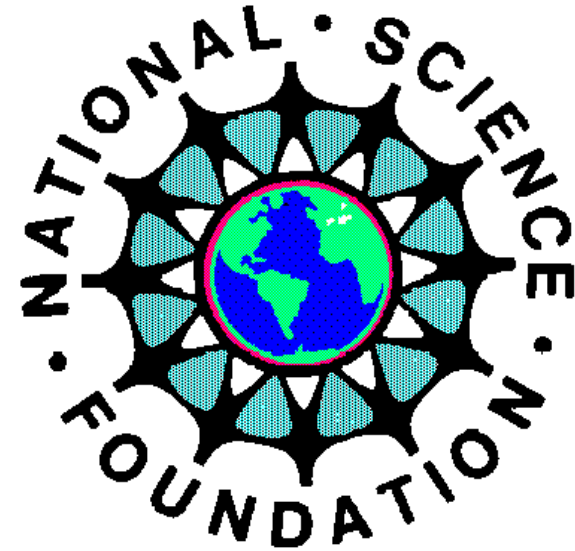


Civil and Mechanical  
Systems (CMS)  
Programs at the  
NATIONAL  
SCIENCE  
FOUNDATION

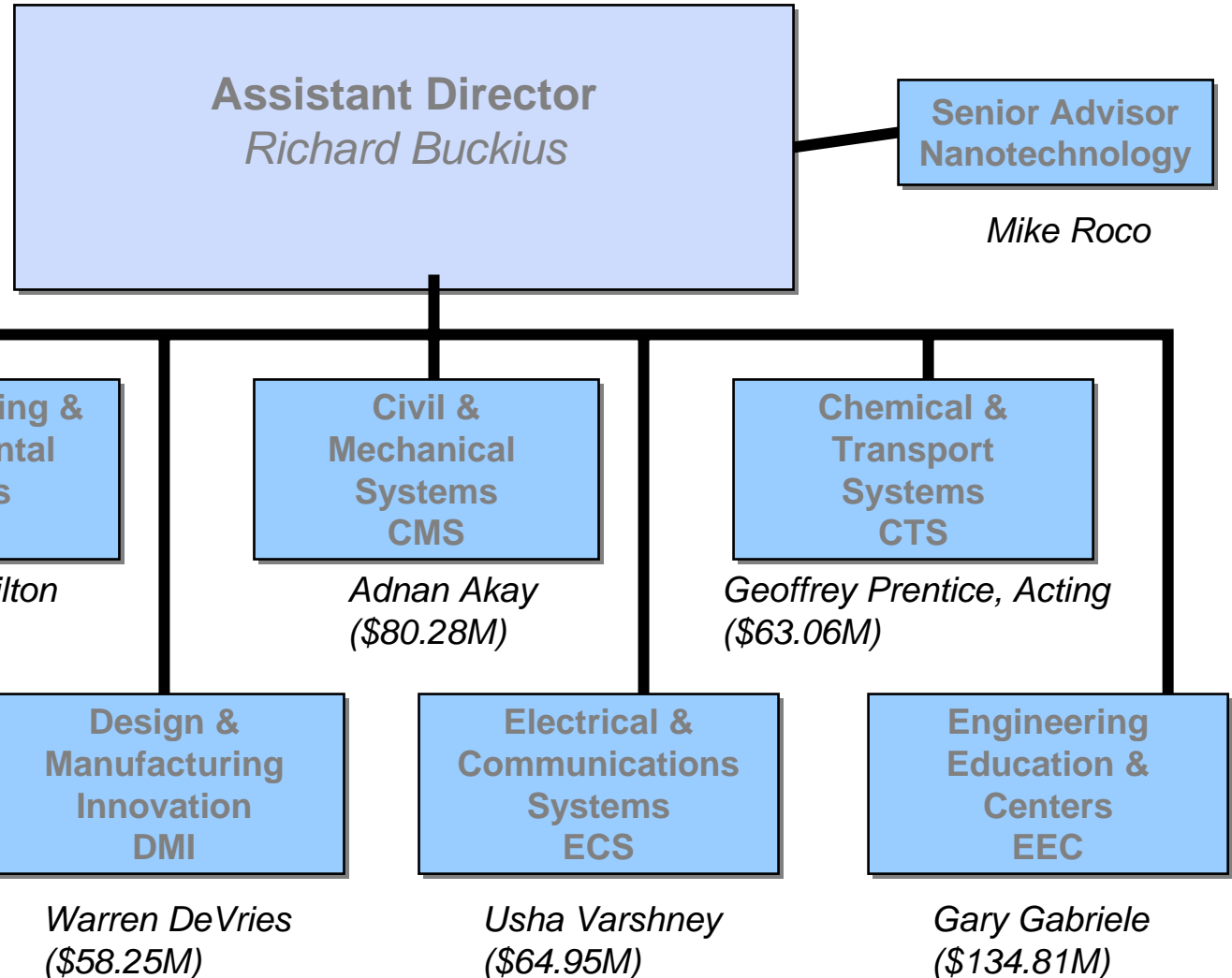


**Shih-Chi Liu, Program Director**  
**Sensor Technology for Civil and**  
**Mechanical Systems**

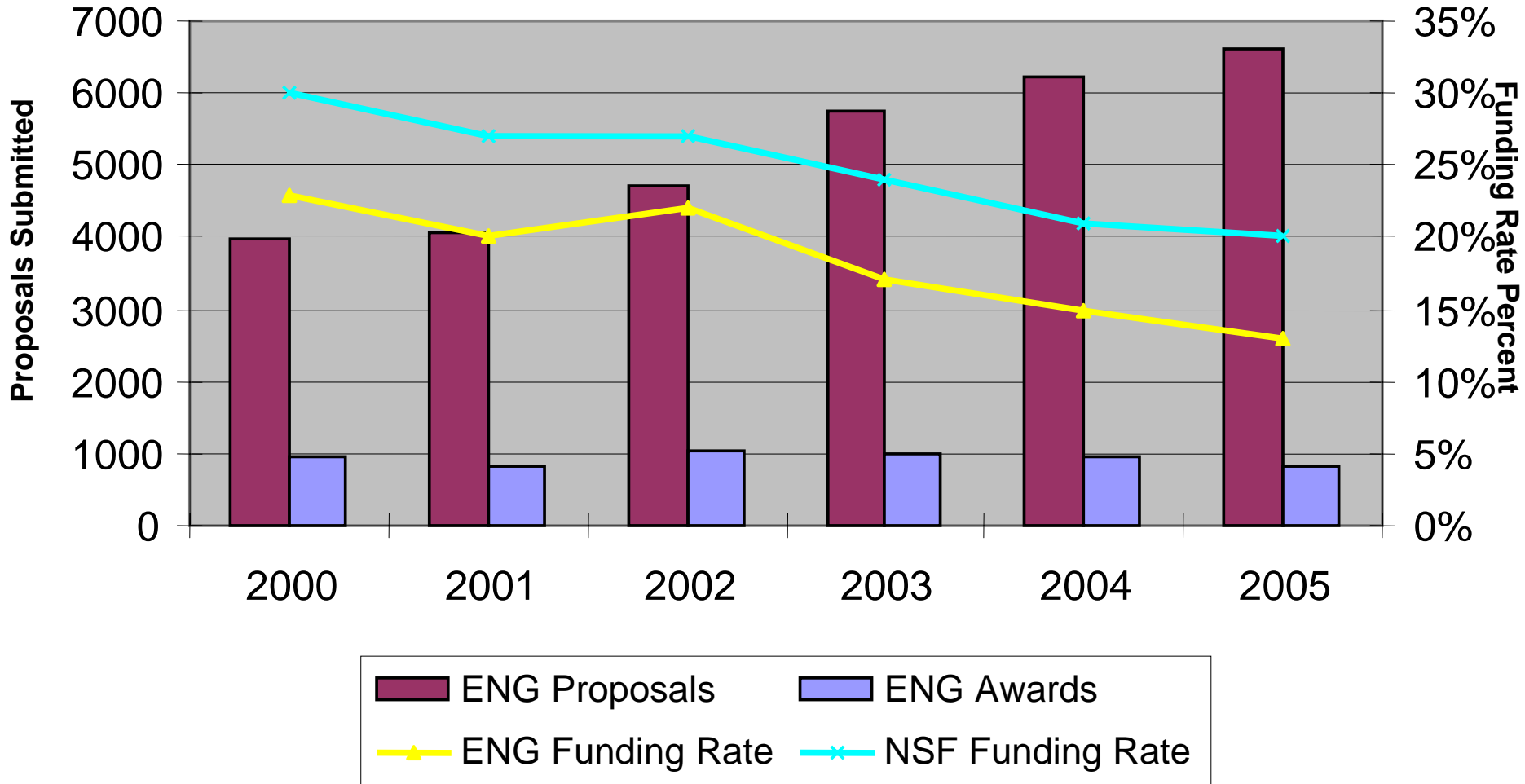
# Directorate for Engineering FY 06 Budget

NSF: \$5,581.17M

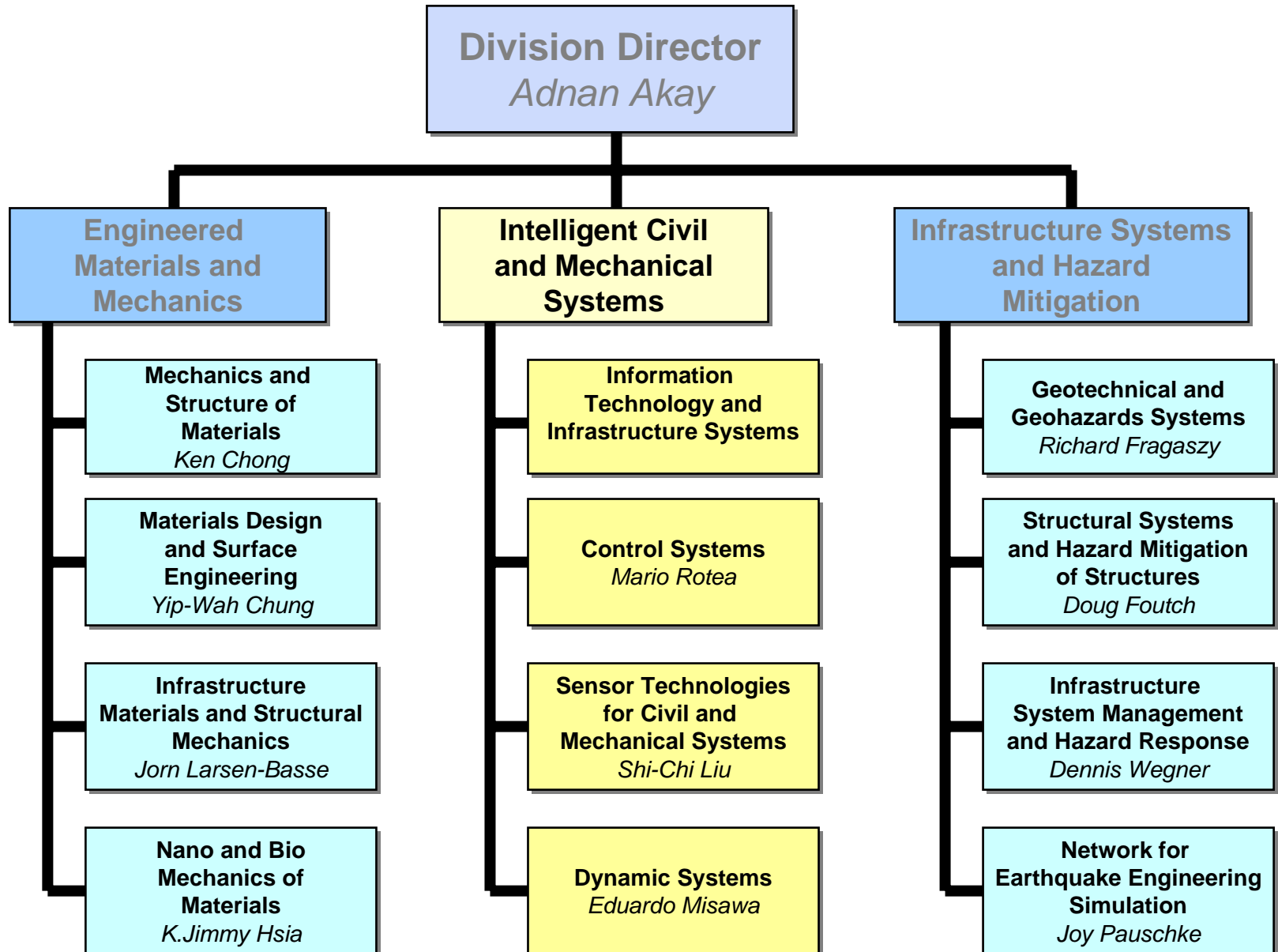
ENG: \$575.38M



# Research Grant Funding Rate

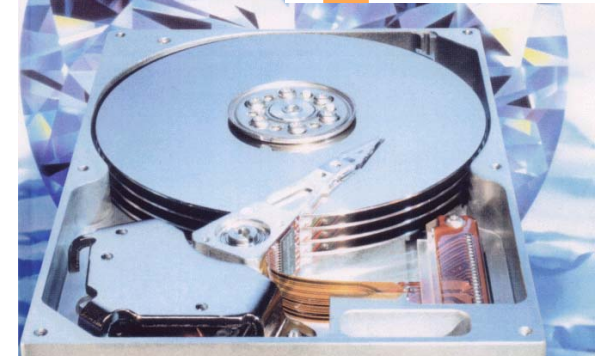
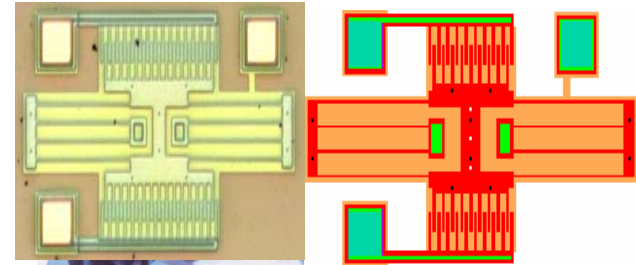


# Civil and Mechanical Systems (CMS)



# Intelligent Civil and Mechanical Systems

- *Research support for:*
  - **modeling** of structural dynamics, vibrations, acoustics, and kinematics relationships.
  - **sensing**, acquiring, imaging and transmitting information at all physical scales
  - **control** of civil and mechanical systems
  - **integration** of sensors, actuators, controllers, and power sources
  - smart materials, smart structures and control strategies for them.
- *Applications to*
  - mechatronic systems
  - from nan/micro systems to civil infrastructures such as bridges and buildings



# Sensor Technologies for Civil and Mechanical Systems Program

- *New*
- *Rapidly emerging importance*
- *Diverse fields: no uniquely identifiable community*
- *Transformation of engineering practices*
- *Extreme industrial and commercial values*

# **Sensors and Sensor Networks (Sensors)**

***Program Solicitation***

**NSF 05-526**

***Replaces Document 03-512 & 04-522***

**National Science Foundation**

Directorate for Engineering

Directorate for Geosciences

Office of Polar Programs

# **Sensors and Sensor Networks (NSF03-512, 04-522 & 05-526)**

- **NSF wide initiative started in 2003.**  
--\$45M
- **FY 2004**  
– ~\$39M
- **FY 2005**  
– -\$30M



## Sensors and Sensor Networks ENG Funding Profile (\$K) FY2004

	ECS	BES	CMS	CTS	DMI I	Total ENG
SIRG	1,800	529	500	400	0	3229
SST	2455	2382	2520	1732	2815	11,904
SII	1745	2208	2040	2342	1817	9,521
II Pre- solic.	1000	1000	976	915	2000	5890
	7000	6119	6035	5388	6002	30,544

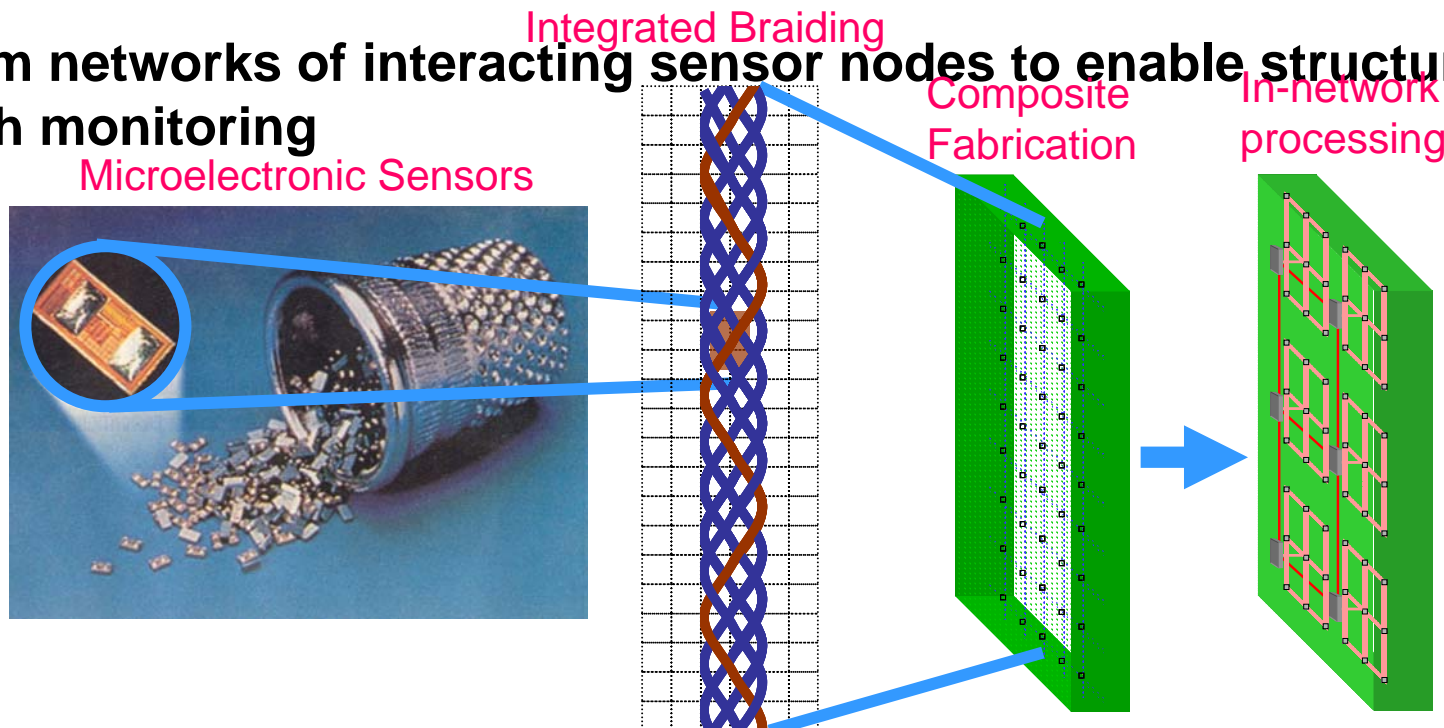
**\$24,655K in ENG awards for proposals submitted directly to NSF 04-522 (13% for SIRG, 48% for SST and 39% for SII)**

# Self-Monitoring Structural Composite Materials with Integrated Sensing Networks

University of California, San Diego  
*Sia Nemat-Nasser, David Meyer, David R. Smith*

## Objective:

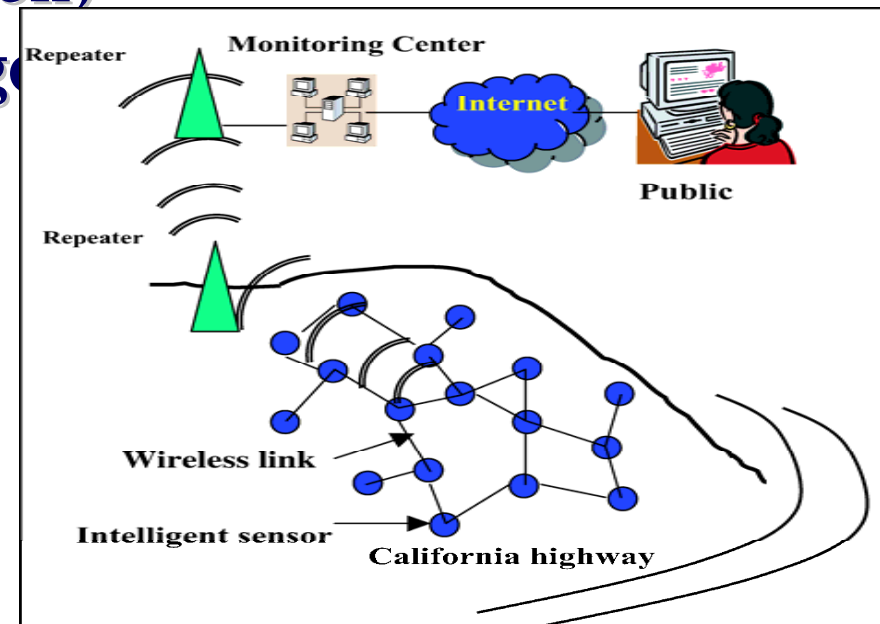
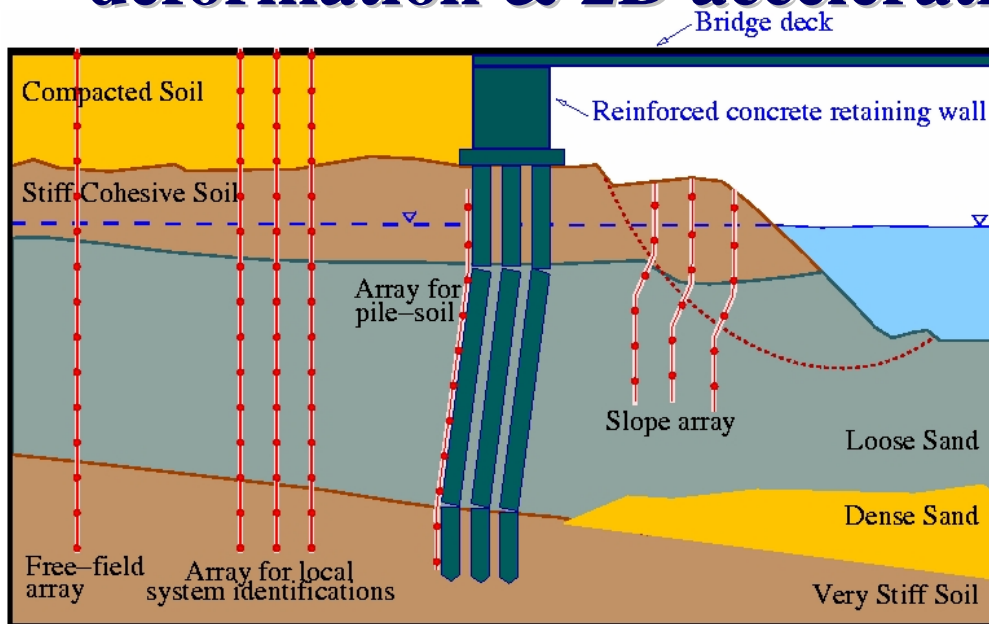
- Embed micro sensors and microcontrollers within fiber braids and weaves used in composite fabrication
- Form networks of interacting sensor nodes to enable structural health monitoring



# Advanced Sensing For Geotechnical Systems

## Objective:

- Develop a novel *wireless shape-acceleration sensor array* based on **Fiber-optic & MEMS** technologies (**3D deformation & 2D acceleration**)



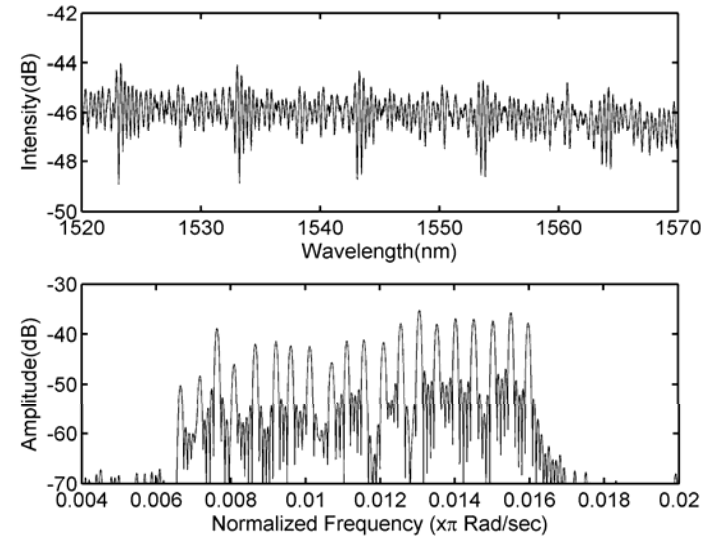
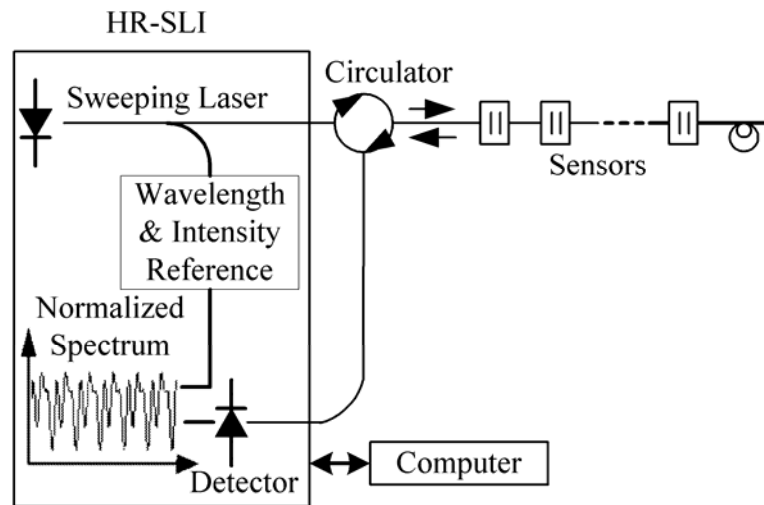
Vision of installed *shape-acceleration sensor arrays* in an active soil systems

Wireless network for real-time monitoring of geotechnical systems

*Tarek Abdoun, Mourad Zeghal & Alhussein Abouzeid (RPI)*

# Infrastructure Multiplexed Optical Fiber Sensing Networks Monitoring

PIs: Anbo Wang, G. Pickrell, K. Cooper, T. Lin, L. DaSilver  
Virginia Polytechnic Institute and State University



- Multiple sensors along single fiber
- Different frequencies for sensors with different cavity lengths
- Demodulated in frequency domain
- Large multiplexing capacity

# Sensors for the Detection of Explosives



**2007**  
BUDGET  
REQUEST

**\$20  
million**







**Tsing Ma Bridge**



**Kap Shui Mun Bridge**



**Ting Kau Bridge**



**Stonecutters Bridge**



**Shenzhen Western Corridor**



**Sutong Bridge, Jiangsu, China**



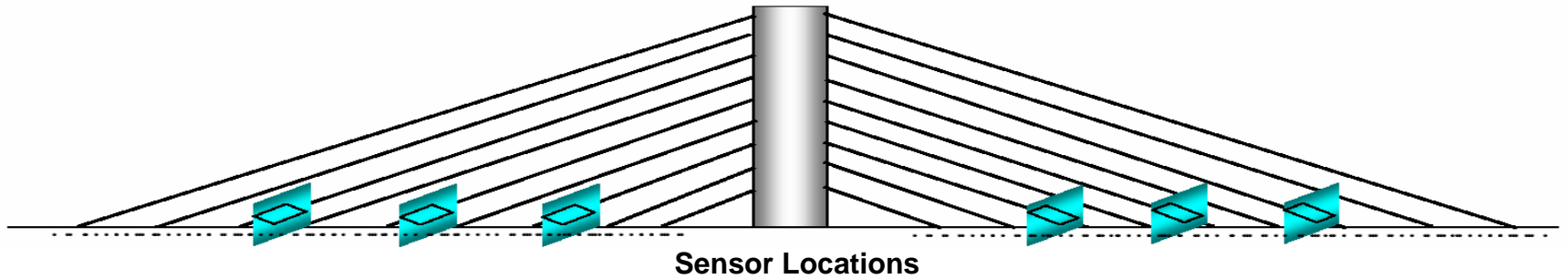
**4<sup>th</sup> Qianjiang Bridge, Hangzhou, China**



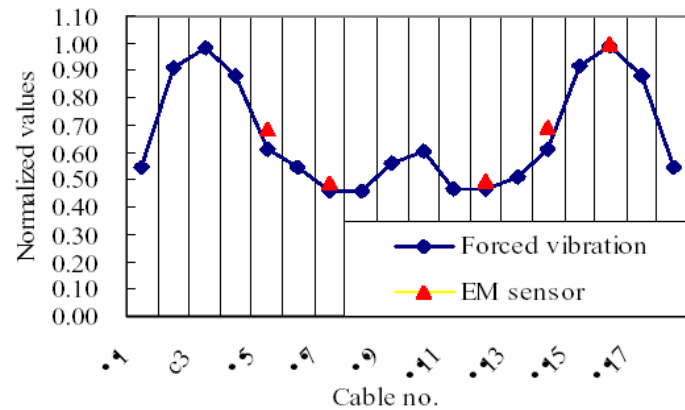
**Jiangyi Bridge, Jiangsu, China; Main-span 1385m**

# EM Stress Sensors on Asidagawa Cable Stayed Bridge (Japan)

University of Illinois-Chicago and KRC Japan



Sensor Beneath the Deck



Measured Results

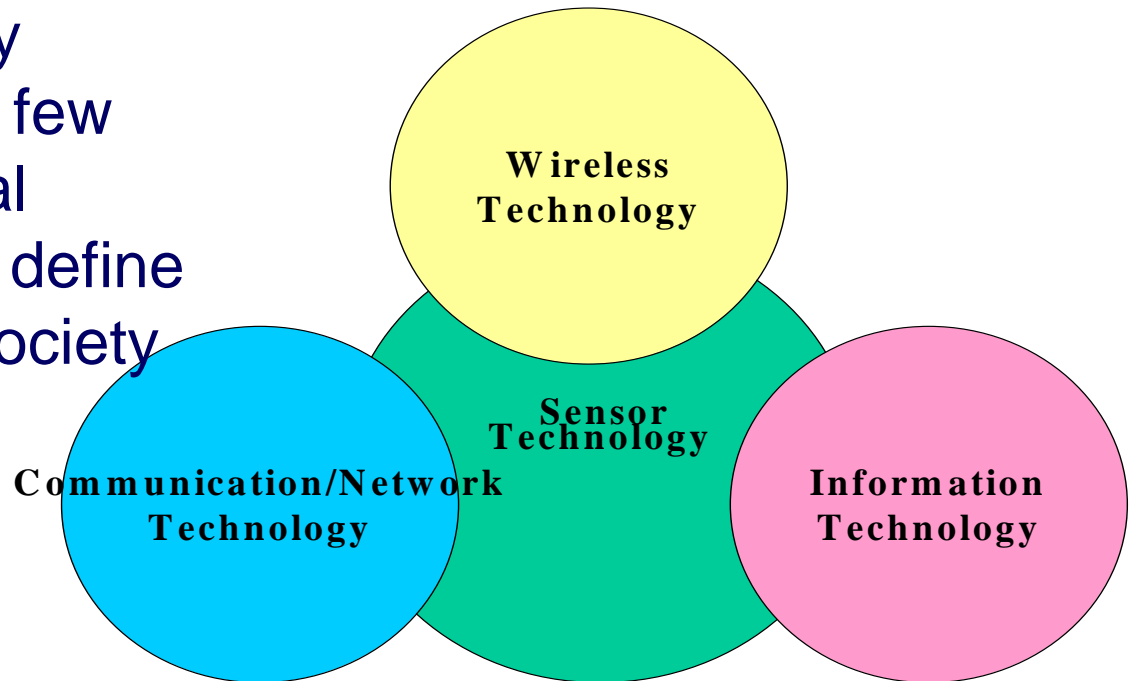


# **Current Challenges of Structural Health Monitoring**

- ❖ **Development of a structural health monitoring system to fully achieve the above objectives and benefits is still a challenge at present, and needs well coordinated interdisciplinary research;**
- ❖ **The current challenges for bridge structural health monitoring are being identified as**
  - ❖ **distributed and embedded sensing,**
  - ❖ **data management and storage,**
  - ❖ **data mining and knowledge discovery,**
  - ❖ **diagnostic methods,**
  - ❖ **decision making on maintenance and management.**

# SENSORS TECHNOLOGY RESEARCH

- Sensor technology transforms engineering from the old data-poor practice to the modern data-rich practice.
- Sensor technology closely interfaces a few most transcendental technologies which define our modern living society
- Significant industrial and commercial value.



# International Collaborations

- **Asian-Pacific Network of Centers of Research on Smart Structures Technology (ANCRISST) that includes the USA, Japan, Korea and China.**
- **Collaboration between NSF and European Science Foundation (ESF) in Smart Structures Technologies.**
- **Collaboration between NSF and funding agencies in Asian countries.**

# Autonomous Intelligence

**Target:** Enhancing human performance for next generation technology

**Purpose:** Development of fundamental bases, principles, and tools for creation of systems and devices with embedded human-centric and human-like intelligence and autonomy

**Application:** Improved health (particularly for disabled and aging population), security and safety

# **Transformative Idea & Research**

- **Biomimetic and biocompatible materials for implantable & wearable devices**
- **New generation biomimetic and bio-inspired sensors and actuators animating human senses & control**
- **New paradigms of sensor fusion and on-line informatics**
- **Autonomous systems with cognitive capabilities for self awareness and learning**

# Transformative Idea & Research (Cont'd)

- Human cognitive robotic systems
- Human-machine-environment interfaces and cooperative protocols
- Connective human-like

# Research Thrust Areas

- **Multi-functional materials & morphic systems design and control**
- **Next generation self-powered smart sensing and actuating systems on micro and nano scales**
- **Implantable & wearable intelligent devices**
- **Next generation of intelligent robotic systems**
- **Synergistic research between cognitive and system sciences to enable self awareness and learning**

**Sensor Technology for Civil & Mechanical Systems**  
**Program 1639 Program Director: Shih-Chi Liu**

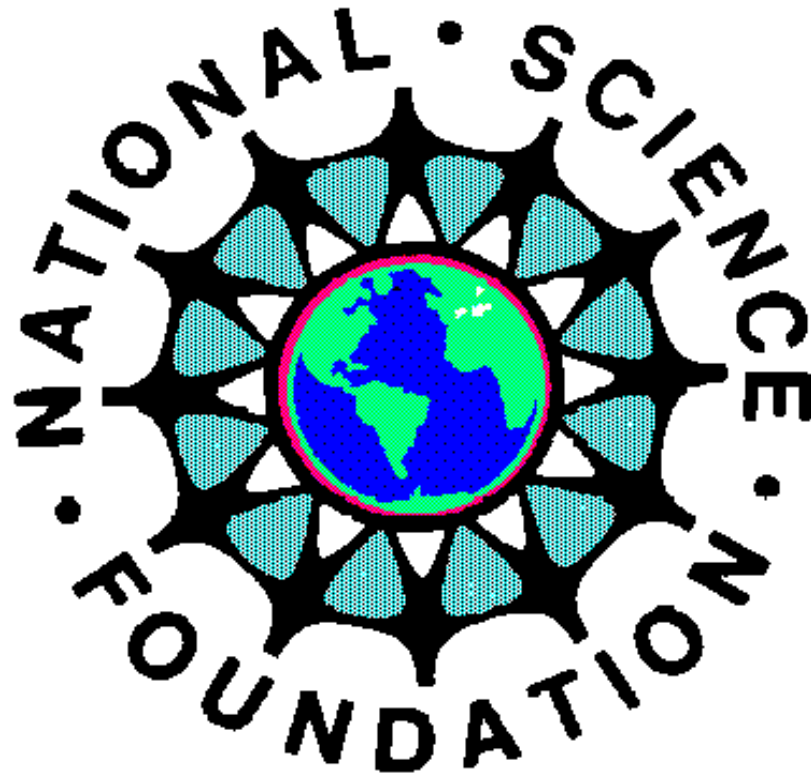


**Systems & Structures with Autonomous Intelligence**



# Useful Web Addresses

- **National Science Foundation:** [www.nsf.gov](http://www.nsf.gov)
- **Civil & Mechanical Systems:** <http://www.eng.nsf.gov/cms/>
- **Grant Proposal Guide:**  
<http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf0423>
- **FY2004 Guide to Programs:**  
<http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf04009>
- **Sensors and Sensor Networks (FY2004 version):**  
[http://www.nsf.gov/pubsys/ods/getpub.cfm?ods\\_key=nsf04522](http://www.nsf.gov/pubsys/ods/getpub.cfm?ods_key=nsf04522)
- **Mathematical Sciences: Innovations at the Interface with the Sciences and Engineering (FY2004 version):**  
[http://www.nsf.gov/pubsys/ods/getpub.cfm?ods\\_key=nsf04538](http://www.nsf.gov/pubsys/ods/getpub.cfm?ods_key=nsf04538)
- **Program Officers (Dynamic Systems, Modeling, Sensing and Control)**



<http://www.nsf.gov>

FY 2004 Guide to Programs [nsf04009]  
Grant Proposal Guide [nsf04002]