

# RESEARCH INFRASTRUCTURE SUBGROUP

The Committee concluded that there has been significant achievement for the Research Infrastructure outcome goal.

## Introduction

The Research Infrastructure Subgroup of the Advisory Committee for GPRA Performance Assessment was asked to assess activities at the NSF in the area of Research Infrastructure. Specifically, it is a goal of the Foundation to “Build the nation’s research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure and experimental tools” (NSF Strategic Plan FY 2006-2011).



## Process Followed and Criteria Used

### Subgroup Members

Mary Ellen Sheridan (Chair)  
University of Chicago

Jorge L. Diaz-Herrera  
Rochester Institute of Technology

Samuel M. Rankin, III  
American Mathematical Society

The Research Infrastructure Subgroup reviewed 115 highlights classified under this goal. Each member of the Subgroup reviewed approximately 35-40 highlights. Highlights selected for inclusion in the report for this strategic outcome goal reflect the broad diversity and functional objectives of investments under Research Infrastructure.

The Subgroup was asked to review and evaluate the accomplishments against one or more of the following criteria:

### Major Multi-user Research Facilities

- *Promote discoveries at large multi-user research facilities supported by NSF which may be centralized or may consist of distributed installations. These facilities may incorporate large-scale networking or computational infrastructure, multi-user instruments or networks of such instruments; or other infrastructure, instrumentation, and equipment having a major impact on a broad segment of a scientific or engineering discipline. This category includes accelerators, telescopes, research vessels, aircraft, and geographically distributed but networked earthquake engineering simulation equipment.*

### Instrumentation

- *Provide tools, instruments, and facilities to enable the STEM community to conduct research that could not otherwise be performed without this advanced instrumentation infrastructure.*
- *Expand opportunities for U.S. researchers, educators, and students at all levels to access state-of-the-art science and engineering facilities, laboratory*

*instrumentation and equipment, databases, and advanced computing resources, research networks, and other infrastructure.*

## **Cyberinfrastructure**

- *Enable discoveries facilitated by world-class cyberinfrastructure that drives discovery in all fields of science and engineering.*
- *Explore the use of potential cyberinfrastructure in integration of research and education.*

## **Results of Analysis**

Research Infrastructure encompasses the entire scope and scale of science, mathematics, technology, and education, enabling the conduct of leading-edge research while educating the next generation and future generations of scientists and engineers. Imagine funding the discovery and development of probes that can detect the most singularly quantifiable constituents of the nucleus of an atom or production of an educational video that describes the “life” of a single electron that travels around any nucleus. Research infrastructure has evolved to a point where scientists and engineers can develop and use instrumentation and probes to study phenomena that are smaller than a single strand of hair. At the other end of the spectrum, research infrastructure supports construction, maintenance, and upgrades for telescopes that explore galaxies “far, far away,” where distance is measured in millions of light years. While grade school children are using desk top computers and digital hand-held games that have more computing power than mainframe computers of a generation ago, researchers advancing the frontiers of cyberinfrastructure are developing hardware that together with software and communication systems enables petascale computing power. That’s one million billion [ $10^{15}$ ] operations per second – virtually an incomprehensible much less imaginable number if the results weren’t there to be reckoned with. For example, a million billion seconds would work out to be 32 million years.

The significance of the Research Infrastructure goal is easier to grasp if one thinks of these investments as the critical facilities, tools, and resources that breach the boundaries of yesterday’s research and educational programs and enable new and more challenging questions to be answered while enriching educational experiences for graduate students and postdoctoral scholars. NSF’s Research Infrastructure investments are on the seas with ships carrying equipment and investigators to and from the Antarctic, and under the seas with submarines that explore the seabed. They are on virtually every continent with telescopes, particle detectors, and cyberinfrastructure collaborations. In addition to petascale computing tools, NSF also supports the preparation of searchable digital libraries and enormous databases that offer better teaching aids for K-12 teachers and students, or facilitate storm prediction or atmospheric modeling for the most challenging research questions. Predominantly undergraduate institutions benefit from Research Infrastructure investments in advanced instrumentation and programs that offer targeted research experiences for high school and college students to attract and train American students in science, technology, engineering, and mathematics (STEM) disciplines. Research-intensive institutions and special subject centers receive funding from NSF to

develop new research tools and to apply unique research capabilities targeted to practical purposes that will benefit the public. NSF's Research Infrastructure portfolio also includes the collection and analysis of data related to STEM for public information and national science policy analysis; NSF's Science and Engineering Indicators 2008, the foremost compendium of quantitative STEM data, is regarded internationally as the gold standard of such reports. The flavor and vast impact of some of these extraordinary "enablers" in each of the programmatic areas is highlighted below. The Subgroup selected the following highlights as examples of significant achievements in the area of Research Infrastructure.

### Major Multi-user Research Facilities

NSF's major multi-user facilities primarily benefit scientific inquiry while providing opportunities for integrating education and research. How safe is a modern-day operating hospital room in a moderate to severe earthquake? Investigator from SUNY at Buffalo (**Hospital Room Shook Up in First Seismic Experiment of Its Kind**, *Highlight 14938*, Awards [0429331](#) and [0402490](#)) used the Buffalo Structural Engineering and Earthquake Simulation Laboratory to explore the impact of shaking on nonstructural elements such as portable equipment, wall-mounted EKGs, ceilings, pipes, and internal walls in a model hospital room. Their findings will help hospitals to anticipate the impact and plan accordingly for the safety of patients and hospital personnel. Researchers at Stanford University (**Holding the San Andreas Fault in our Hands**, *Highlight 14818*, Award [0323938](#)) have been amassing data from samples bored into the San Andreas Fault, the most notorious earthquake zone in the United States. Scientists are using these samples to better understand episodic tremors and slips – the little fault line activities that accumulate strain slowly along the Fault plates. For the West Coast residents who live with the San Andreas Fault as a neighbor, improved understanding of fault behavior is practical research with tremendous potential public

"**When Planets Collide**" sounds like a Star Wars movie plot or a GameBoy title. But this is the report of exciting observations by a team from UCLA and the Spitzer Science Center from NSF's Gemini Observatory, which supports telescopes in Hawaii and Chile for observing from both the Northern and Southern hemispheres (*Highlight 15617*, Award [0525280](#)). Astronomers have found the first clear evidence of planet formation through observation of young stony planets which appear to have formed from a collision around one of the stars in the Pleiades clusters. Northern winter sky watchers recognize the Pleiades as one of the most brilliant star clusters.



### Instrumentation

A group of engineers at the National High Magnetic Field Laboratory at Florida State University (**Novel Technique to Study the Structure of Proteins**, *Highlight 16236*,

Award [0084173](#)) have developed a novel probe that will permit the use of nuclear magnetic resonance (NMR) for the study of proteins that don't dissolve in water. These new tools are opening up a new frontier in protein structure determination.

**Development of an In-Line Cylinder Bore Inspection System** (*Highlight 15077*, Award [0723669](#)) features an In-line Cylinder Bore Inspection System. This Small Business Innovation Research (SBIR) award to Industrial Optical Measurement Systems supported transformative research that replaces inefficient human visual inspection of cylinders of engine blocks with an automated total inspection of cylinder bore surface finish at the speed of a production line. This novel probe pushes automation and efficiency up a notch in the highly competitive automotive market with a potential to stem the market share loss of domestic producers.

In the midst of all this sophistication, there is also room in the NSF portfolio to explore good old-fashioned slime. For many youngsters, a little “play” with worms could be the pathway to a scientific career. The Nebraska State Museum teamed with a local academic lab to lead some middle schoolers for a romp through parasitology (**The Worms Crawl In, The Worms Crawl Out!**, *Highlight 15805*, Award [0646356](#)). What's not to like about cuddly worms, a fair portion of yuck, lots of curiosity, an admirable “ick” factor, worm humor, and learning. This project demonstrates that attracting young



people into scientific careers may begin with a real lab experience on a college campus. These students found out the getting a ‘hands-on’ worm experience was better than just watching “CSI.” NSF continues these enriched experiences for potential STEM careers through programs at minority and primarily undergraduate institutions providing sophisticated research instrumentation and summer research participation programs to allow students to preview scientific and technical opportunities.

## Cyberinfrastructure

NSF's leadership in high performance computing is generating computing capacities and capabilities that approach petascale ranges. Solving problems at a scale that was unimaginable and beyond our reach just a few years ago is now within reach. NSF's investments help anticipate and resolve the real problems and challenges of petascale computing: storage, manipulation, and mining of massive amounts of data that rely on complex hardware architectures, networking of parallel computing power, and heroic software solutions.

**Computer Recognizes Facial Expressions Better Than Humans Can** (*Highlight 16396*, Awards [0454233](#) and [0627822](#)) describes how researchers at the University of Buffalo and University of California, San Diego have developed the Computer Expression Recognition Toolbox that can be used by social scientists, education researchers, cognitive neuroscientists, and vision researchers. A particularly interesting

finding from their experiments was that automated classifiers were able to differentiate real pain from fake pain significantly better than inexperienced human subjects. Computers were able to detect driver drowsiness with more than 98% accuracy, perhaps telling us that computers can recognize facial expressions better than humans can. Research in these areas will also provide critical information for computer science and engineering efforts to make computers and robots that interact effectively with humans and understand nonverbal behavior.

Digital libraries offer delightful educational “shopping trips” for teachers and budding scientists. With **Chemistry Comes Alive**, (*Highlight 14835, Awards [0632303](#), [0632247](#) and [0632269](#)*), a collaborative project between the University of Wisconsin and the American Chemical Society, the curious can observe dangerous chemical reactions and learn about demonstrations or experiments that rivet the attention of young students. Dramatic footage and supplemental educational materials make this a wonderfully attractive and easily accessible resource. This project addresses both the Research Infrastructure and Learning goals by providing teachers and students the opportunity to view a diverse array of chemical reactions that demonstrate concepts in chemistry.



Recent advances in computational linguistics enabled by NSF funding have produced the Sanskrit digital library (**International Digital Sanskrit Library Integration**, *Highlight 16177, Awards [0535207](#) and [0535038](#)*). This resource challenged the most sophisticated computer scientists – because robust techniques involving recognition factors, selection, and mapping rules made this venture a veritable romp in computational linguistics. The digital Sanskrit tool and infrastructure provide an internationally accessible tool that will replace outmoded grammars, reference books, and other printer materials that will facilitate and broaden participation in linguistics research.

NSF’s interest in accumulating massive data bases spans disparate fields, from aggregations of huge volumes of astronomical observations to atmospheric histories that promote challenging modeling and simulation research. Climate modeling has direct relevance for global climate change research and policy issues leading to factual, informed decision making. **Creation of a new satellite-based hurricane database** (*Highlight 15823, Award [0614812](#)*) describes the development of the URSAT dataset which contains 170,000 storm-centered satellite observations in over 2,000 storms worldwide. Researchers at the University of Wisconsin and NOAA’s National Climatic Data Center have developed the first global homogeneous record of tropical cyclone intensity estimates from 1978-2006. Hurricanes and tropical storms have a major impact on U.S. and global economy; this database may provide better insight into how increasing temperatures could affect the intensity of hurricanes and cyclones.