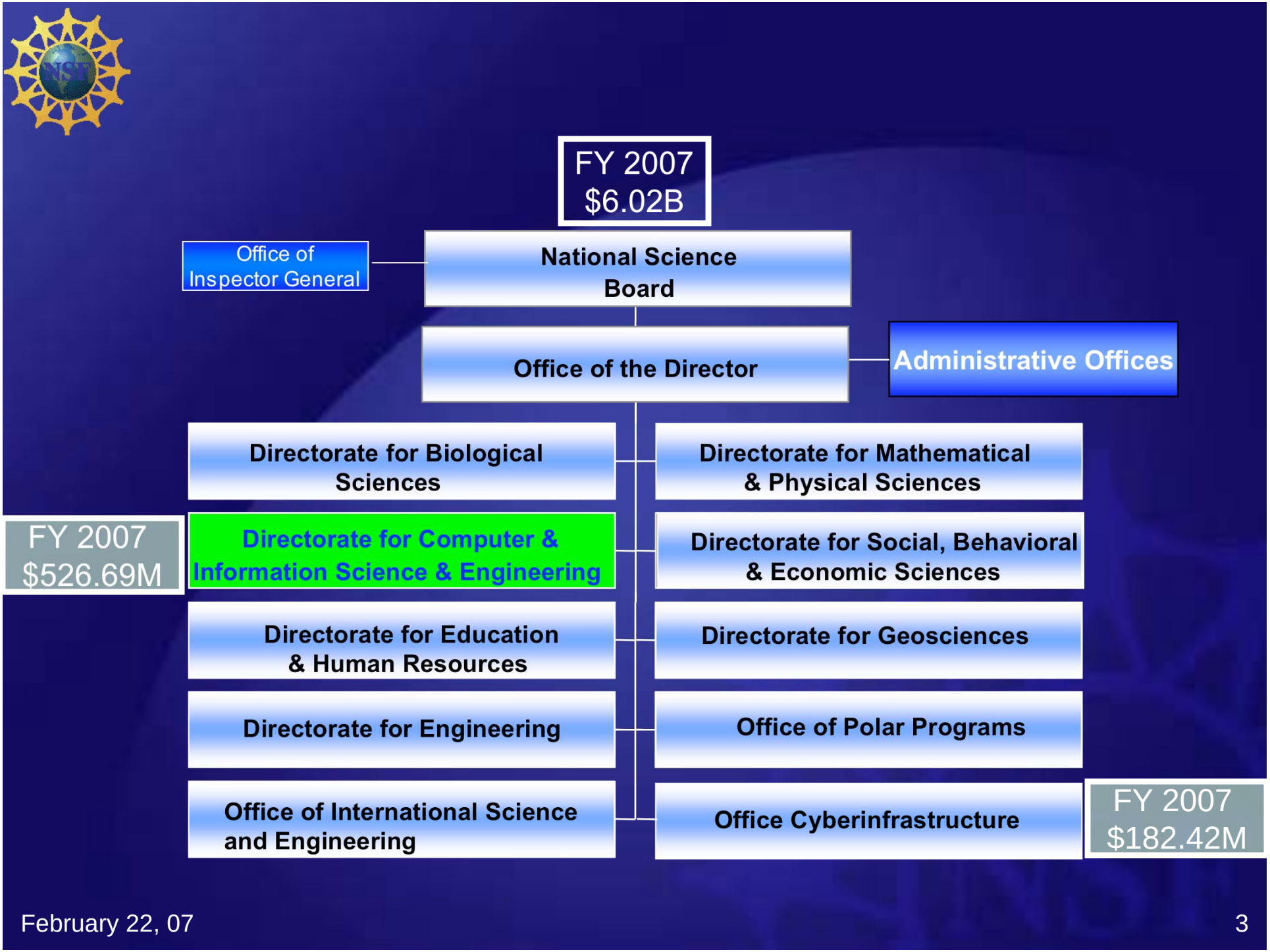
Outline

- NSF Overall Research Funding Direction
  - High Impact High Risk (Transforming Research)
  - Fundamental Research
- Highlights of NeTS Cluster
- Networking Of Sensor Systems (NOSS)
- Connections to NASA Sensor Webs


FY 2007
$6.02B
Office of Inspector General
National Science Board
Office of the Director
Administrative Offices
Directorate for Biological Sciences
Directorate for Mathematical & Physical Sciences
FY 2007
$526.69M
Directorate for Computer & Information Science & Engineering
Directorate for Social, Behavioral & Economic Sciences
Directorate for Education & Human Resources
Directorate for Geosciences
Directorate for Engineering
Office of Polar Programs
Office of International Science and Engineering
Office Cyberinfrastructure
FY 2007
$182.42M

Societal Needs

- New (Renewed) Critical Infrastructures
  - Transportation
  - Water
  - Electricity
  - Cyber, Financial, E-Government
  - Oil and Gas
- Energy
  - Alternative Sources: solar, hydrogen, bio-fuels
  - Decentralized generation and consumption
  - Nuclear fuel
  - Demand Side: HVAC, ...

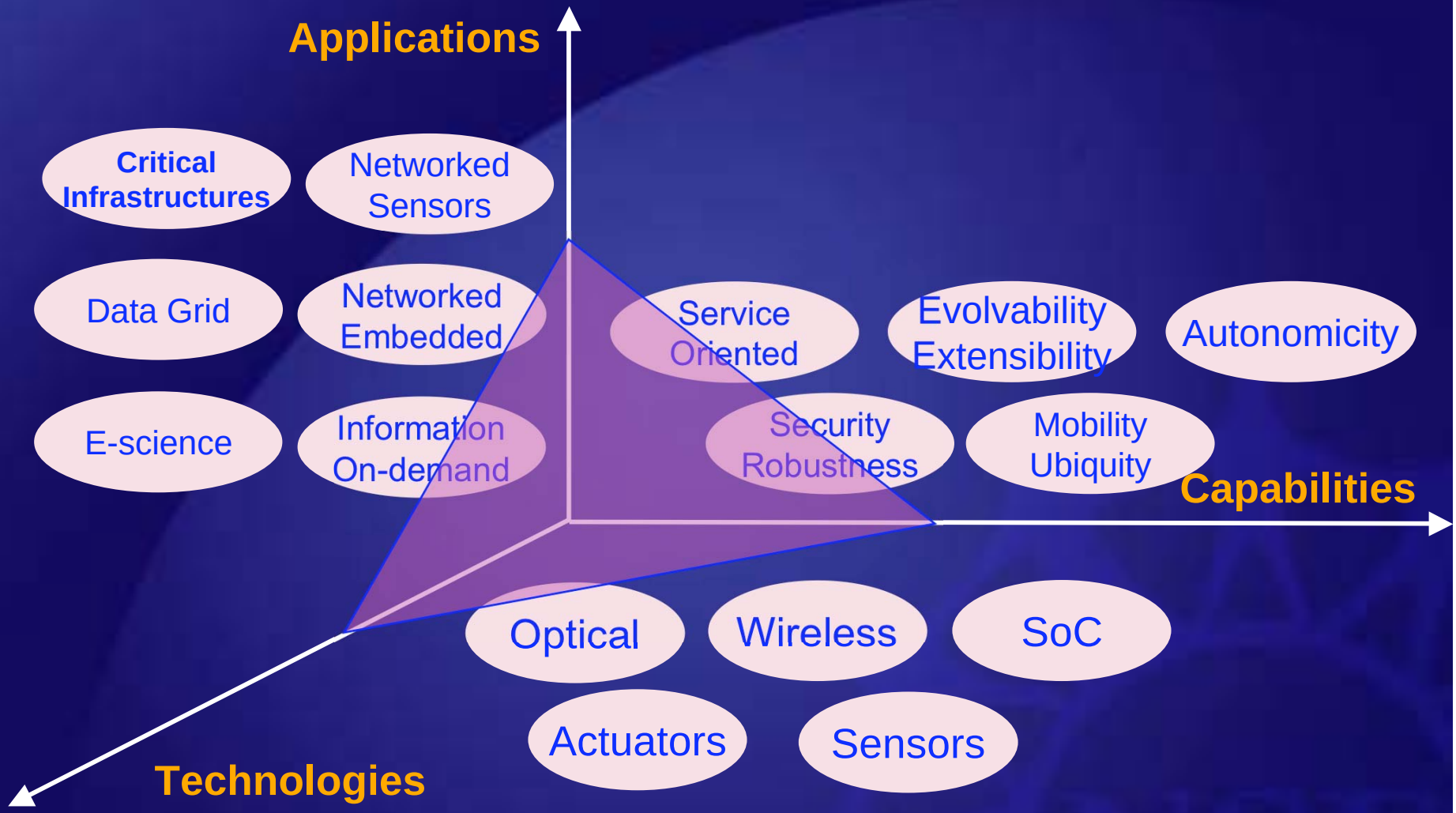
Societal Needs

- Health Care
  - Rapid bug to drug
  - Better sensing and monitoring for elders
  - Better delivery using ICT
  - Tele-medicine/tele-surgery
  - Personalized medicine
- Homeland Security
  - Less vulnerable and recoverable infrastructures
  - Command and control for reconstituting damaged infrastructures
  - Security with privacy in information exchange and gathering

Societal Needs

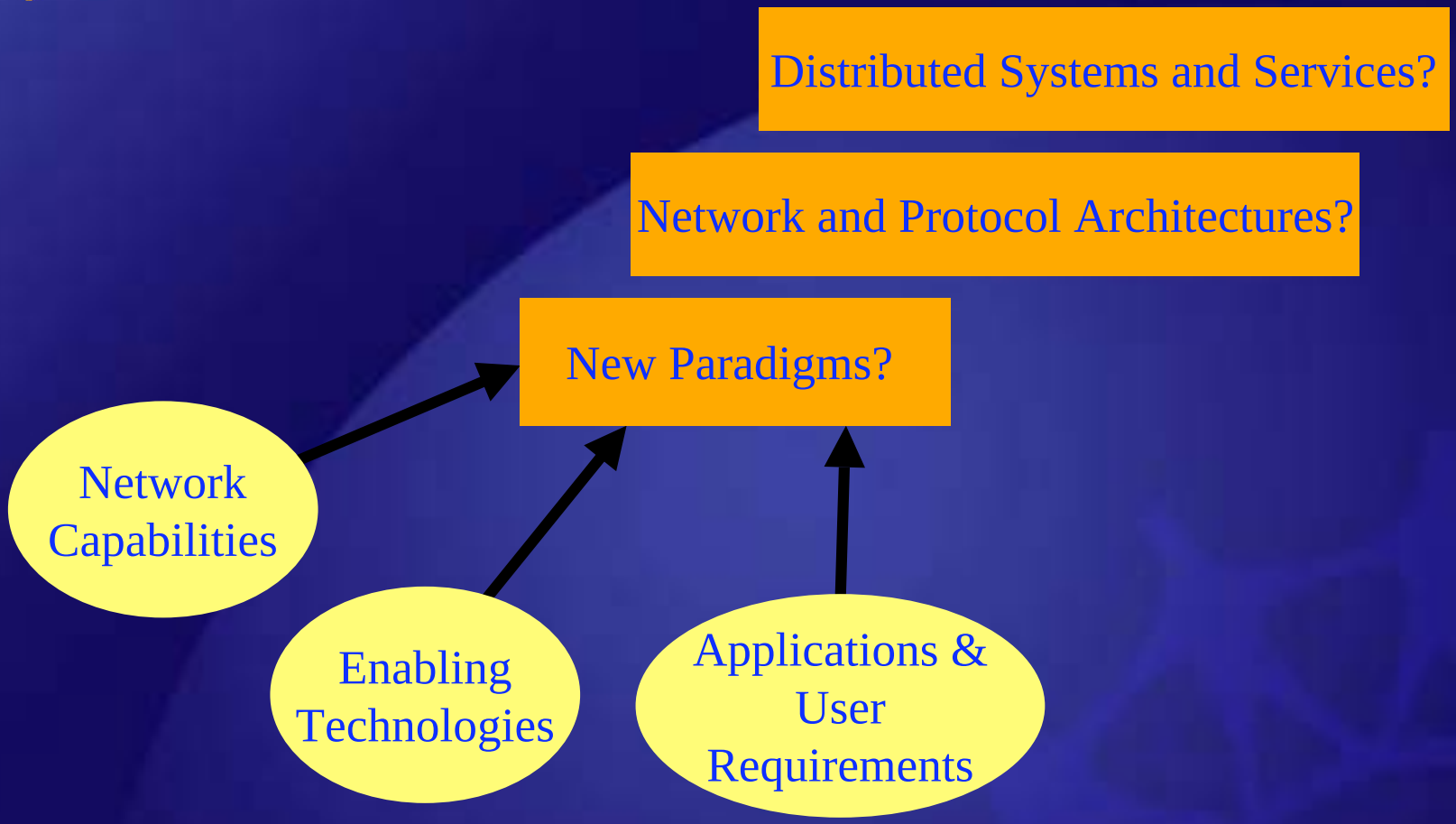
- National Security
  - Unmanned vehicles (UXVs)
  - Human centered automation
  - Networked Systems (GIG)
  - Embedded Software and Systems
  - Propulsion
  - Space access, exploration
- Data Storage, Query and Retrieval
  - Semantic Web, Intelligent Storage
  - Multi-modal data annotation, query
  - Search beyond Google
  - Data integrity, provenance and privacy

Looking Ahead



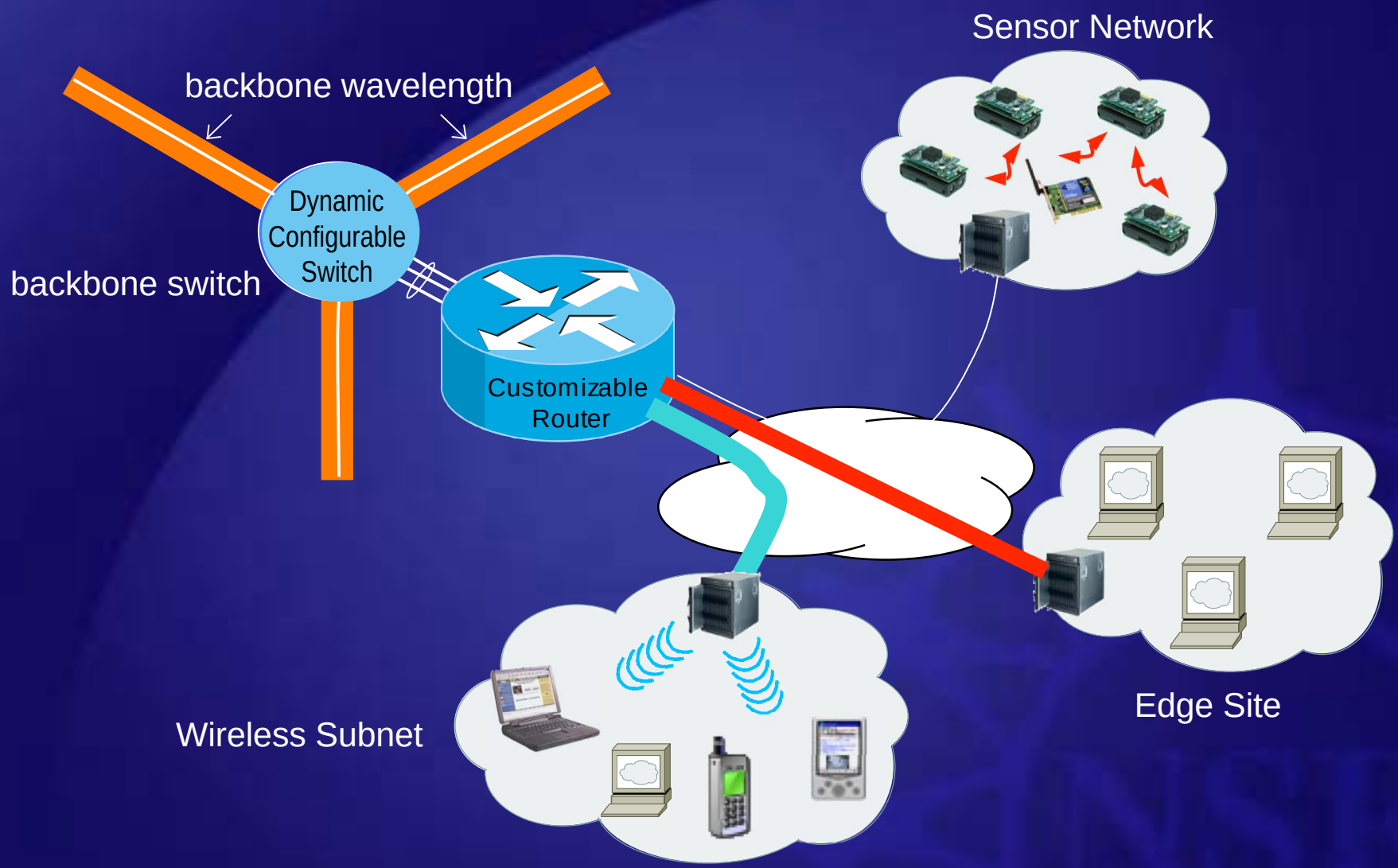
Highlights of NeTS Cluster

Future Internet (GENI)?



Need a clean-slate approach

Closer Look of GENI



Future Internet

Must

- Be worthy of our society's trust
  - Even for managing and operating critical infrastructures
- Provide a bridge between physical and virtual worlds
  - Via instrumented and managed sensorized physical environment
- Support pervasive computing
  - From wireless devices to supercomputers
  - From wireless channels to all optical light-paths
- Enable further innovations in S&E research
  - Seamless access to networked instruments, supercomputers, storage,

Context: NeTS Solicitation

- NSF 07-507 (proposal due on January 22, 2007)
  - FIND: a new focus area
  - WN (Wireless Network) to replace ProWin
- Expected value $40+ million
- Four Program Elements
  - Focus Area: Wireless Networks (WN)
  - Focus Area: Networking of Sensor Systems (NOSS)
  - Focus Area: Future Internet Design (FIND)
  - Networking Broadly Defined (cover the rest) (NBD)

NeTS Program Very Competitive

- FY06 submissions to NeTS
  - Record number of proposals (650)
  - 120+ projects in NOSS, 90+ in FIND
- 10% - 20% proposals likely to be funded
  - More than 75% of strong proposals to be funded
- Funding for each area is “fenced”
  - decisions in one category will not affect allocation of funds to or within other categories

Focus Area:
Networking Of Sensor Systems
NeTS-NOSS

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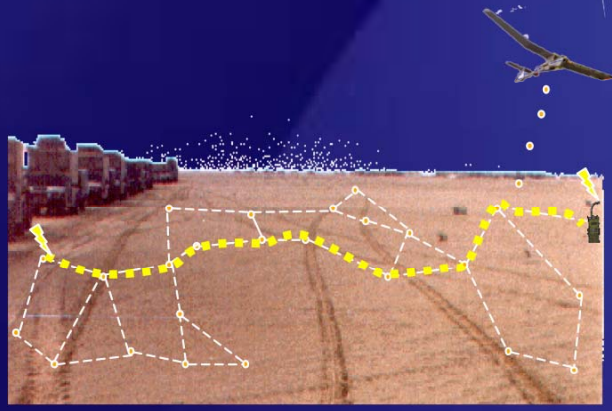
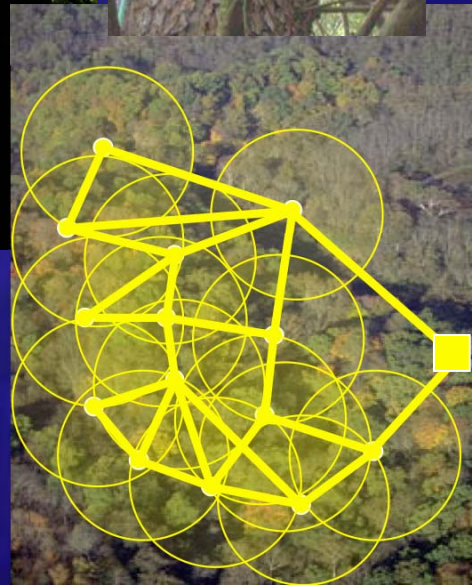
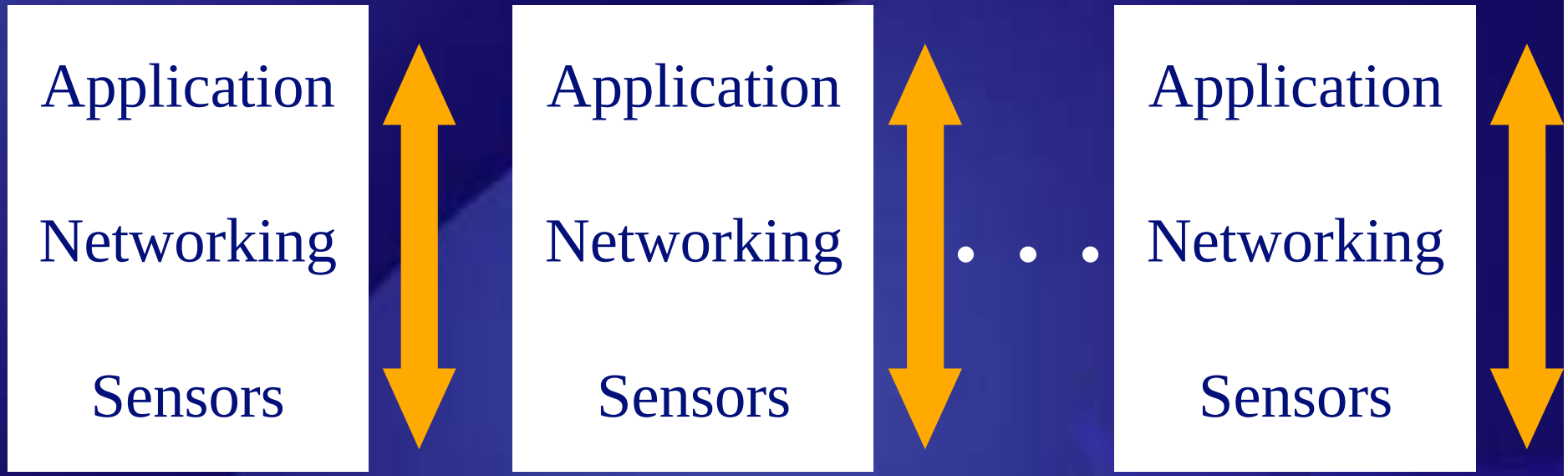
Instrument the World



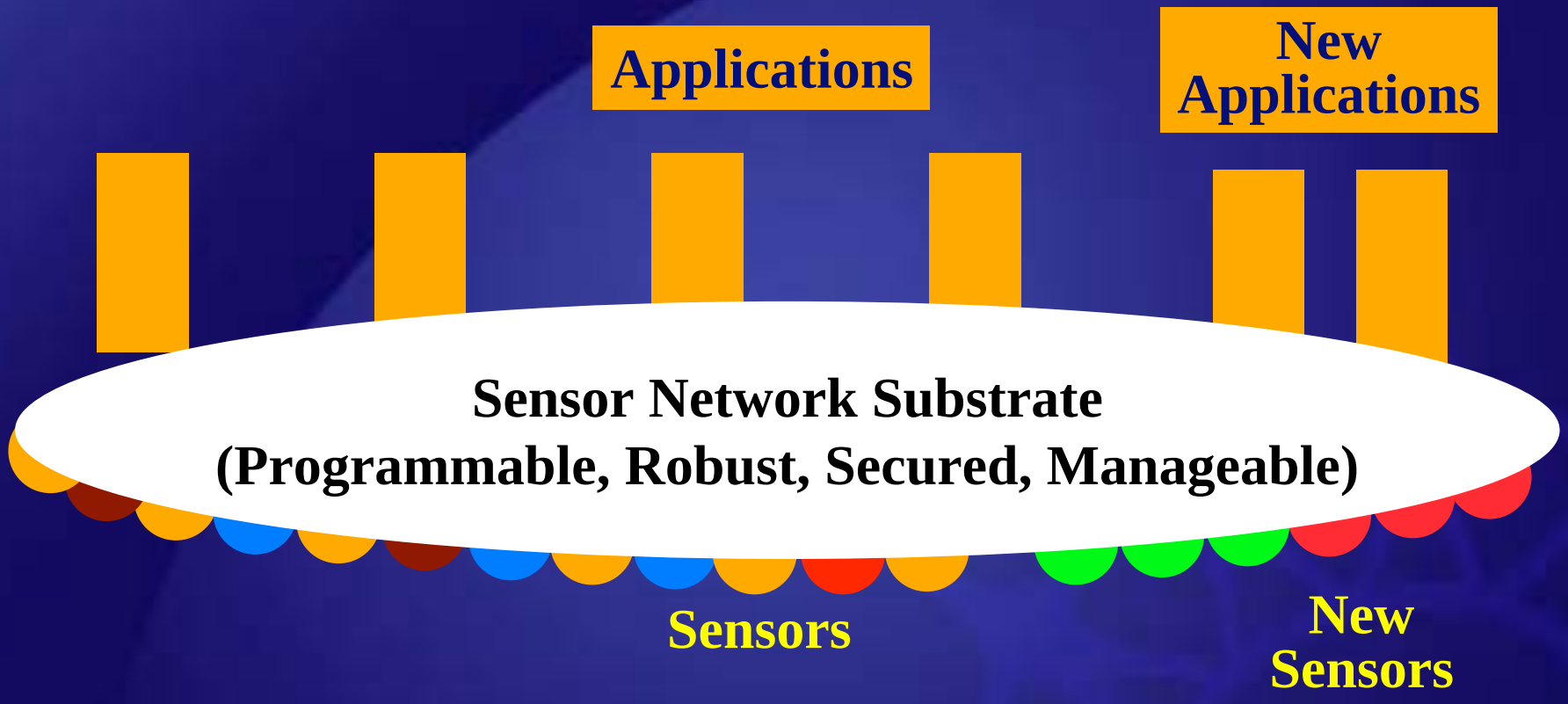


Sensor Networking Stage 1: Vertically Integrated



- Natural for an emerging area
- Stove pipe approach may not work for wider deployment

Stage 2: Plug and Play Sensor Network Substrate



Conceptual framework

Which Stage Are We In?

Focus of NOSS from 2003-Now

Monitoring, Sensing, Processing, Communicating & Actuating of Physical Systems/Environments

Applications

Network Technology Gap

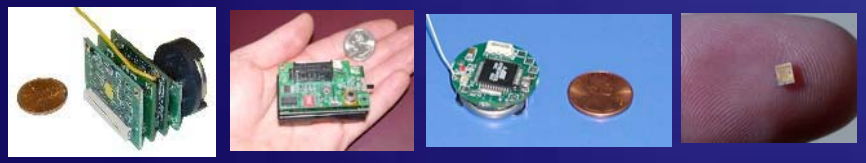
Network Programming

HW/SW Systems

Protocols Algorithms

Privacy Security

Network Architecture



Miniature Connections to Physical World

Focus Area Approach

Driven by Real Applications
Creating Societal Impact

Focus of This Program

Close Coupling Required

Foundations Research

Experimental Systems

Reusable Systems & Science

Deployed Infrastructure Applications

Commercial Solutions

Accelerate Progress
Realize Full Potential

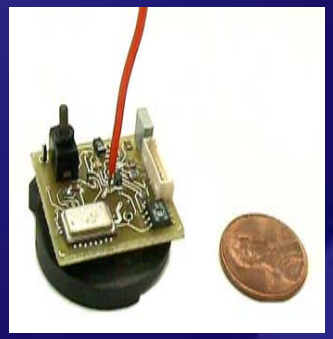
Challenge of the Moment

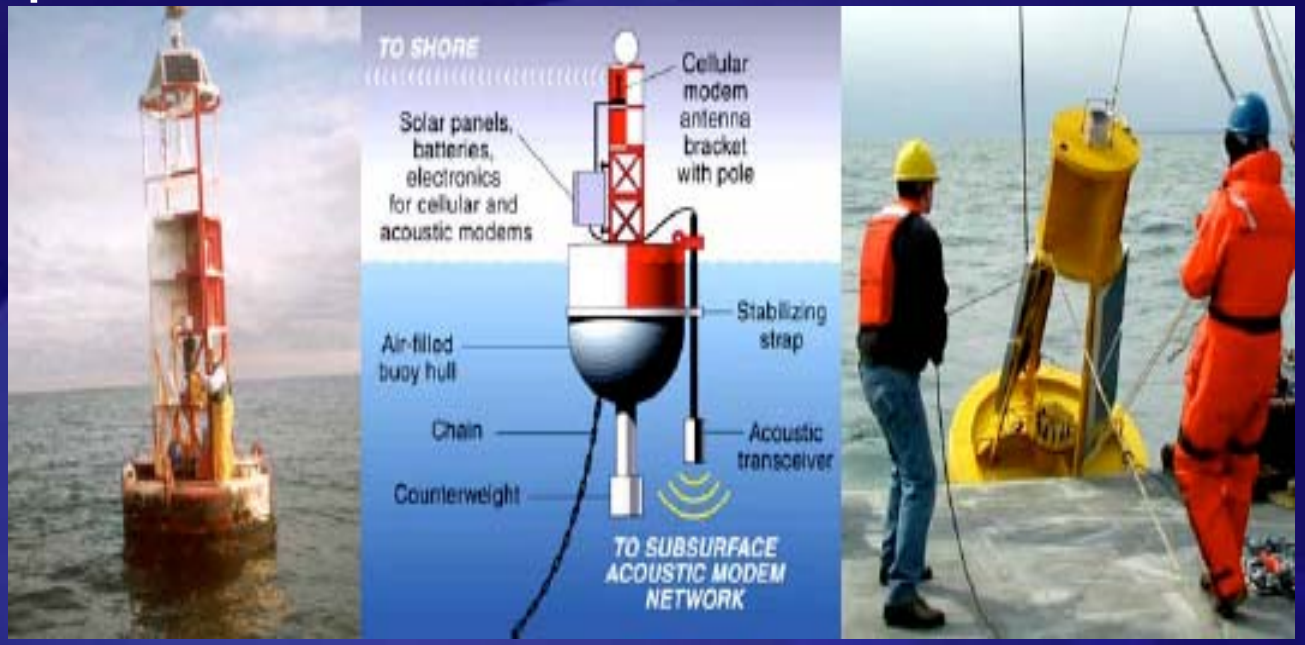
How can we, the research community, lead the sensor network revolution by

- Championing an architecture for supporting future/real applications
- Realizing the architecture in hardware and software
- Building testbeds and applications
- Increasing fundamental understanding of senor networks (go beyond motes)
- to enable a programmable, robust, secured, manageable sensor network substrate (over future Internet)
- Integrated solution from sensor, data communications, data processing, actuation, and feed back to environmental changes for real applications.

Challenges (Cont.)

- Motes vs. Special Sensors





- Accurate vs. Fuzzy Data
- Lacking Application Domain Knowledge
- Lacking Accesses to Real Data
- Ideal vs. Real Environment

Protocols/Algorithms Challenge

Given

- New types of devices with differing capabilities
- A variety of wireless and some wired links
- Different connectivity and failure modes
- Applications with very different requirements

Need to invent new protocols, algorithms, & their implementations

System Design Challenge

- Challenging space of trade-offs
  - Energy vs duty cycle
  - Failure rates and redundancy
  - Computing vs communications
  - RF power vs range
  - Time
  - Space
- Need new design and verification models, methodologies and tools to help system design
- Need new hardware and software systems
  - **Sensor node, OS, programming environment, in-network processing**

Security and Privacy Challenge

- Very different and challenging
  - Physical environment cannot be protected
  - Traditional firewall & key distribution approaches do not work
  - A compromised sensor node or application can easily disrupt, carefully alter, or snoop operation
  - Damage would be very serious
- Need new thinking and solutions
  - Implications on hardware, OS, networked programming tools
  - Have just barely started

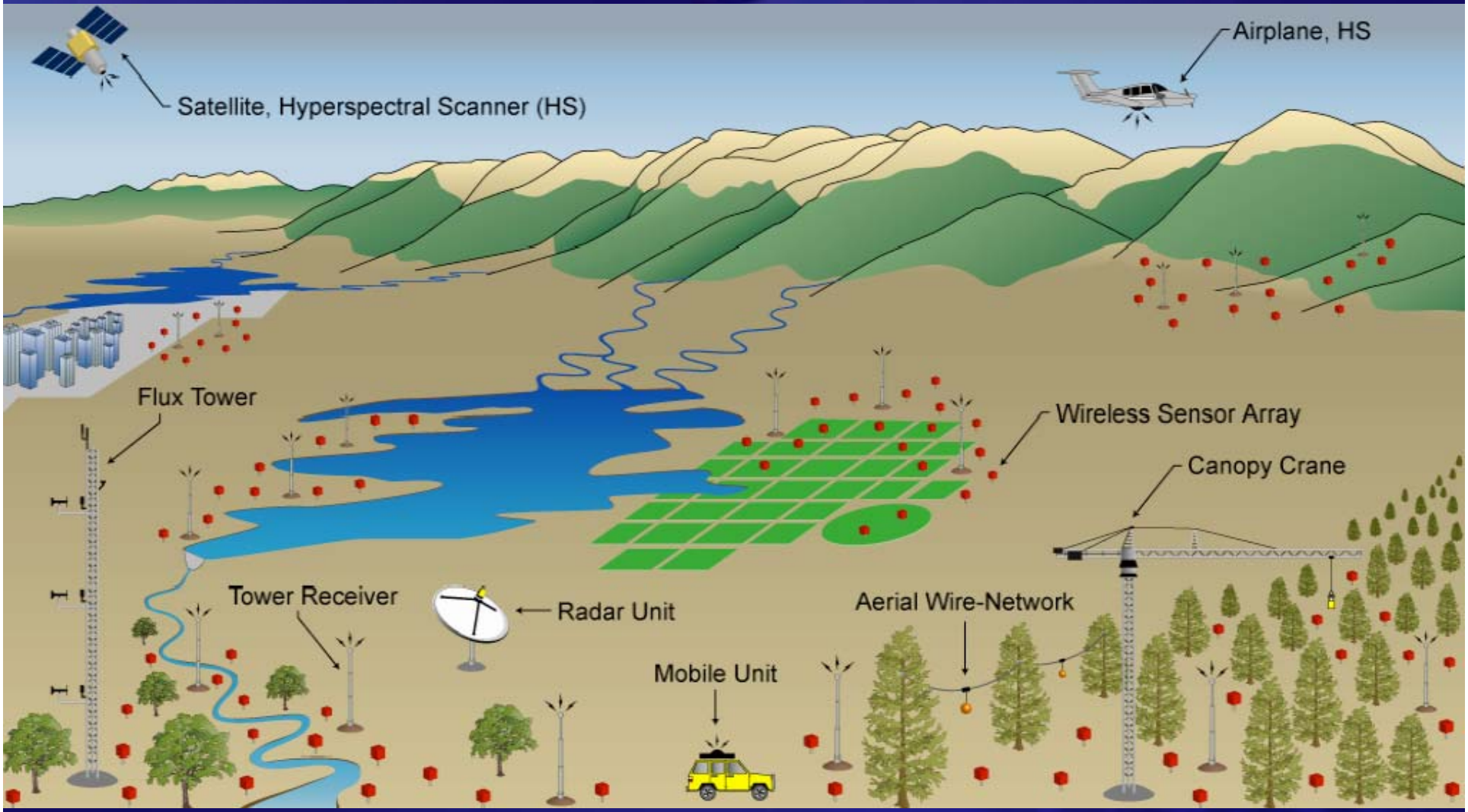
Network Programming Challenge

- Need to program a group of potentially 1000s of sensor systems with a set of unique constraints
- Need new programming models and tools
  - equivalent of “socket” interface
  - Increase ease of programming and reusability
  - New abstractions and automatic mapping on an array
  - Assure privacy and security
- In-network computing an integral part

Coordination and Opportunities

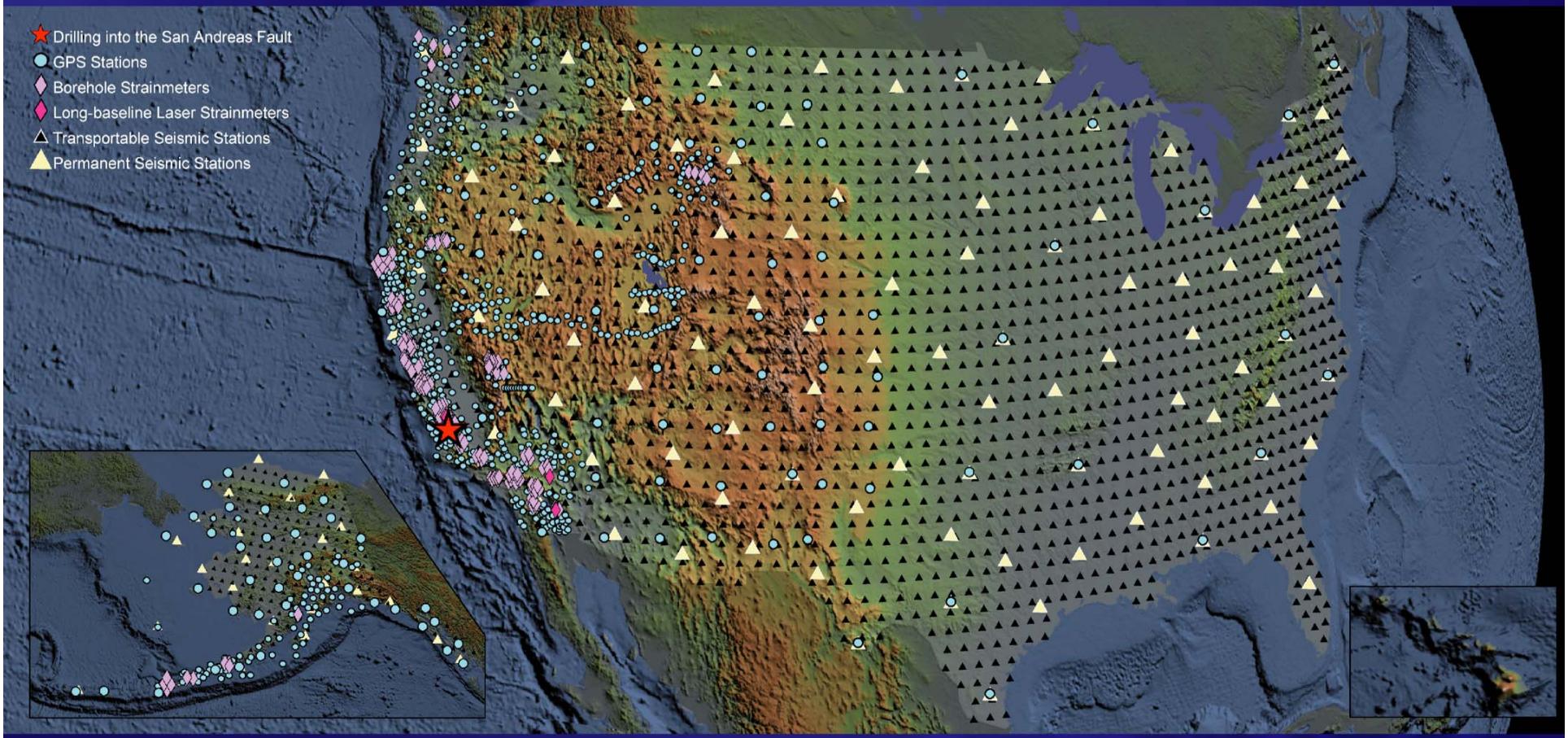
- Within NSF
  - Engineering Directorate Sensor Initiative
  - Cyber Trust on Security and Privacy
  - CSR on Embedded Systems, Storage, Applications
  - IIS on Robotics and Data Management
  - NEON
  - EarthScope
  - Polar Program
- Navy Undersea Water Sensor Networks
- Army Sensor Network Program
- Air Force UAV and Target Tracking
- NASA Sensor Web

NEON:
National Ecological Observatory Network

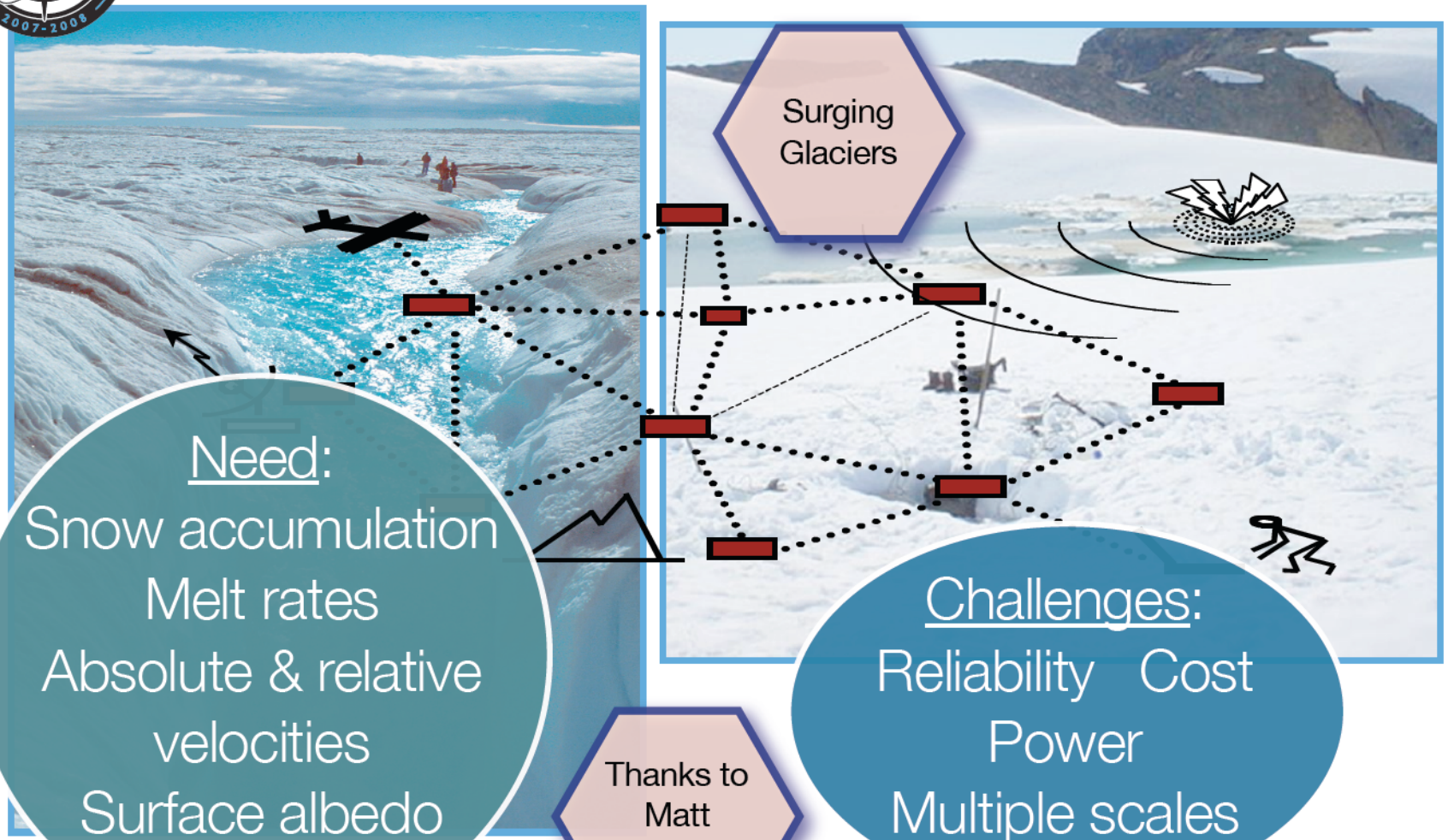


EarthScope: A Continental-Scale "Sensor Network"

- 15-year effort to understand earthquakes, volcanism, and plate movements in N. America
  - 400 seismometers, 1000 GPS stations, 180 strainmeters

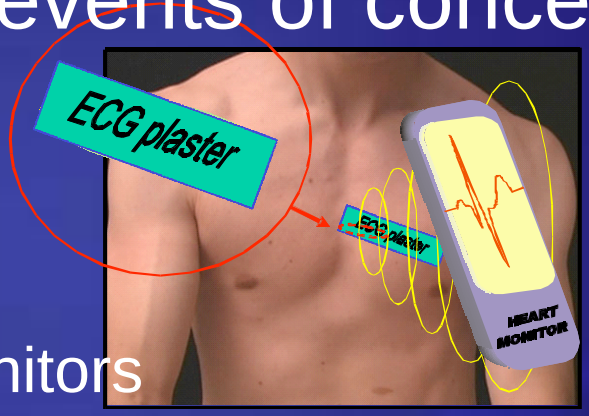


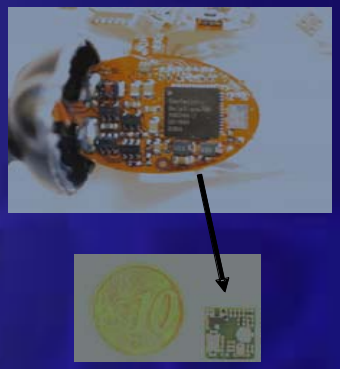
Sensor Networks in Antarctica



Smart Sensors in the environment and on the people

- The monitors and sensors include embedded software systems which can autonomously detect events of concern, e.g.:
  - Wearable sensors
    - Fall sensors
    - Heart rate or pulse monitors
  - Stationary sensors
    - Motion detectors
    - Camera systems





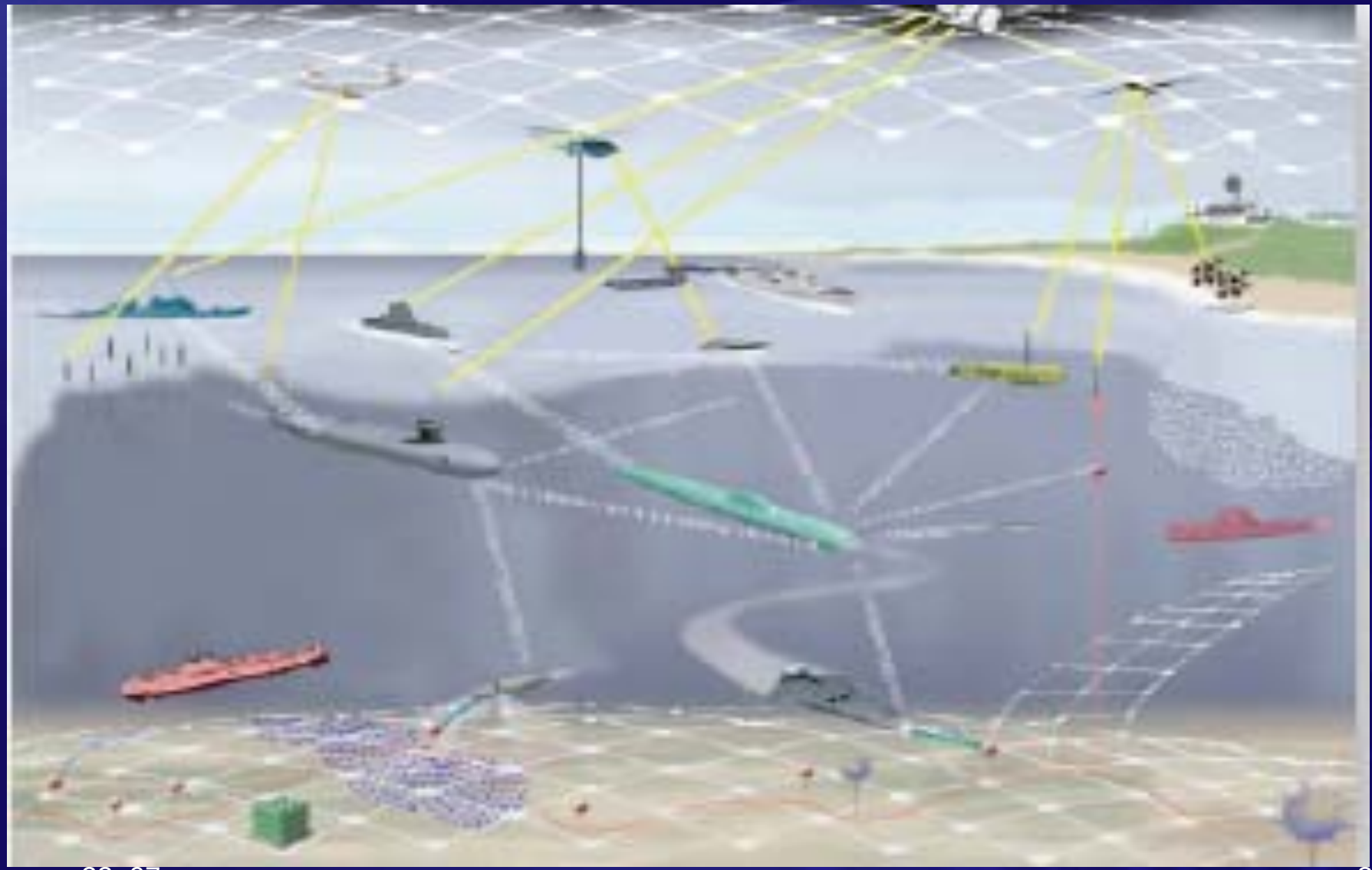
System Miniaturization and Integration for 3D Stacked SiP by TUT/ELE

- On their own, we can not expect to have sufficient accuracy, however in combination they will

Next Generation SCADA/DCS: Cyber Control of our Physical Infrastructures

- Our critical physical infrastructures depend on SCADA and DCS. SCADA and DCS depend on the gathering, monitoring, and control of information from distributed sensing devices.
- The advent of advances in wireless network embedded systems for distributed sensing devices and software, present an opportunity for a new generation of secure critical physical infrastructures

Next Generation of Undersea Warfare



Connections to NASA Sensor Web

- Collaboration on Research Funding
- Joint PI Meeting
- Share Data on Real Applications
- Share Sensor Network Testbeds
  - What is a sensor network testbed?
- Research Results and Information Exchange
- Others?

Summary

- Potential Big Societal Impact with Real Applications
- Hard to Design Hardware/Software Platforms for Sensor Networks
- Multi-disciplinary in Nature
- Tradeoffs in Senor, Networking and Data Processing
- Require Lots of Coordination to Be Successful
- Want to be a reviewer for NeTS. Please visit http://www.nsf.gov/cise/reviewer/index.cfm?cise_div=cns&key=cns_nets07507