THE STATE OF RESEARCH INFRASTRUCTURE AT U.S. UNIVERSITIES

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

FEBRUARY 23, 2010

Serial No. 111–77

Printed for the use of the Committee on Science and Technology

Available via the World Wide Web: http://www.science.house.gov

U.S. GOVERNMENT PRINTING OFFICE

55–835PDF WASHINGTON : 2010

For sale by the Superintendent of Documents, U.S. Government Printing Office
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February 23, 2010

THE STATE OF RESEARCH INFRASTRUCTURE AT U.S. UNIVERSITIES

TUESDAY, FEBRUARY 23, 2010

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION
COMMITTEE ON SCIENCE AND TECHNOLOGY
Washington, DC.

The Subcommittee met, pursuant to call, at 2:03 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Daniel Lipinski [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

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COMMITTEE ON SCIENCE AND TECHNOLOGY

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WASHINGTON, DC 20515–6301
(202) 225–6375
http://science.house.gov

Hearing on

The State of Research Infrastructure at U.S. Universities

Tuesday, February 23, 2010
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Leslie Tolbert
Vice President for Research, Graduate Studies and Economic Development
University of Arizona

Mr. Albert Horvath
Senior Vice President for Finance and Business
Pennsylvania State University
and Chair, Board of Directors, Council on Government Relations

Dr. John R. Raymond
Vice President for Academic Affairs and Provost
Medical University of South Carolina
and Chair, State of South Carolina EPSCoR Committee

Dr. Thom Dunning
Director of the National Center for Supercomputing Applications
University of Illinois at Urbana-Champaign

HEARING CHARTER

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

The State of Research Infrastructure at U.S. Universities

TUESDAY, FEBRUARY 23, 2010
2:00 P.M.–4:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

The purpose of this hearing is to examine the research and research training infrastructure of our universities and colleges, including research facilities, and cyberinfrastructure capabilities, the capacity of the research infrastructure to meet the needs of U.S. scientists and engineers now and in the future, and the appropriate role of the Federal government in sustaining such infrastructure.

2. Witnesses:

- **Dr. Leslie Tolbert,** Vice President for Research, Graduate Studies and Economic Development, University of Arizona
- **Mr. Albert Horvath,** Senior Vice President for Finance and Business, Pennsylvania State University
- **Dr. John R. Raymond,** Vice President for Academic Affairs and Provost, Medical University of South Carolina, and Chair, State of South Carolina EPSCoR Committee
- **Dr. Thom Dunning,** Director of the National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign

3. Overarching Questions:

- What is the state of the nation's academic research facilities? Are current academic research facilities keeping U.S. scientists and engineers competitive with their international counterparts and are they allowing for cutting edge science? How are universities and colleges maintaining and improving their research facilities? How has the economic climate affected short-term and long-term planning and investments in academic research facilities?
- What is the status of the nation's cyberinfrastructure? Do our research and education networks have the capacity to support computational, storage, data transfer and scientific exchange needs that have become critical to performing innovative research? How are universities and colleges investing in their own cyberinfrastructure? How are universities partnering with state and local governments as well as the private sector to build regional cyberinfrastructure capabilities?
- What is the appropriate role of the Federal government in supporting the research infrastructure of our universities and colleges? How do Federal agencies such as the National Science Foundation support research infrastructure that benefits the science and engineering enterprise? Given the trade-off between support for research and the support of research facilities should NSF revive their Academic Research Infrastructure Program? What other options, beyond targeted programs, are there for Federal science agencies to support academic research infrastructure?

4. Background

University Research Infrastructure

Since 1988, NSF has conducted a biennial survey on the status of research facilities at academic institutions, nonprofit biomedical research organizations and university hospitals. The survey currently includes data on: the amount of research space, the condition of research facilities, current expenditures and plans for new construction as well as the renovation of research facilities, sources of funds for construction and renovation, and information technology capabilities.

According to the latest NSF survey,[1] 77 percent of the respondents rated the condition of their research space as satisfactory or superior with the remainder indicating that their research space needed to be renovated or replaced. The survey also showed that academic institutions spent $6.1 billion on new construction and $2.4 billion on the repair and renovation of research facilities, but deferred $10.2 billion in new construction projects and $3.5 billion in renovation projects. Despite deferred investments, the amount of research space at academic institutions has steadily increased to 192 million square feet in 2007, although the rate of increase has slowed to 3.7 percent, down from its peak of 11 percent between 2001 and 2003.

Academic institutions fund their capital investments through a combination of sources: the Federal government, state and local governments, and institutional funds, which include endowments, private donations, and facilities and administration (F&A) costs recovered from the Federal government. The Federal share of these capital investments is generally about five percent, with the state/local governments accounting for 22 percent, and the institutions themselves contributing 72 percent. As just noted, the institutional share does include F&A costs reimbursed by the Federal government as part of Federal contracts and grants, primarily research grants. The reimbursed funds are used for such activities as operation and maintenance of research facilities, library expenses, department administration, including secretaries, academic deans, and grant compliance officers. However, according to a 2000 RAND study,[2] the true F&A costs incurred by an institution are higher than the rate for which they are reimbursed and analyses indicate that universities are recouping between 70 to 90 percent of the amount they are actually spending on facilities and administration.

Cyberinfrastructure

Advances in information technology have changed the way research is conducted. In 2005, NSF created the Office of Cyberinfrastructure (OCI) to ensure a comprehensive vision and set of investments in the research, development, acquisition, and operation of cyberinfrastructure across NSF's research directorates. Cyberinfrastructure, which consists of computing systems, data storage systems, data repositories, advanced instruments, and the networks and software that link these systems, has become increasingly important to all science and engineering disciplines. OCI requested a budget of $228 million in FY 2011, a 6.4 percent increase from FY 2010, with the largest investment proposed for the development of petascale computing capabilities.

NSF's recent Science and Engineering Indicators report[3] shows that all institutions of higher education have access to the internet, which was not the case earlier in the decade, but the bandwidth capability or speed of internet connection varied across institution type. The overwhelming majority (83 percent) of institutions with a bandwidth of at least 1 gigabit per second were doctoral degree granting institutions, and all but one institution with a bandwidth greater than 2.4 gigabits per second granted doctoral degrees. Despite the current differences in capabilities, data from NSF indicates that all colleges and universities are investing heavily in the expansion of their networks and are improving wireless campus coverage as well as their external and internal network speeds.

NSF's Academic Research Infrastructure Program

The Academic Research Infrastructure (ARI) program was originally authorized by the Science and Technology Committee in 1988, with funding authorized through 1993. The authorization level grew from $80 million in 1989 to $250 million in 1993. The original ARI program consisted of two components: support for the acquisition or development of major research instrumentation and support for the improvement of research and research training facilities.

ARI was included in appropriations bills from 1990 until 1996. It was initially funded at $20 million, and rose steadily to $100 million with an anomalous peak of $250 million in 1995. Beginning in 1997, NSF continued the instrumentation part of ARI only, and renamed it the Major Research Instrumentation (MRI) Program. The funding level for MRI in 1997 was $50 million, half the level the full ART pro-

[1] *http://www.nsf.gov/statistics/nsf07325/*
[2] *http://www.rand.org/pubs/monograph_reports/MIR1135-1/*
[3] *http://www.nsf.gov/statistics/seind10/*

gram received the year before. Today, it receives approximately $100 million annually with a FY 2011 budget request of $90 million. MRI also received $300 million in the Recovery Act, which helped NSF fill in much of the backlog in demand from universities.

The long defunct facilities portion of the old ART program received $200 million in the Recovery Act. NSF stood up a revised version of the program, the Academic Research Infrastructure Program: Recovery and Reinvestment (ARI–R^2), that does not require cost sharing and goes beyond physical research facilities, allowing for the modernization of virtual research space. Last August, NSF received 495 applications for funding under the ARI–R^2 program, proposing a total of $1.2 billion in renovations. NSF plans to award 125 grants between February and September in three size categories: $250,000–$2 million, $2 million–$5 million, and $5 million–$10 million. According to NSF, the vast majority. of awards will fall into the $250,000 to $2 million range. Additionally, nearly half of the awards (46 percent) will go to doctoral degree granting institutions, with the remaining going to a variety of master's degree granting institutions, undergraduate institutions, minority serving institutions and non-profit research organizations. The overall success rate of 25 percent is similar to the Foundation-wide success rate for its competitive awards.

NSF Support for Research Infrastructure Broadly

In addition to supporting cutting edge science through research grants, NSF invests in the infrastructure that enables such research. Approximately 24 percent ($1.8 billion) of NSF's FY 2011 budget is devoted to research infrastructure. These infrastructure investments are generally large, multi-user facilities, distributed instrumentation networks, or large pieces of equipment such as telescopes, research vessels, or accelerators that benefit an entire scientific discipline and could not be achieved without significant Federal support. For example, the Ocean Observatories Initiative, currently under construction with funding from the Major Research Equipment and Facilities (MREFC) account, will create a network of sensors for the continuous and real-time measurement of the physical, chemical, geological and biological variables of the ocean and seafloor.

In addition to these targeted large-scale investments, NSF also supports the development of university research infrastructure through the Experimental Program to Stimulate Competitive Research (EPSCoR) program. EPSCoR was created in 1978 to build research capacity in States with few research intensive universities; in order to be eligible a state must receive less than 0.75 percent of the total NSF funding awarded in the previous three-year period. The intent of the program is to improve a state's competitiveness for R&D funding primarily by supporting sustainable research infrastructure improvements across the states' academic institutions. NSF has requested $154 million for the program in FY 2011, a five percent increase from FY 2010. The success of NSF's EPSCoR program in the 1980s resulted in the creation of six other EPSCoR-like programs within DOE, DOD, NIH, NASA, EPA, and USDA. In FY 2008, these programs invested a total of $419 million across the approximately 25 EPSCoR-eligible states.

5. Questions for Witnesses

Dr. Leslie Tolbert

1. How does the University of Arizona plan for its research infrastructure needs, including its research facilities? What is the current state the University of Arizona's research infrastructure and its plans for the next 5–10 years? How is the University of Arizona partnering with state and local governments as well as the private sector to improve the region's research infrastructure and capabilities?

2. What federal funds currently support the University of Arizona's research infrastructure, including research facilities? Please include a description of all sources of funding for your research facilities, including indirect costs reimbursed from federal research grants. What are your unmet research infrastructure needs? Would you support funding for the Academic Research Infrastructure Program if it meant decreasing NSF's research budget by an equivalent amount? Are there other options beyond targeted programs for Federal science agencies to support the research infrastructure of our universities?

Mr. Albert Horvath

1. Please describe how research infrastructure is financed at Pennsylvania State University, including the financing of research facilities, cyberinfrastructure and other investments in the university's research capabilities? What federal funds cur-

rently support Penn State's research infrastructure, including research facilities? Please include a description of all sources of funding for your research facilities, including indirect costs reimbursed from federal research grants. What are your unmet research infrastructure needs?

2. How is Penn State partnering with state and local governments as well as the private sector to improve the region's research infrastructure and capabilities?

3. Would you support funding for the Academic Research Infrastructure Program if it meant decreasing NSF's research budget by an equivalent amount? Are there other options beyond targeted programs for Federal science agencies to support the research infrastructure of our universities?

Dr. John R. Raymond

1. Please describe the current National Science Foundation EPSCoR grant awarded to South Carolina. What role have EPSCoR funds played in facilitating partnerships with state and local governments as well as the private sector to improve the region's research infrastructure and capabilities? How have EPSCoR funds been leveraged across institutions to improve the region's cyberinfrastructure capabilities? Specifically, how have EPSCoR funds been used by the Medical University of South Carolina?

2. Please describe the state of Medical University of South Carolina's research infrastructure, including its research facilities. What are your unmet research infrastructure needs?

3. Do you have any specific recommendations on how to improve the EPSCoR program? Are there other options beyond targeted programs for Federal science agencies to support the research infrastructure of our universities?

Dr. Thom Dunning

1. Please describe the state of the University of Illinois's cyberinfrastructure, including the Blue Waters project. How is the University of Illinois partnering with state and local governments as well as the private sector to build regional cyberinfrastructure capabilities?

2. In your opinion, as the lead of one of six task forces established by NSF's Advisory Committee for Cyberinfrastructure to address long-term cyberinfrastructure issues, what is the state of the Nation's cyberinfrastructure? Do our research and education networks have the capacity to support computational, storage, data transfer and other scientific exchange needed to perform innovative research? Are we appropriately prioritizing our investments in cyberinfrastructure? What, if any, critical investments or opportunities are we missing?

Chairman LIPINSKI. This hearing will now come to order.

Good afternoon. I want to welcome you to the Research and Science Education Subcommittee hearing on the state of our universities' infrastructure for research and research training. This is one in a series of hearings and roundtables that we are holding as this Subcommittee works on the bill to reauthorize the National Science Foundation and the Committee works on the reauthorization of the *America COMPETES Act.* Our focus on this legislation is a direct acknowledgement of the fact that America's science and technology enterprise underpins the long-term economic competitiveness of our country, and we need to do whatever we can to make sure we maintain that.

Over the past 60 years, a great number of our societal and economic benefits have come out of the highly successful partnership between the Federal Government and our Nation's colleges and universities. Not only do these institutions train the workforce needed in a modern economy, but they also conduct the research that generates new knowledge and technologies. It is a testament to the productivity of this arrangement that 80 percent of the National Science Foundation research dollars go to academic institutions.

But successful R&D takes more than intellectual freedom and grant funding. You also need state-of-the-art lab space, networks, instruments and computing facilities, and I have heard some concerns from the academic community that this infrastructure is being neglected. Public institutions especially are suffering as the recession has eroded state support. I am worried that unless we actively modernize our R&D facilities that we could not only be spending federal research dollars inefficiently, but that we could lose our position as scientific leaders, finding it harder to attract top scientists and engineers.

Our competitors are investing in all aspects of their R&D ecosystems. Only a decade ago, if you asked an exceptional Chinese graduate student in science or engineering whether they would rather return home or stay and become an American citizen, nearly all of them would have chosen the latter. But that is no longer the case, with the best students increasingly being lured back home. At least part of the reason for this is the new availability of cutting-edge facilities and support they need to succeed as researchers.

Today we want to examine the state of our universities' research infrastructure and to consider the federal role in supporting this infrastructure, in particular the appropriate balance between investing in the research itself and investing in the infrastructure that underlies and supports both research activities and workforce training.

Currently, universities maintain and upgrade their own campus-based facilities with funding from a variety of sources. Federal agencies such as the NSF directly or indirectly support some of this infrastructure, but their primary mission is to support research and multi-user facilities that benefit the scientific enterprise and society broadly. Historically, however, the NSF has at times funded merit-based academic research infrastructure. For example, in the 1960s and 1970s the NSF ran a laboratory development program, an institutional science grant program, and a development program for University Centers of Excellence. In the mid-1980s, this Committee systematically examined the issue, beginning by requiring the NSF to prepare biannual reports on the research facilities needs of universities, and ultimately passing the *Academic Research Facilities Modernization Act.* This Act led to both the NSF's Major Research Instrumentation Program and the Academic Research Infrastructure Program.

But apart from one-time funding in the stimulus bill last year, federal programs to modernize scientific infrastructure have languished in recent years. Perhaps as a result, the 2005 Survey of Science and Engineering Research Facilities found that academic institutions were deferring $3.5 billion in needed renovation projects.

During today's hearing, I want to hear our witnesses' thoughts on whether they think the NSF should once again directly invest in research infrastructure for universities. Obviously, even with increases in NSF funding, tradeoffs would have to be made. I also hope to learn about how academic institutions are currently leveraging federal investments to improve the research capacity of their institutions. I would also like to hear our witnesses' ideas on how best to ensure that our research infrastructure keeps up with both the frontiers of the science and our international competitors. Finally, I am interested in learning about the opportunities to expand our research and educational capabilities through growing our cyberinfrastructure.

I want to thank the witnesses for their flexibility in the rescheduling of today's hearing. The Committee already had a very full calendar over the next few weeks, and with hearings postponed by this month's record snowfall, some changes had to be made, and I want to thank the witnesses for their flexibility. Thank you for being here this afternoon and I look forward to your testimony.

Before I move on and recognize Dr. Ehlers, I just want to say that I am going to—with the announcement that Dr. Ehlers made that he will not be running again for reelection, I want to say how much I will miss having him here. We only had about a year here on this Subcommittee together but he has always provided not only his knowledge but his passion for what we are working on, and we have worked very well together. I know that things don't always run very well up here on Capitol Hill but Vern has made things run very well, and I think for the betterment of this Committee and the betterment of our country, and I look forward to the next ten more months that we have to work together on this Committee.

[The prepared statement of Chairman Lipinski follows:]

PREPARED STATEMENT OF CHAIRMAN DANIEL LIPINSKI

Good afternoon and welcome to this Research and Science Education Subcommittee hearing on the state of our universities' infrastructure for research AND research training. This is one in a series of hearings and roundtables that we are holding as this subcommittee works on the bill reauthorizing the National Science Foundation and the committee works on the reauthorization of the *America COMPETES Act.* Our focus on this legislation is a direct acknowledgement of the fact that America's science and technology enterprise underpins the long-term economic competitiveness of our country.

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But successful R&D takes more than intellectual freedom and grant funding. You also need state-of-the-art lab space, networks, instruments, and computing facilities, and I have heard some concerns from the academic community that this infrastructure is being neglected. Public institutions *especially* are suffering as the recession has eroded state support. I am worried that unless we actively modernize our R&D facilities that we could not only be spending Federal research dollars inefficiently, but that we could lose our position as scientific leaders, finding it harder to attract top scientists and engineers.

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Chairman LIPINSKI. I will now recognize Dr. Ehlers for his opening statement.

Mr. EHLERS. Thank you, Mr. Chairman. I appreciate those kind words, and I am impressed now that we have come back together after all the snow how many of my colleagues appreciate me. It is too bad they didn't say that before I decided not to run again. But at any rate, I appreciate your comments, and I just think, I have been here 16 years, it will be almost 17 by the time I leave, and I think that is a good long time and it is time for someone else to carry the banner, but I do hope we can get more scientists to run for the Congress. I have been told that I was the first research physicist ever to be elected to the Congress. I can't vouch for the accuracy of that but there is not much evidence to say that I wasn't. But at any rate, I hope we get a lot more scientists interested in the political arena because it is desperately needed.

Thank you for holding this hearing too. It is a very important issue. And now that I am officially achieving old fogey status, I thought I might give a little historical perspective on research institutions, and I want to assure you, I was not born 200 years ago but that is roughly where I will start, because back then at the time of Newton and before there was no such thing as a government grant; occasionally a very bright individual would get support from the local king, prince, duke, noble, whatever, provided, of course, he also devoted some energy and time to developing better instruments of warfare. But that was a very informal arrangement for many years.

That continued well into the 19th century, but that is when things began to change somewhat, and the first person I think who really has led to the development of modern science was Mr. Faraday, and there is a marvelous biography of his that is out there, so I recommend everyone to read that, but an amazing man. When he got out of school, he went to work in a bookstore selling books, and part of his pay was to have a room up in the attic so he literally lived in the bookstore, and proceeded to read virtually all the books in the bookstore. So he was self-educated. He did not have any higher education. Then he discovered scientific books and read them and devoured them and started doing some experiments on his own in the bookstore at night and made some interesting discoveries. For example, he discovered the effect that led to the generation of electricity by rotating electrical coils in magnetic fields, and he developed very good scientific techniques. He eventually became a member of the Academy of Sciences equivalent in the British Empire, and he popularized science for the people by scheduling special lectures, I think it was every other week or something like that, and the public turned out in full force for them. It was as popular to go to the science lectures as it was to go to the symphony, and was well respected. Unfortunately, we have slipped from that. But he really educated a lot of laymen about science. He also worked on war efforts. He developed an oatmeal that would last and stay fresh much longer than any he ever had before and he was awarded medals by the British Navy because they were out at sea for months and so it was a problem to keep the food fresh. So he went into many different fields but his primary contributions were to electricity.

The lectures he established were a real effort to educate the public and became very popular. But one time he invited Mr. Ohm to speak, and we are all familiar with the term ohm because that is the unit of resistance and electricity is named after him. So he was invited to give a lecture, and when they went down the stairs to enter the lecture room, and Faraday was going first because he was going to introduce Mr. Ohm, and when Mr. Ohm entered the room, looked around and saw 200 people, he panicked. He was a bit of an introvert. He panicked and ran back up the stairs and left. So Faraday wrote a little note. Being the scientist that he was, he had to record all the data, so there was a little note in his data book, "When escorting speakers to the auditorium, be sure to follow them and not lead them." So he was a very good observer.

Well, that is enough of history. Well, let me add just another bit that is more recent and I am more familiar with because I did some of my research using the cyclotron that resulted from that. E.O. Lawrence was hired by the president of the University of California at Berkeley to teach in the physics department and he was hired primarily because someone said that E.O. Lawrence is likely to get a Nobel Prize at some point. He was very bright. And the president said he wanted a Nobel Prize winner on the Berkeley campus so he offered him a job. They now have more Nobel Prize winners there than any other university, I believe. But in any event, E.O. Lawrence invented the cyclotron. It was small enough to sit on a kitchen chair. In fact, I have seen that original cyclotron and the kitchen chair. And then he realized he could scale up but where would he ever get a magnet that was big enough, and he discovered that AT&T, which had planned to send radio waves across the ocean, the Pacific ocean, a very long distance, and they were going to send those so that they could get telegrams across oceans, and they had the magnet and things just didn't work out right and then they started laying undersea cables so the magnet was in Palo Alto, and E.O. Lawrence heard about it, went and saw it, persuaded AT&T to donate it to the University of California, and that became the 60-inch cyclotron at Berkeley, which was the biggest accelerator in the world for quite a few years and enabled us to learn enough about nuclear physics that we could develop the ultimate weapon that ended World War II.

Well, that is a lot of history, but the reason I am bringing that up, because the tradition over the years has been that universities provided the facilities for research. That came out of their tuition funds. It came out of their gifts from alumni and so forth, and the buildings were considered the university's responsibility. The money for research initially came primarily from donors, largely industry such as AT&T, and later on the universities took it upon themselves to also fund some of the research. Nowadays, universities are in tough financial times and so more and more they are trying to find other sources of money to build their buildings and their laboratories. The Federal Government has been fairly generous in funding equipment. That has just carried over. That has been considered a part of the responsibility of the central Federal Government. State governments contribute some as well but not as much. But it has always been considered the universities' requirement that they provide the buildings whether they get it from contributions or from state government, and that it how it has been for quite a while.

What we are talking about today is what is the—and I am not trying to take words out of your mind or rephrase your objectives, Mr. Chairman, but basically the issue is, should the Federal Government be more active in providing not just grants for researchers to pay them or the graduate students or to buy equipment but should the Federal Government also become involved in building laboratories outside of the national laboratories, and that is a very important issue. I have mixed feelings about it. It would be a change in direction, although NSF has, by funding its Centers of Excellence, has gotten to a certain extent into the business of paying for buildings, but it is a very small part of their budget.

So the issue we are discussing today, Mr. Chairman, I see as a very important issue and it is good for you to bring it up, but at the same time recognize that we are plowing new fields at this point by saying well, maybe the Federal Government should be providing more money for facilities, not just for salaries, not just for equipment but for the facilities that house these devices. And so I just wanted to emphasize that long history because as I say, it is a very important issue and we have to understand the history of it.

In my formal statement, I go on to point out that universities have to have state-of-the-art science and technology facilities in order to remain at the cutting edge of research. With proper laboratory buildings, equipment and computing systems, students will graduate well prepared for the workforce. As the institutions represented here today know well, the most innovative students are attracted to universities with the best facilities. However, it is also important that we recognize that the National Science Foundation's expertise lies in the support of peer-reviewed basic research. They appoint panels of like-minded scientists to review proposals. These panels take it very, very seriously and they know that from personal experience because my son is currently sitting on the panel of the National Science Foundation and every few months he spends four days here in Washington, before that reads voluminous numbers of proposals and takes it very seriously and his colleagues on the panel do the same. It is not clear that the National Science Foundation has the expertise nor could it appoint the panels that have the expertise to research and judge proposals involving specialized facilities. Those new panels would have to be created, where we would get the people power to review it. I am just simply pointing out it would be quite a change for the National Science Foundation as they get very heavily into providing funding for facilities, buildings and so forth.

We also recognize that science funding has changed dramatically in another area, and I apologize for going too long but I want to bring all these things together. When I was first elected to the Congress, Newt Gingrich asked me to write a science policy study to recommend science policy for the next generation. The last policy was written in 1945 by Vannevar Bush, and Newt and I both agreed that was a bit outdated, from 1945 to 1995, and so I pointed out that with the increasing expense of major facilities, the Federal Government was no longer even going to be able to fund the research facilities, not just the buildings but also the equipment, because of the huge cost, and recommended that we should concentrate on international cooperation to do that, and that is come to an ITER, which the idea was originated in the United States. When we dropped it, the Japanese thought they would pick it up, then decided not to. Now the French are doing it with international collaboration, and that may be the direction of the future for the really expensive things such as CERN. CERN is another cooperative international effort which we are now joining. And it is very interesting to watch this evolution.

As the projects get bigger and bigger, get more and more expensive, the buildings get extremely more expensive and so you are on the forefront of a major issue, Mr. Chairman, in terms of outlining where is the money going to come from and whether it is NSF or DARPA or ARPA-E or whatever. I think it is a major problem that has to be faced and discussed by the Congress and not just this Committee. So this gives us all a chance to do that.

With that, I yield back.

[The prepared statement of Mr. Ehlers follows:]

PREPARED STATEMENT OF REPRESENTATIVE VERNON J. EHLERS

Universities must ensure they have state of the art science and technology facilities in order to remain at the cutting edge of research. With proper laboratory buildings, equipment, and computing systems, students will graduate well-prepared for the workforce. As the institutions represented here today know, the most innovative students are attracted to universities with the best facilities.

However, it is important that we recognize that the National Science Foundation's expertise lies in the support of peer-reviewed, basic research. That research often requires the use of various types of equipment and specialized facilities. Many scientific questions we are faced with today will only be answered through the use of very expensive facilities, such as ITER, that often require the participation of multiple countries to construct. There are also many smaller facility needs at our research institutions, some of which the NSF currently funds. However, I have some reservations about expanding this type of support, because it does not fit well into the primary mission and expertise of the NSF.

I thank the Chairman for holding this hearing today, and look forward to hearing from our witnesses how we can support high-quality, sustainable research and infrastructure at our universities.

Chairman LIPINSKI. Thank you, Dr. Ehlers. You knew after I said all those wonderful things about you that I wouldn't gavel you. I thought maybe you were going to filibuster until the end of your term.

Mr. EHLERS. Well, that is a very good deductive process.

Chairman LIPINSKI. I am an engineer, so—as you were telling that first story about Faraday and Ohm, I was wondering what the punchline was going to be, and I thought it might be something about Ohm's second law or something like that.

With that, we are here to hear from the witnesses so maybe we should move on. We will have more time for this in the Q&A. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman and Ranking Member for holding today's hearing on, "The State of Research Infrastructure at U.S. Universities".

The United States' world-class university infrastructure is one of our greatest strengths that we must sustain to remain competitive in the 21st century. It is a bastion for academic research and education and a catalyst for scientific innovation. I am pleased that significant funding in the budget and the Recovery Act has been set aside towards expanding and sustaining our research and infrastructure.

I am pleased that in 2010 the majority of our Nation's colleges and universities have access to high-speed internet. Additionally, according to the latest National Science Foundation (NSF) survey on the status of research facilities, 77 percent of universities nationwide rated their condition as satisfactory or superior. We must strive for excellence by funding initiatives and seeking new ways to improve our universities research facilities. Programs such as the Major Research Instrumentation (MRI) Program and the (ARI–R^2) Program among others are good beginnings.

As you are aware, nationally, our rate of increase in research space construction has slowed from 11 percent in 2003 to 3.7 today. These past few years, many colleges and universities have been hit hard by our recent economic recession, particularly Historically Black Colleges and Universities (HBCU's). Last year, $85 million in the additional funding was omitted from the federal budget for HBCU's. Many struggling universities have been forced to cut faculty and staff, delay construction, and furlough payrolls in order to survive during our current economic climate. Increased federal investment in our nation's research infrastructure is necessary to keep our colleges and universities competitive during these tough times.

When considering the state of our national research infrastructure at U.S. universities we must protect those hurting the most first. For example, Historically Black Colleges and Universities graduate students in STEM degrees higher than most traditional universities and currently are conducting world-class research in AIDS and Cancer research. We must do what we can to help and protect minority serving institutions.

While the topic of today's hearing is focused primarily on the research infrastructure of Universities, I must emphasize the bigger issue at hand which is increasing the number of U.S. students who enroll and graduate from these institutions. What sense does it make to have a world-class facility that is only half full? The United States faces a looming shortage of students enrolling in STEM disciplines. The key problem facing us right now is that we need more students in our university research infrastructure.

I am interested in hearing from today's witnesses who are experts from universities across the nation. I thank you for your thoughtful testimonies as we look to address these issues. I am interested in hearing from you on how the federal government can strengthen our national university research infrastructure. I am also curious as to how our resources can be effectively distributed to institutions of higher learning that are in need the most.

Thank you Mr. Chairman, I yield back.

So at this time I am going to introduce our witnesses. First we have Dr. Leslie Tolbert, who is the Vice President for Research, Graduate Studies and Economic Development at the University of Arizona. We have Mr. Albert Horvath, who is the Senior Vice President for Finance and Business at Pennsylvania State University, as well as the Chair of the Board of Directors for the Council on Government Relations. I will now yield to my distinguished colleague, Mr. Inglis, to introduce our third witness.

Mr. INGLIS. Well, and I thank you, Mr. Chairman. It is wonderful to have Dr. John Raymond here today, the Vice President for Academic Affairs and Provost at the Medical University of South Carolina, a practicing nephrologist and a physician with the Department of Veterans Affairs. He has been with the Medical University since 1996, lending his expertise in medicine and academia to one of the strongest and oldest schools of medicine in the South. Dr. Raymond is also a prolific researcher. He has published over 100 full-length manuscripts and has received over $25 million in competitive research grants from the National Institutes of Health, the Department of Veterans Affairs and various foundations. As Chair of South Carolina's EPSCoR Committee, he plays a major role in expanding South Carolina's scientific and technical research. In 2009, South Carolina received a $20 million award from the National Science Foundation to work on biofabrication of human tissues. It is the largest NSF grant in our state's history. It will bring together the work of diverse South Carolina institutions including Greenville Tech and Furman University. The Medical University of South Carolina is playing a very significant role in this work and I know that Dr. Raymond shares my excitement about the great step forward this grant presents for both medical science and the research engine in South Carolina.

Thank you, Dr. Raymond, for all the work you have done to expand opportunities in South Carolina and thank you for sharing your expertise with us today, and thank you, Mr. Chairman, for the opportunity to introduce this fine South Carolinian.

Chairman LIPINSKI. Thank you, Mr. Inglis.

And finally we have Dr. Thom Dunning, who is the Director of the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign.

As our witnesses should know, you will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you have all completed your spoken testimony, we will begin with questions. Each Member will have five minutes to question the panel

So we will start here with Dr. Tolbert.

STATEMENT OF DR. LESLIE P. TOLBERT, VICE PRESIDENT FOR RESEARCH, GRADUATE STUDIES AND ECONOMIC DEVELOPMENT, UNIVERSITY OF ARIZONA

Dr. TOLBERT. Chairman Lipinski, Ranking Member Ehlers and other distinguished members of the Subcommittee, thank you for the opportunity to speak with you today on the state of research infrastructure in our Nation's universities. I am Leslie Tolbert. As you heard, I am the Vice President for Research, Economic Development and Graduate Studies at the University of Arizona in Tucson, Arizona. I am here speaking on behalf of the University of Arizona and also the Association of American Universities and the Association of Public and Land Grant Universities.

The astounding research accomplishments in our universities have been the backbone of our country's economic competitiveness, our high living standard and our national security for over 60 years. In recent decades, though, our global leadership position in innovation is being threatened.

As the major provider of support for our university-based research, the Federal Government must act quickly to build on the *American Recovery and Reinvestment Act of 2009* to make continued strategic investments in research itself, and also the subject of today's hearing, in the physical foundation for that research, which includes research instrumentation and cyberinfrastructure as well as bricks-and-mortar laboratories.

In the current economic crisis, state support for research-related expenses in public universities and charitable giving and returns on endowment to universities have declined precipitously. Federal support for research is as important as ever before. Federal support for research infrastructure comes in part through the provision of facilities and administration, or F&A, cost recovery that is included in grant awards. F&A is intended to reimburse universities for the collective hidden but real expenses of research. But growing federal mandates, for research compliance in particular, consume more and more of those funds, leaving little to support the physical infrastructure. The Federal Government also has embedded in a number of agencies mechanisms that are designed specifically to fund research infrastructure. I will mention some of these in a moment but first let me discuss the situation at my university, which I think provides a useful model for study.

The University of Arizona, or UA, is a large comprehensive land grant university with annual R&D expenditures in science and engineering amounting to $550 million. We are one of the top 25 research universities in the Nation, and we are number one in the physical sciences in the latest NSF rankings. UA revenues come roughly one-quarter from state appropriations, one-quarter from student tuition and fees, and half from other sources, which includes sponsored grants and contracts, which come primarily from the NIH, the NSF and NASA.

The State of Arizona appropriations for its three public universities have fallen steeply in the last two years, precipitating the deepest crisis in recent history. In these last two years, the UA's annual state appropriation has been reduced by $100 million. Founded in 1985, the UA has many science buildings that are old and deeply in need of repair. State funding for new buildings and for building maintenance has been very small over the years. For building maintenance and repair in the last decade, we received $11 million from the state to address a documented need that now exceeds over $200 million.

Given our constraints, careful planning is essential. Our current planning efforts are driven by several principles, two of which are using flexible open design laboratories. That is economical. They promote collaboration and they allow individual projects to grow and shrink without the expense of moving walls. And another thing we do is, we support shared equipment facilities over facilities that are dedicated to individual researchers, to maximize the impact of these facilities.

It has become clear at the UA and across the country that more federal support is needed for the research infrastructure that enables federally funded research. My colleagues and I would recommend that the NSF strive to increase the percentage of the budget that it spends on infrastructure from 24 to 27 percent by fiscal year 2016. Building to that level gradually as the overall NSF budget grows should minimize the impact on funds available for research grants.

The increasing infrastructure support, I would argue, should go to several programs. One is the Academic Research Infrastructure program that provides critical funding to modernize existing research laboratories. Funding from ARRA this year was very welcome and we point to the importance of continuing that program beyond ARRA. The Major Research Instrumentation and Major Research Equipment and Facilities Construction programs are also essential to provide state-of-the-art research equipment priced in the range of several millions of dollars or above tens of millions of dollars. In my written testimony, I have outlined several specific changes in these funding mechanisms that would give them greater impact.

Perhaps most importantly, we recommend that OSTP create a national science and technology working group to assess instrumentation and infrastructure programs at all federal agencies, and make recommendations concerning steps that the government should take to ensure adequate support for its national research infrastructure. Our researchers, if armed with direct research funding and a strong research infrastructure, can continue to lead the world in innovation and discovery.

Thank you for the opportunity to present this testimony.

[The prepared statement of Dr. Tolbert follows:]

PREPARED STATEMENT OF LESLIE P. TOLBERT

Chairman Lipinski, Ranking Member Ehlers, and other distinguished Members of the subcommittee, thank you for the opportunity to speak with you today on the state of research infrastructure at our nation's research universities.

My name is Leslie Tolbert. I serve as the Vice-President for Research, Graduate Studies, and Economic Development at the University of Arizona, in Tucson, Arizona. I am honored to have the opportunity to offer testimony on behalf of the University of Arizona, the Association of American Universities, and the Association of Public and Land-grant Universities.

Overview

Our nation's research universities are falling behind in their ability to provide the physical infrastructure—both the laboratory buildings and the high-end technical facilities in those buildings—needed to keep our researchers working at full capacity. As state and private sources of funding dwindle, even more quickly during the current economic slump, federal support is growing in importance. Strategic investments in research infrastructure by the federal government are absolutely essential to maintaining a global leadership position for U.S. science. The University of Arizona, with its sharply declining support from the state, provides a useful model for understanding the current situation in a large public research university and the specific remedies that federal resources could provide.

Background and Context

Funding for University-based Research

The record of research accomplishment of U.S. universities is astounding. For the past 60 years, at least, these accomplishments have been the backbone of our economic competitiveness, high living standard, and national security. As documented in the National Academies "Rising Above the Gathering Storm" report, our leadership position in education and innovation has been threatened in recent decades as other countries have sought to emulate us by making huge investments in their research enterprises. U.S. leadership in science and engineering will be maintained only if we maintain a modern and effective research infrastructure.

For many decades, the federal government has assumed the responsibility of providing the dominant support for university-based research and research training, providing billions of dollars in support, virtually all of it on a competitive basis to ensure that the most meritorious research ideas receive funding. Our system of competition through review and ranking of applications by peers is the envy of the world.

In recent years, however, federal support of university research in science and engineering, while still substantial, had become essentially flat in real dollars (AAAS Report XXXII *Research and Development FY 2008,* Chapter 2: *Historical Trends in Federal R&D; http://www.aaas.org/spp/rd/08pch2.htm*), even while that of other countries was growing. The American Recovery and Reinvestment Act of 2009 has provided much needed federal funding to reverse this trend for two years, but it is unclear what the picture of federal research support will look like after ARRA funding ends.

Adding to the problem, as the states have faced growing economic challenges, state support for research-related expenses in many public universities has declined precipitously, and charitable giving and endowment returns to both public and private institutions have also fallen sharply (Council for Aid to Education, *http://www.cae.org/content/pdf/VSE_2009_Press_Relsease.pdf,* and National Association of College and University Business Officers, *http://www.nacubo.org/Documents/research/2009_NCSE_Press_Release.pdf*). As a result, American research productivity and scientific advances are likely to diminish. The private sector spends more than twice as much as the federal government spends on research and development (National Science Board, Science and Engineering Indicators 2010), but in tight economic times, private industry is driven increasingly to focus its research dollars on applied research and development for short-term profit, leaving to the universities the basic research—and unexpected discoveries—that ultimately must form the basis for future applications.

Maintaining America's universities' competitiveness in fundamental research and research-enriched education has become a serious challenge. Meeting this challenge will require strategic investments in the physical infrastructure for research as well as in the research and educational activities themselves.

Funding for Physical Infrastructure for Research in Universities

The physical infrastructure for research includes not just bricks-and-mortar buildings, but also research instrumentation and a robust cyberstructure (for internal and external communication and for research requiring high-performance computing). The increasing complexity of science and engineering requires advanced technical equipment and tools, as well as specialized workspaces that encourage and enhance collaboration and interdisciplinary pollination of ideas.

The physical infrastructure that must be in place for cutting-edge research was historically provided by a combination of federal and state government and university funds. Federal dollars for infrastructure have decreased, however. As described by Homer Neal, Tobin Smith, and Jennifer McCormick in their book, *Beyond Sputnik—U S. Science Policy in the 21st Century* (U. Mich. Press, 2008):

> *"In the years following World War II and immediately after Sputnik the .US government invested heavily in the development and funding of scientific infrastructure at universities, national laboratories, and other federal research facilities. However, by the early 1970's many federal programs that had previously existed to support construction and renovation of research facilities ended, and federal obligations for research facilities and large equipment in colleges and universities dropped significantly. During this period, the neglect of laboratory instrumentation and the erosion of the physical infrastructure for research threatened the long term vitality of even leading universities."*

Today, federal dollars are directed primarily to supporting research operations, with little targeted directly to the costs of providing the necessary research infrastructure. To fill this gap, universities have relied heavily upon state support, endowments, gifts, and other institutional resources to support their physical research infrastructure needs. However, declines in state support for public universities and in endowments and gifts for public and private universities, have made it increasingly difficult for us to sustain and renovate existing laboratories or to build the new facilities that are required for increasingly sophisticated research.

As a result, universities are falling behind the need to provide the physical facilities to do the research that will propel our economy forward. According to the National Science Board's 2010 report of "Science and Engineering Indicators:"

> *"Research performing colleges and universities continued a two-decade trend of increasing the amount of research space at their institutions. [. . .] In recent years though, the rate of increase in research space has begun to slow. [. . .] The rate of increase peaked in FY 2001–03 at 11%. Since then, the rate of increase has gradually declined [. . .] In conjunction with the slowdown in the increase in research space, the total amount of newly constructed research space also began to slow at the beginning of the decade (table 5–5). Since FY 2002–03, the total amount of new research space constructed declined by approximately 45%."*

Current Situation Regarding Federal Support for Research Infrastructure

The federal government provides support for research infrastructure in several ways. Some support for research facilities comes through the provision of Facilities and Administration (F&A), or "indirect," cost recovery that is included in grants and contracts awards. F&A cost recovery is intended to reimburse universities for expenditures on the buildings, utilities, equipment, libraries, and administration that collectively support their research.

A large portion of the funds awarded for F&A costs are, in fact, not available for the kinds of infrastructure projects I have mentioned. Most notably, growing federal mandates and research compliance requirements have pulled institutional funds away from support of research facilities. A 2004 report from the Council on Government Relations ("A New Research Business Model: Incentivizing Research") points out that universities actually provide significant cost-sharing:

> *"Universities contribute to the direct costs and the indirect (i.e., F&A) costs of federal research. The National Science Foundation's (NSF) annual survey on Research and Development (R&D) Expenditures at Universities and Colleges shows the significant and increasing financial contributions made by all colleges and universities, in total, to the research enterprise over the past sixty years. [. . .] when shown as a percentage, the important role of Institutional Funds is clear. Over the period from 1976 to 2006, the share of R&D expenditures in this category has grown faster than any other category. According to the 2006 NSF Sur-*

vey, Institutional Funds account for 19.0% of all R&D expenditures, compared to 12.0% of all R&D expenditures in 1976. To put this in another context, the increased share from 12.0% to 19.0% represents a growth factor of 58%."

In addition, there are a limited number of federal mechanisms designed specifically to fund research infrastructure. These include NSF's Major Research Equipment and Facilities Construction (MREFC) program and their Major Research Instrumentation (MRI) program; NIH's Shared Instrumentation Grants and High-End Instrumentation Grants; the NCRR Animal Facility, Research Facility Improvement (C06), and Core Facility Renovation, Repair, and Improvement (G20) programs; research facility construction funds from the National Institute of Standards and Technology; and the Department of Defense's University Research Instrumentation Program. Some of these infrastructure programs and their scopes were temporarily expanded with the use of American Reinvestment and Recovery Act (ARRA) funds. One program that was revived with ARRA funds was the NSF's Academic Research Infrastructure (ART) program, which I will discuss further in my recommendations.

How the University of Arizona Supports Research Infrastructure

At the University of Arizona, one can see firsthand the impact of all the aforementioned issues, including the precipitous decline in state funding as well as the shrinking funding for research infrastructure from federal sources. I think you will find the UA to be a useful case study.

The University of Arizona is a large, comprehensive land-grant university that includes, together on one campus, liberal arts colleges and colleges of medicine, pharmacy, nursing, public health, engineering, optical sciences, and law. On a separate campus, we have a Science and Technology Research Park. We are one of the top 25 research universities in the nation and a member of the Association of American Universities. In FY 2008, our Science and Engineering Research and Development expenditures amounted to $546 million; we were ranked #1 in total R&D expenditures in physical sciences by the NSF. Approximately 27% of our operating expenses are in support of research.

In FY 2010, 22% of UA revenues were from state-appropriated funds; 27% were from student tuition and fees; and the remaining 51% were from other sources, including sponsored grants and contracts, auxiliary funds, gifts, and investment income. [See **Table 1** below.] Each year, sponsored grants and contracts come primarily from the federal government, with the remainder from industrial sponsors, foundations, and private contributions. Among federal sponsors, the Department of Health and Human Services (HHS) provides the largest single share of sponsored grants and contracts (primarily via the National Institutes of Health), followed by NASA, National Science Foundation, Department of Defense, and Department of Agriculture.

Table 1 – University of Arizona Funding Sources	1999-2000 (Actual) in thousands		2009-2010 (Budget) in thousands	
State Support	$320,912	34%	$348,941	22%
Net Tuition	$128,929	14%	$311,464	19%
Tuition Funded Aid	$ 31,722	3%	$123,747	8%
Grant & Contracts	$291,604	31%	$537,504	33%
Ancillary Units	$ 91,509	10%	$157,792	10%
TRIF *	$ 0	0%	$ 21,645	1%
Gifts & Endowments	$ 37,294	4%	$ 54,058	3%
Investment Income & Other	$ 36,532	4%	$ 63,860	4%
TOTAL	$938,502	100%	$1,619,012	100%

* Technology Research Infrastructure Fund (TRIF) supports university research, development, and technology transfer related to the knowledge-based global economy through a six-tenths-cent increase in state sales tax.

To date, we have been awarded $83.7 million (including anticipated year 2 amounts) in ARRA federal stimulus funds for a wide range of important projects on topics ranging from solar electric materials to optical imaging methods for cancer detection to methods for monitoring soil moisture in arid lands. Most of the ARRA support is for research projects; $4.7 million from the U.S. Department of Commerce supports a new biotechnology park; and just under $1 million from NSF is for research equipment.

Another federal funding source from which we will receive support in the near future is the MREFC program at NSF. We will serve as the Southwest's core site for the National Ecological Observatory Network, or NEON, for regional—to continental-scale ecological research. The project has recently passed its Final Design Review and the President's FY 2011 budget proposes $433M in MREFC funds to begin the construction phase of NEON. The exact amount of funding that will flow to the UA is not yet determined.

In contrast to federal funding, State of Arizona support of its public universities has fallen steeply in the last two years, precipitating a crisis deeper than any other in recent history. As shown above in **Table 1,** the percent of the UA budget that comes from the state has fallen from 34% to 22% in the past decade. **Table 2** below shows the dramatic decline in just the last three years, from $443 million appropriated to the UA in FY 2008 to $348 million appropriated in FY 2010.

Table 2 – State of Arizona University System – General Fund Appropriations	FY 2008 (original budget)	FY 2009	FY 2010
Arizona System (3 public universities and system office)	$1,121,095,300	$938,248,800	$901,652,800
University of Arizona portion	$443,343,400	$362,544,900	$348,496,800

Our research buildings range from modern and well-equipped to outdated and deeply in need of maintenance. The university was founded in 1885, and most of our science related buildings were built in the 1960s through the 1990s. Our older buildings do not meet current safety codes, limiting their utility for research involving hazardous biological or chemical agents. With their small, compartmentalized spaces, they certainly are not conducive to current modes of collaborative research. We struggle to find the resources to update those buildings, as well as to build new research buildings that can provide the new lab space that we need.

We received no State of Arizona funds for new building projects between the early 1980's and FY 2008. House Bill 2529, signed into law in 2003, provided significant relief in the form of state appropriations of over $440 million for Research Infrastructure Financing for the three state universities over 23 years (FY 2008—FY 2031). From HB 2529, the UA receives $14 million per year for debt financing. **Table 3,** below, shows the sources of funding for our ten most recently constructed research buildings.

Table 3 – University of Arizona Research Building Projects – by Funding Source	4 New Buildings (2000-2005)		6 New Buildings (2006-2009)	
Debt Financed *	$26,818,000	52.2%	$190,512,000	83.7%
Institutional Funds	$ 6,272,000	12.2%	$ 6,393,000	2.8%
Gifts & Endowments	$ 15,671,000	30.5%	$ 24,288,000	10.7%
Federal Grants	$ 1,940,000	3.8%	$ 6,301,000	2.8%
Other Grants	$ 722,000	1.4%	$ 0	0.0%
Total	$51,423,000	100%	$227,494,000	100%

* Source of debt service payments: Student retained collection, State appropriations, Indirect Cost Recovery, Technology Research Infrastructure Fund from state sales tax increment

A major shortage of state support for Building Renewal at the universities contributes to the challenges of using existing aging buildings for research. The state has a formula forcalculating Building Renewal needs based on the replacement values and ages of our buildings. The state provided only partial funding for the universities' Building Renewal needs in 1987–2001, and has failed to provide any Building Renewal funds for eight of the past nine years. Over the past five years, FY 2006–10, we should have received $200 million. Instead, we received only $10.9 million, in FY 2007, thus falling short by $178 million for this period ,alone. Added to the shortfalls from before 2001, this leaves the UA with an accumulating Building Renewal need that far exceeds $200 million in FY 2010. Old chemistry and engineering buildings are in particular disrepair and can not be used for most types of research in their nominal fields.

In sum, it has become clear that the state cannot fund the improvements needed to keep pace with emerging research needs, and the university struggles to fund the improvements needed to comply with general laboratory safety codes as well as emerging research needs. To guide that struggling effort, the UA has a Space Committee, chaired by the Provost and the Senior Vice President for Business Affairs. The Committee plans building renewal and construction, assessing and balancing research infrastructure needs against the availability of funding and a university-wide commitment to safety and environmental stewardship.

Our conceptual framework for efficient, cost-effective campus build-out addresses several key issues:

- We have accepted an urgent mandate to protect the environment even as we continue to build. When addressing space needs, we first consider refurbishment of old buildings. Often it is too expensive to upgrade existing research facilities, so older research space is converted to offices and classrooms instead. When new buildings are needed, we are committed to building them to at least LEED silver specifications, which is more expensive in the short run but will provide future energy savings to help offset the expense. For laboratory research buildings, which use more energy than office buildings, these savings over time can be great.
- We build out the campus utility infrastructure sector by sector, rather than building by building, in accordance with our campus master plan and capital improvement planfor the coming 5–10 years. This coordinated approach is very economical, allowing the infrastructure and new buildings to be constructed as efficiently and inexpensively as possible. For example, we have applied for a $15M NIH C06 ARRA grant to build a new research building for imaging sciences. The building construction cost and schedule are greatly reduced because utility infrastructure is already in place. Thus, any funding received will be most effectively used for its core research-support purposes.
- New laboratory buildings generally have a flexible open-laboratory design. This is economical, promotes collaboration among research groups, and allows space for particular projects to grow and shrink as funding waxes and wanes, without the expense of moving walls or utility spines. This approach leads to research funding and discovery successes that would otherwise not occur. Within a few years of the opening of our new open-configuration, interdisciplinary life sciences building, our faculty landed a $50M NSF grant (the largest ever to an Arizona institution) to support collaboration of molecular plant biologists, ecosystems biologists, information scientists, earth-imaging specialists, and others to tackle Grand Challenge problems in plant biology.
- Shared equipment facilities are preferable to facilities under the control of individual researchers. At the centers of our new open-lab buildings are shared core facilities for the most expensive instruments they need, such as those for microscopy, genomic and proteomic analysis, and high-end computing. These core facilities are an economical way to provide large numbers of researchers access to the latest equipment, equipment that they could not afford on their individual grants.

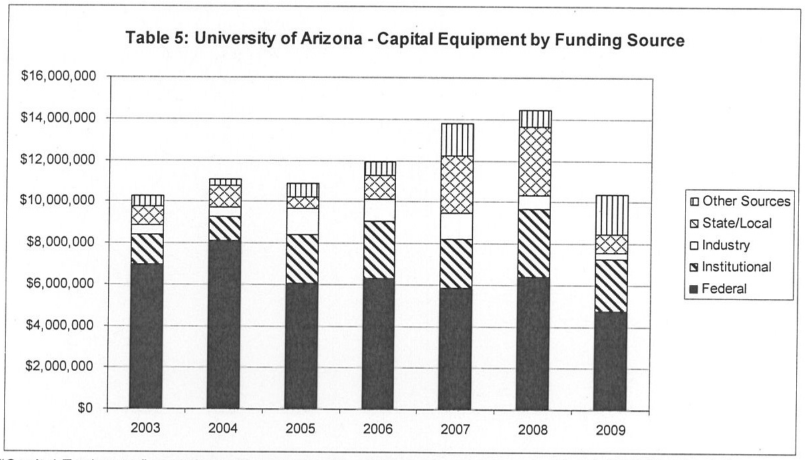
The UA has built ten new research buildings in the past ten years and our Capital Plan includes plans to build three more in the coming two years, to meet our most urgent projected needs. One of these, a research support building for our new College of Medicine arm in Phoenix (in partnership with Arizona State University), will be funded primarily with ARRA funding through an NIH C06 award. Incidentally, the development of that entire medical campus has been a collaboration of many entities dedicated to research advancement, including the UA, the City of Phoenix, and public-private partnerships.

Our recently constructed buildings, in both Tucson and Phoenix, are funded by a combination of state and local funds. Projected sources of funds for the next three new research buildings and for research-related renovations on our Capital Plan are shown in **Table 4,** below. We take advantage of the State of Arizona's recently approved Stimulus Plan for Economic and Educational Development (SPEED), a creative mechanism whereby the State will provide 80% of annual debt service payment from state lottery funds, while the universities will cover 20% of the annual debt service payments through institutional funds (which include student retained collections; State appropriations; and indirect cost recovery). Indirect cost recovery alone will be expected to cover approximately 10% of the debt service.

Table 4 - University of Arizona Sources of Funding for Future Projects	SPEED *	Gift Funds	Federal Funds **
New Research Buildings	$466,000,000	$12,200,000	$15,000,000
Building Renewal	$ 57,600,000	$0	$0

* State of Arizona's Stimulus Plan for Economic and Educational Development
** From recently approved NIH C06 award (ARRA funding)

In addition to building renewal and construction, we track our expenditures on capital equipment (item cost >$5,000). While the total investment in capital equipment varies year to year, the percent contribution from federal funds has declined systematically in recent years, from 68% in FY 2003 to just 46% in FY 2009. [See **Table 5** below.] Thirteen percent ($10 million) of our equipment purchased with federal funds in the past ten years has been purchased with funds designated for shared-use instrumentation.



"Capital Equipment" as defined in the University of Arizona's rate agreement and OMB Circular A-21

In addition to our primary campus in Tucson and second medical campus in Phoenix, we have a Science and Technology Park in the outskirts of Tucson. With more than 7,000 employees, the UA Tech Park reflects one aspect of our partnership with the private sector in regional development and is one of the region's largest employers. It is home to 40 high-tech companies and business organizations, including several emerging technology companies, as well as branches of five Fortune 500 companies. It includes a business incubator, which currently hosts 12 emerging companies, several of which are spin-offs from the university. The Park is an independent legal entity [501(c)3]. We currently are developing a second UA Tech Park, focused on biotechnology, closer to the UA campus, and recently received $4.7 million in ARRA funds from the U.S. Department of Commerce to build the utility and roadway infrastructure that will allow us to develop the property.

Gaps in Our Ability to Provide Necessary Research Infrastructure

All of the innovative collaborations and approaches being used to facilitate leading-edge research require new or upgraded research facilities, for which there is currently insufficient funding. Under current conditions, many of these needs will likely go unmet.

As we seek multiple funding sources and new arrangements to fund building renewal and upgrades, the UA and other universities across the country face a specific and severely hobbling gap in funding opportunities. Donors may be willing to help to fund new buildings, but they are very rarely willing to contribute to ongoing operations, maintenance, or upgrades. For lack of funds, maintenance and upgrading are often deferred or neglected. Allowing our universities' older research buildings to languish raises the future costs of providing the necessary physical research infrastructure. As discussed earlier, the University of Arizona has a growing need for refurbishment of its buildings that exceeds $200 million today.

Beyond a shortage of funds for building renewal, universities face a confounding problem: a gap in funding opportunities for mid-scale instrumentation facilities. NSF's Major Research Equipment and Facilities Construction (MREFC) program supports the acquisition, construction, and commissioning of large scale research facilities and equipment, in the tens to hundreds of millions of dollars range, that uniquely advance the frontiers of science and engineering. Initial planning and design, as well as follow-on operations and maintenance costs of the facilities, are provided. NSF's Major Research Instrumentation (MRI) program funds the acquisition or development of single pieces of research instrumentation, up to $4 million in cost (or $6 million, with ARRA funds), that are to be shared by multiple investigators. The program explicitly does not support acquisition or development of the whole suite of instruments that is often needed to outfit high-end research facilities. Similarly, the NIH has a Shared Instrumentation Grant (SIG) program that supports the purchase of instruments up to $600,000 in cost. The huge gap between these two funding mechanisms and the MREFC makes it very difficult to fund medium-scale infrastructure.

A smaller but still constraining issue arises from the fact that the MRI and SIG programs support the purchase or development of expensive pieces of scientific instrumentation, but do not provide for the renovations that often are needed for installation of the new instruments and do not provide for personnel, ancillary equipment, and upgrades to keep the instruments at the cutting edge as technology advances. In addition, the MRI program requires universities to provide 30% in matching dollars. Because of the difficulty in finding the funds to fulfill those particular requirements, we are sometimes unable to apply for needed instruments, and even if we do obtain the funds to purchase new items, good instrumentation may fall away from the cutting edge, even when relatively inexpensive upgrades could have kept them up to date.

Recommendations

In light of the severity of the issues I have raised, we recommend the following:

1) *The NSF should increase the percentage of its budget that it spends on infrastructure to 27 percent by FY2016—in accordance with the recommendation made by the National Science Board in its 2003 report, "Science and Engineering Infrastructure for the 21" Century: the Role of the National Science Foundation," (http://www.nsf.gov/od/lpa/news/03/pr0340.htm).*

Recent figures suggest that NSF currently devotes some 24 percent of its funding to infrastructure support. As the Congress and the Administration seek to double funding for the agency by FY 2016, we believe the 27 percent target set forth by the National Science Board is a reasonable goal. Moreover, slowly increasing the percentage of funding NSF devotes to infrastructure over five years as the overall NSF budget grows should minimize the negative impact on the funds potentially available for research grants and awards.

To help to achieve this goal, we specifically recommend that:

a. *The Congress and NSF should continue to support the Major Research Instrumentation (MRI) and Major Research Equipment and Facilities Construction (MREFC) programs.*

These programs are essential to provide state-of-the-art research equipment priced in the range of several millions of dollars or above tens of millions of dollars. It would be especially helpful for MRI grants in the future (1) to fund not only the purchase of the equipment, but also renovations, ancillary equipment, and personnel that may be needed to put those instruments to best use, and (2) not to require the significant (30%) matching dollars currently required of universities. Absent that additional support, the full costs of providing new technical capabilities are so high that some universities are unable to participate in the MRI program.

b. *The Committee should authorize and funds should be appropriated for the Academic Research Infrastructure (ARIA program to enable NSF to solicit proposals to make additional ARI awards beginning in FY 2012.*

Renovation of existing facilities is a critical need for which it is often difficult to find funding solutions. The inability to modernize existing research facilities often decreases research productivity, meaning that the value of the research funding provided is not fully leveraged, as researchers are forced to conduct their research in suboptimal facilities.

The NSF Academic Research Infrastructure (ARI) program was originally authorized to try to address this very issue. Unfortunately, the program was never very well funded and its last solicitation was in 1996 which is, in part, why the funding provided with ARRA dollars this year for the ARI–R^2 program was received so favorably by the universities I represent here today. The program is right on the mark, aimed at modernizing existing shared research facilities. It will be important in helping to ensure that our research infrastructure keeps pace with our science—that is that the research that NSF funds can be done in appropriate research facilities—but it is funded for one year only, at $200 million. In its single solicitation, it received proposals for $1.02 billion in projects. Extension and expansion of the ARI program, through authorization and funding in FY 2012 and beyond, is critical, and the return on this investment will be high. Placing the emphasis on shared facilities ensures maximum impact per dollar.

c. *The NSF should develop a new program to support mid-scale infrastructure projects not currently eligible for support through the MRI and MREFC accounts.*

Such a program would be a significant means to support major research infrastructure needs. The National Science Board (NSB) has identified several specific areas where mid-scale infrastructure is needed. These areas include: acquisition of an incoherent scatter radar to fill critical atmospheric science observational gaps; replacement or upgrade of submersibles; beam line instrumentation for neutron science; and major upgrades of computational capability.

As the 2003 NSB report on scientific and engineering infrastructure noted, *"In many cases the midsize instruments that are needed to advance an important scientific project are research projects in their own right, projects that advance the state-of-the-art or that invent completely new instruments."* Thus, this program would advance the state of research technology, as well as spread the use of such high-end technologies.

2) *OSTP should convene a National Science and Technology working group to assess the effects of the serious decline in state and private funding for university research infrastructure and recommend steps by the federal government to ensure adequate support for the nation's academic research infrastructure.*

The need for such analysis and thought on the financial future of research universities is so dire that, in multiple forums, university leaders across the country already are convening for discussion of, among related topics, specific research infrastructure needs and the most effective solutions that could be implemented. An OSTP working group could incorporate the perspectives of individual agencies and these university discussions to move the national conversation forward with focus, in time for deliberations around the 2012 budget formulation.

Specifically the OSTP working group should:

a. *Assess existing and propose new research instrumentation and infrastructure programs at all federal agencies, including those recommended above for the NSF.*

In recent years, the funds available for research infrastructure programs outside of NSF, such as those supported by the NIH's National Center for Research Resources Division of Research Infrastructure, have dwindled. Meanwhile, the need and demand for these programs remains very high. As just one example, NIST's competitive university facilities construction grant program, which received funding of only $24 million in FY08, was able to support only three out of 93 proposals. Through additional funds provided to this program in FY 09 and through ARRA, NIST has been able to go further to address some of the pent up demand for new research facilities, however, the demand is still very high. Moreover, this demand will only grow as we move to increase the amount invested in research activities at key agencies such as the NSF, Department of Energy Office of Science, and NIST, as called for by the President and in the America COMPETES legislation which this committee will be looking to reauthorize this year.

b. *Conduct a critical review of the increasing financial pressures that impede the ability of research universities and other institutions to adequately support critical physical research infrastructure needs.*

In recent years the amount that universities, including the University of Arizona, have had to spend to ensure compliance with an increasing array of federal regulations has dramatically increased, requiring a significant amount of university revenues to go to supporting a greatly expanded "research compliance infrastructure." Many of these costs are not currently reimbursable by our sponsoring agencies. Thus, they must be paid out of the universities' own institutional funds, draining the resource pool that otherwise is available to help to support the university's physical infrastructure needs. The increasing financial pressure, as well as the impact of increasing cost sharing requirements on universities, should be carefully examined.

Conclusion

The National Academies "Rising Above the Gathering Storm" report had proposed that the government:

> *"Institute a National Coordination Office for Advanced Research Instrumentation and Facilities to manage a fund of $500 million in incremental funds per year over the next five years—through reallocation of existing funds or, if necessary, through the investment of new funds—to ensure that universities and government laboratories create and maintain the facilities, instrumentation, and equipment needed for leading-edge scientific discovery and technological development. Universities and national laboratories would compete annually for these funds."*

While we stop short of endorsing the specific amount of funding for infrastructure programs across all government agencies, we feel that there clearly is a need for a revitalization of existing agency infrastructure programs as well as the development of new programs. It is therefore time that the Congress, OSTP, and all federal agencies work together to conduct a serious assessment of what the government can do to ensure that research infrastructure needs required to support government-sponsored research activities are being met adequately.

The significant amount of money devoted to research infrastructure programs in ARRA provided a critical shot in the arm which helped to inoculate the nation against the effects of years of neglect of our research infrastructure. That being said, additional federal support for research infrastructure is still very much needed after ARRA funds end, to carry forward our ability to meet the significant needs that exist for renovation and upgrade of aging facilities across the country. This is particularly true in light of declining alternative funding sources that universities have traditionally been able to rely upon to support their infrastructure needs.

The return on this investment will be high. Our researchers, armed with direct research funding and supported by a strong research infrastructure, will be able to continue to lead the world in innovation and discovery. At my own institution, we have seen what can happen when modem infrastructure is made available: our faculty members almost certainly would not have landed the $50 million grant from the NSF to address major global issues in plant biology if they had not been located in well-outfitted facilities that were designed to enhance cross-disciplinary collaboration.

Thank you for the opportunity to present this testimony.

BIOGRAPHY FOR LESLIE P. TOLBERT

Leslie P. Tolbert, Ph.D., has been the Vice President for Research, Graduate Studies, and Economic Development of the University of Arizona since 2005. In this role, she supports the research and other scholarly activities of a $565M research enterprise, promotes technology transfer and commercialization, and oversees the graduate programs of the university. Dr. Tolbert received her undergraduate and Ph.D. degrees from Harvard University and obtained postdoctoral training at Harvard Medical School. She has been on the neuroscience faculty of the University of Arizona since 1987. She currently is a Regents' Professor with appointments in the College of Science and in the College of Medicine. For over 25 years, she has led a research group that investigates the critical role of sensory input in guiding the development of the brain. Dr. Tolbert has served as president of the Association of Neuroscience Departments and Programs and of the Association for Chemoreception Sciences, is active in the Society for Neuroscience and the American Association for the Advancement of Science, and is a member of numerous boards, including those of the Arizona Center for Innovation, the Arizona Alzheimer's Consortium, and the Large Binocular Telescope. She has served on numerous review and advisory panels of the National Science Foundation and National Institutes of Health.

Chairman LIPINSKI. Thank you, Dr. Tolbert.

Mr. Horvath.

STATEMENT OF MR. ALBERT G. HORVATH, SENIOR VICE PRESIDENT FOR FINANCE AND BUSINESS, PENNSYLVANIA STATE UNIVERSITY, AND CHAIR, BOARD OF DIRECTORS, COUNSEL ON GOVERNMENT RELATIONS

Mr. HORVATH. Thank you, Mr. Chairman and members of the Subcommittee for allowing me to participate as part of this distinguished panel.

Research is central to the mission at major universities like Penn State. The research enterprise is complex, requiring a robust infrastructure that is modern and flexible. Elements include dedicated buildings, specialized equipment, high-end computing and substantial administrative support. Such an infrastructure is complicated and expensive to develop and maintain. Universities have had to subsidize the physical and administrative infrastructures supporting research with revenues other than funding from sponsors. Major infrastructure investments are commonly financed with substantial amounts of long-term debt, based upon an expectation that research funding will continue over the term of the issued bonds. The bonds are repaid used unrestricted revenue sources, including a portion of recovered facility and administrative costs, F&A, on federally sponsored research awards.

Three recent events have caused anxiety around the sustainability of these expensive assets. First, unpredictable funding available for major federal research sponsors puts pressure on universities' plans to service its external debt. Second, the economic downturn of the last 18 months has reduced endowment values and constrained future borrowing potential. And third, other sources of possible funding for research facilities, namely philanthropy and state investments, have fallen considerably because of the economic downturn. These events have dampened the ability of research universities to invest in all facilities, including those supporting research.

In light of this challenging environment, the most important element toward encouraging investment in the research infrastructure is a reliable stream of direct research funding. If a long-term commitment is made to predictable growth in funding agencies' budgets, it would help to provide the confidence that revenues would be available to support the activities within them over a 20- to 30-year period. We strongly encourage the continuation of programs that have helped to support research infrastructures such as the ARI and other similar programs. They have provided critical assistance in our ability to meet the needs of our faculty and research staff.

Consider support for research-focused capital investments designed to help reduce the risk of these long-term financial commitments. This could be in the form of low-interest capital made available to universities for specific types of projects, or rate subsidies for borrowings made directly by the university. The success of the Build America bonds program over the past year is an indication of how modest investments by the Federal Government confer significant economic activities.

Allow universities to cover the costs of money on internal funds used to finance research infrastructure investments. This is an allowable cost for commercial recipients of federal funds. The change to our cost accounting guidelines can send more allocation of university reserves to such projects.

We would urge consideration of the removal of the cap that was placed upon administrative cost recovery by universities almost 20 years ago. Most of these universities now exceed the 26 percent cap, resulting in millions of dollars worth of legitimate research support expenses that go unreimbursed. No other type of contractor performing work for the Federal Government is subject to such a cap on supportable allocable costs.

A new, uncapped pool for regulatory compliance costs should be considered if removal of the administrative cost cap is not deemed feasible. Since implementation of the cap, several new requirements and regulations have been enacted that require greater effort by universities. However, none of the incremental costs associated with the regulatory changes can be recovered.

Require all federal sponsors to reimburse F&A costs at approved federal rates. A study by the RAND Corporation in 2000 estimated that universities are subsidizing federally sponsored research by as much as $1.5 billion that would be eligible for reimbursement if all sponsors were paying the approved F&A rate. Dozens of new and expanded federal regulations on the conduct of research implemented since 2000 have surely added to the university subsidy.

In conclusion, the research partnership between the Federal Government and American research universities has enabled great achievements in science, yielded innovation and economic growth and helped our system of higher education become the envy of the world. It is recognized that financial issues for both partners are more complex than ever before. I hope that we can jointly commit to ensuring that the research infrastructure is maintained, nurtured and permitted to evolve along with the science that it supports.

I greatly appreciate the opportunity you have provided to me to present this information, and that concludes my summary.

[The statement of Dr. Horvath follows:]

PREPARED STATEMENT OF ALBERT G. HORVATH

Chairman Lipinski, Ranking Member Ehlers, and other distinguished Members of the subcommittee on Research and Science Education, thank you for allowing me to participate in this hearing on a topic that is very important to those of us who manage the financial and administrative aspects of organized research at major research universities.

My testimony is provided on behalf of the Pennsylvania State University, where I am Senior Vice President for Finance and Business/Treasurer, and representing the Council on Governmental Relations, or COGR, where I currently serve in the role of Chairman of the Board of Directors. COGR is an association major research universities (and affiliated academic medical centers and research institutes) that helps to develop policies and practices that fairly reflect the mutual interests and separate obligations of federal agencies and universities in research and graduate education.

Background and Context

As a chief financial officer of a major research institution, fiscal oversight of the research enterprise is an important and challenging aspect of my responsibilities. Research activities account for almost 19% of Penn State's operating budget, trailing only instruction and patient care in scale. The percentage of total revenues generated by research could be much more significant at other universities, depending on their mix of various mission-driven activities, Research is a complex activity which requires dedicated facilities, specialized equipment, significant physical infrastructure, substantial administrative support, and a number of specific compliance processes.

While research is central to our universities' missions, keeping the research enterprise solvent, and keeping our finances solid, has become a greater challenge. Since the early 1990's, universities have faced tighter regulation with respect to funded research, with more limitations on our ability to effectively and reasonably recover those costs. A COGR paper in 2004 entitled "A New Research Business Model-Incentivizing Universities" (Attachment B) stated:

"Six examples describe the impact of current regulations, all of which provide short-term cost savings to the federal government, at the risk of long-term damage to the research enterprise. The regulations impose:

- *Limits on legitimate cost recovery by agency or type of award,*
- *A cap on administrative cost recovery in a time of growing administrative and regulatory requirements,*
- *Lack of commitment to life cycle costs for capital projects and the requirement to invest capital recoveries,*
- *An artificial distinction between internal and external interest costs on borrowed funds,*
- *The exclusions of many universities from receiving adequate utility cost reimbursement,*
- *Conflicting and duplicative requirements among funding agencies."*

Universities have had to subsidize the physical and administrative infrastructures supporting research with revenues generally provided by State governments (public universities) or private philanthropy (private universities). Following the economic challenges of the past 18 months, both of those funding sources have become seriously constrained.

Additionally, the infrastructure necessary to enable cutting edge research is complex and expensive. Universities have made significant investments in such infrastructure—buildings, major equipment, utility systems, organizational changes and processes with long-term financial commitments based upon an expectation that research funding would continue over the term of amortization. Regulated funding restrictions and budget uncertainty conspire to create tremendous financial risk and anxiety over the ability to fund the debt that has been incurred. It also dampens the willingness to make new investments in the future.

A summary of Penn State's research funding/activity can be found in Attachment A.

How research infrastructure is financed at Penn State

The University's overall capital plan is financed through a variety of sources. The current multi-year plan, which runs through June 30, 2013, anticipates a total of $820 million of projects that will be financed as follows:

Financing Source	4 year total (millions)
Institutional Borrowing	$450
Annual State funding @ $40M per year	$160
Internal reserves	$130
Gifts/fundraising	$70
Special State allocations	$10
TOTAL	$820

Major research facility projects—renovations or new construction—are generally enabled through the issuance of tax-exempt bonds. This long term obligation (20–30 year repayment) is repaid using unrestricted revenue sources, including a portion of recovered facility and administrative costs (F&A) on sponsored awards. The Commonwealth of Pennsylvania, in addition to its annual $40 million commitment of capital funding, sometimes provides special allocations for such facilities, but these commitments historically amount to a modest fraction of total construction cost.

Penn State has a strong credit rating (AA by Standard & Poors, Aa2 by Moody's Investor Services) and has been successful at obtaining favorable interest rates for its tax exempt bond issuances. This access to "reasonably priced" funding has enabled the University, along with many other research institutions, to invest in its facilities and infrastructure particularly as endowments grew and balance sheets strengthened. Encouraged by the commitment to research funding, particularly through NIH during the 1990s, research facilities were expanded or renovated to enable the cutting edge work implied by such Federal investments. However, a few critical changes have caused uncertainty and anxiety around the sustainability of these expensive and complex assets.

1. Once the doubling of the NIH budget was achieved, subsequent years' budgets began to erode some of that growth. While there was no assumption that such extraordinary growth would continue forever, allowing some of that growth to recede was not expected. This has caused uncertainty in planning for the future and put pressure on universities' ability to service its external debt as had been planned.
2. The severe economic downturn, which hit higher education beginning late in 2008, has significantly reduced endowment values and constrained future borrowing potential. The ability to continue to reinvest in research at past levels will be difficult if not impossible, given that those facilities must compete for priority against all other activities of comprehensive universities (classrooms, student support facilities, libraries, student housing and the like). While markets and endowments have somewhat recovered, it will take some time and sustained improvement for values to return to what they were previously.
3. Other sources of possible funding for research facilities—private philanthropy and state investments—have fallen considerably because of the effects of the economic downturn.

The events noted above have dampened the ability of research universities to invest in all facilities, including those supporting research. The specific impact at Penn State has been a delay in our ability to move ahead with our five year capital plan as originally drafted. Projects generally have not been cancelled, but many have been delayed by generally 12–18 months. Also, our borrowing plans, although historically conservative, have become even more so as we monitor the activity of the capital markets and move cautiously with new debt.

As an example of the process followed and the issues encountered with the planning and execution of a major research facility is Penn State's Millennium Sciences Complex. This 175 thousand square foot research facility will house faculty conducting research in material science and the life sciences. The building is intended to encourage collaboration between these two disciplines and will include many of Penn State's most pre-eminent research faculty, The building is projected to cost $215 million and is scheduled for completion in 2011. The Commonwealth has provided $82 million of funding (the majority of which was a Penn State allocation of its annual capital allocation); the $133 million balance is financed with bonds issued in 2009. The interest expense associated with this project is calculated to be $63.8 million over the life of the bonds. Sponsored research funding generated by faculty in this facility will provide partial repayment of the interest costs of the related borrowing through recovery of F&A costs.

Penn State has approximately 1.6 million square feet of space dedicated to research at its University Park campus, with expressed needs for up to another 500 thousand square feet just to support the present research portfolio. There are over $32 million of identified research equipment needs, Over $475 million of deferred maintenance exists in its research buildings, based upon facility condition audits conducted across the campus. Other research needs/initiatives could be addressed with additional facilities that don't currently exist. Clearly, this is a big challenge as these needs must compete for access to funding against other institution priorities (including the Penn State Hershey Medical Center, which also competes for this investment capital and supports a significant research enterprise).

Academic Research Infrastructure Program (ARI)

The inclusion of additional funding for the ARI as part of the American Recovery and Reinvestment Act was most welcome in the research community, While the total amount allocated to funding for renovation and renewal of existing facilities, this was a positive step toward helping research universities to address a critical issue—deferred maintenance and aging facilities, Without a regular stream of funding toward such buildings and equipment, they become obsolete. Many labs exist in buildings built 30 or more years ago. Building systems did not contemplate the requirements of modem day science and engineering research. Often the most difficult part of recruiting new research faculty is the extent to which facilities need to be upgraded or renewed in order to support the research program of the faculty member. Such upgrade can run into the hundreds of thousands or millions of dollars.

Both Penn State and COGR would encourage the Congress to consider extension of the ARI in future years to assist in dealing with the challenge of maintaining facility viability. It will help in generating positive economic activity as well.

The trade-off between increases in direct research funding versus more money in the ARI or other infrastructure support programs is a difficult one. ARI has been most welcome and beneficial. However, a strong, consistent stream of funding for the primary research supporting agencies is also critical, This basic research funding provides the support for labs, research technicians, graduate students, support personnel, as well as funding toward supporting infrastructure. We hope that consideration of accomplishing both of these goals—steady strong research funding and some form of ARI—could be goals that are achievable together and not at each other's expense. Additionally, we would encourage establishment of a larger fund for such projects. As noted earlier in my testimony, the needs for such funding are large and compelling. The ability to fund a larger number and wider range of projects would be extremely effective in maintain facility capability.

Other ideas to provide support for research infrastructure needs

We would encourage the consideration of additional investments by the Federal government to help support the infrastructure that supports research at universities. Such investments will help to ensure that the continued cultivation of the basic science as the fundamental foundation of innovation and progress envisioned by Vannevar Bush several decades ago. Also, the economic benefit that such research provides is demonstrable. However, recognizing the realities of difficult budget choices, I offer some other ideas for ways in which the Federal government can more effectively support research on campuses and reduce some of the growing burdens that this activity places on University finances.

- *Predictable, long term research financing*—By far, the most important element toward reducing risk as universities make substantial financial commitments to research, spanning several years, would be a reliable stream of direct research revenue. As budgets are prepared and business plans developed, a major assumption in the evaluation of a project is the reliability of revenues that will be available to repay debt incurred. If a long term commitment to predictable growth in major funding agencies budgets for extramural research, it would help to provide confidence that the research such facilities are designed to support will, in fact, be able to financially support them over a 20–30 year period.

- *Federal programs to assist in financing research infrastructure*—The Federal government could provide mechanisms to help reduce cost of major investments or the risk of long term decisions. Such programs/systems would help to incentivize new investments in an era following balance sheet declines. The economic benefit of such investments has both a short run component (the activity stimulated during the construction phase) and a long run component (addition of higher paying knowledge jobs).
  - Provide support for research capital investments
    - Pool of capital dedicated to support investments in research buildings, building renovations, computing infrastructures
      - Explore the possibility that a pool of dedicated capital could be made available to research universities with very favorable repayment terms. These funds would be accessed by institutions, according to specific criteria (types of facilities/uses) to finance new facilities and would be repaid at subsidized interest rates. This pool then would be self-sustaining over time and could help to ease some of the tough choices universities face on how to invest its limited capital.
    - Debt service subsidies for university-issued bonds
      - Provide subsidies for payment of debt service on borrowing undertaken by research universities for new facilities, major renovations or major equipment purchases that benefit Federal sponsors.
  - Provide "grants" to fund a portion of new facilities, major building renovations or capital equipment acquisitions, This would serve to reduce the overall amount needed from bond issues or other external borrowings, thus reducing the impact on an institution's credit rating/debt capacity issues.
- *Allow recovery for the cost of internal capital, which is permitted for commercial contractors*
  - There are a number of differences between the cost accounting rules that exist for commercial and non-profit recipients of Federal funds. One notable example is the inability for universities to recover the "cost" of internal funds (reserves) that are used to finance research assets. Changing OMB Circular A21 to allow such costs to be recovered would help to incent perhaps a greater commitment of institutional reserves into such projects. This cost would become a component of the institution's F&A rate, which is audited and approved by its cognizant Federal agency.
- *Consider elimination of the administrative cost cap in OMB Circular A–21*
  - While not directly related to "bricks and mortar," the cap that was placed upon administrative cost recovery by universities almost 20 years ago continues to create burdens on institutions. Most of the major research institutions have calculated administrative cost components which exceed the 26% cap, resulting in millions of dollars worth of legitimate research support expenses that go unreimbursed. No other type of contractor performing work for the Federal government is subject to such a cap on supportable, allocable support costs. Since implementation of the cap, several new requirements and regulations have been enacted that require greater effort by universities; however, none of the incremental costs associated with the regulatory changes are recoverable (if the institution is over the administrative rate cap).
  - If removal of the administrative cost cap is not considered feasible, then consideration of the creation of a new, uncapped pool for regulatory compliance costs should be considered. As mentioned above, the growth of new requirements, seemingly every few weeks, has placed financial pressure on universities which other non-research revenues must subsidize. Universities WANT to be compliant,, and often the regulations are complex, requiring new investments or additional staff. This is not a signal of inefficiency but recognition of the cost of being compliant. A listing of new compliance requirements implemented since imposition of the administrative cost cap was compiled by COGR in March 2009, and demonstrates this point effectively (Attachment C).
- *Require all Federal agencies to reimburse universities at Government-approved F&A, rate*—A study by the Rand Corporation in 2000 estimated that univer-

sities are subsidizing Federally sponsored research by roughly $0.7 billion and $1.5 billion that would be eligible for reimbursement through negotiated/approved F&A rates if all sponsors were paying the approved rate. We would support changes in appropriate regulation that would require Federal sponsors to pay the negotiated Federal rate on all research it funds.

Conclusion

The research partnership between the Federal government and U.S. research universities has enabled great achievements in science, innovations that have fueled economic growth, and helped our system of higher education to become the envy of the world. It is recognized that financial issues for both partners are more complex than ever before. Infrastructure—in the form of buildings, equipment, computing networks, and other necessary support ingredients—allow this research to flourish and discoveries to be made. We must jointly commit to ensure that this infrastructure is maintained, nurtured and permitted to evolve along with the research that it supports. As discussed in the 2003 COGR paper "New Research Paradigms Call for Regulatory Change:" (Attachment D).

"The essential premise for a new business relationship between the government and universities is the simple acknowledgment that both parties engage as "business partners". This means, among other things, a recognition of complementary interests in the cost effective administration of awards and the providing of adequate funds to meet the joint expectations for the outcomes of research."

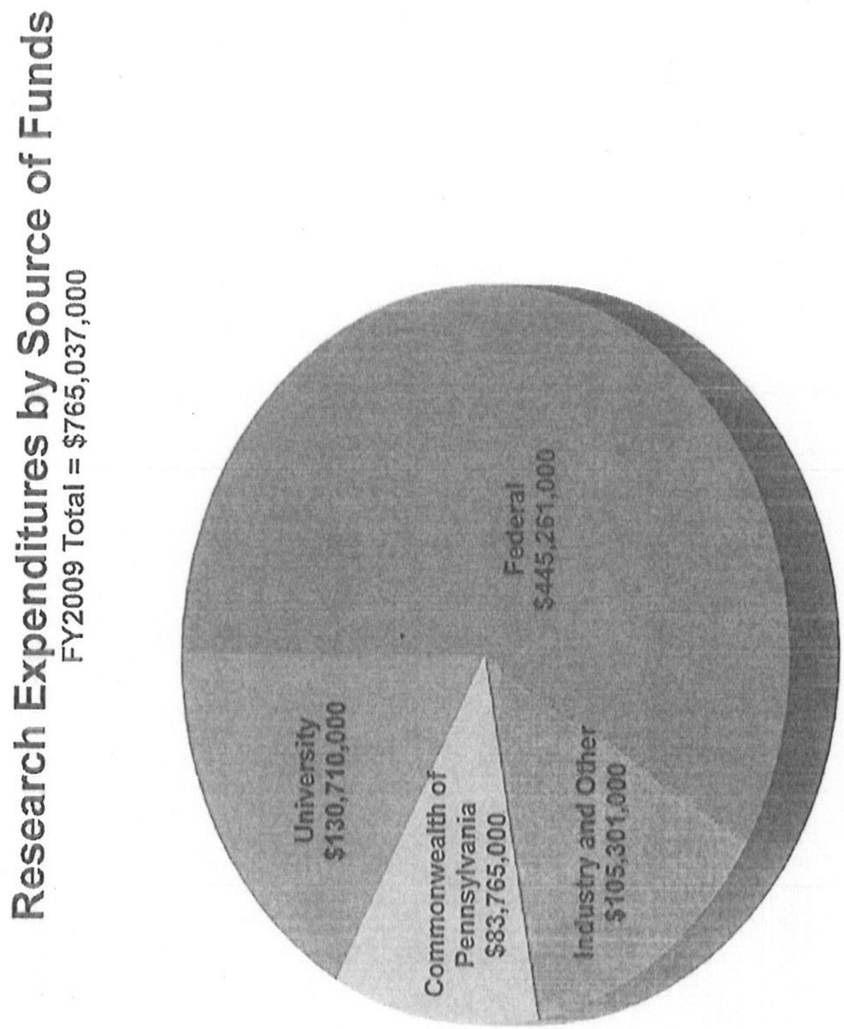
Steady, predictable streams of research funding form the foundation for the science and technology discoveries that result. A commitment by the Federal government to such funding will help to make future investments in facilities and support by universities less risky projects. Additionally, the continuation of programs like the Academic Research Infrastructure Program, NSF's Major Research Instrumentation program, among others will assist in the development of new facilities along with ensuring the viability of existing facilities. Finally, changes to policies that will enable full and reasonable recovery of costs associated with research will help to ease pressure that caps and other funding reductions have created.

I greatly appreciate the opportunity you have provided to present this information.

Attachment A

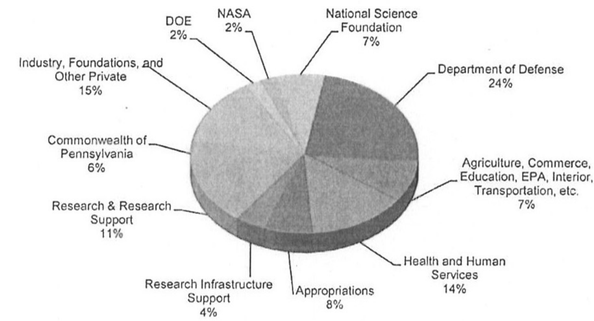
Summary of Sponsored Research Activity

Penn State University



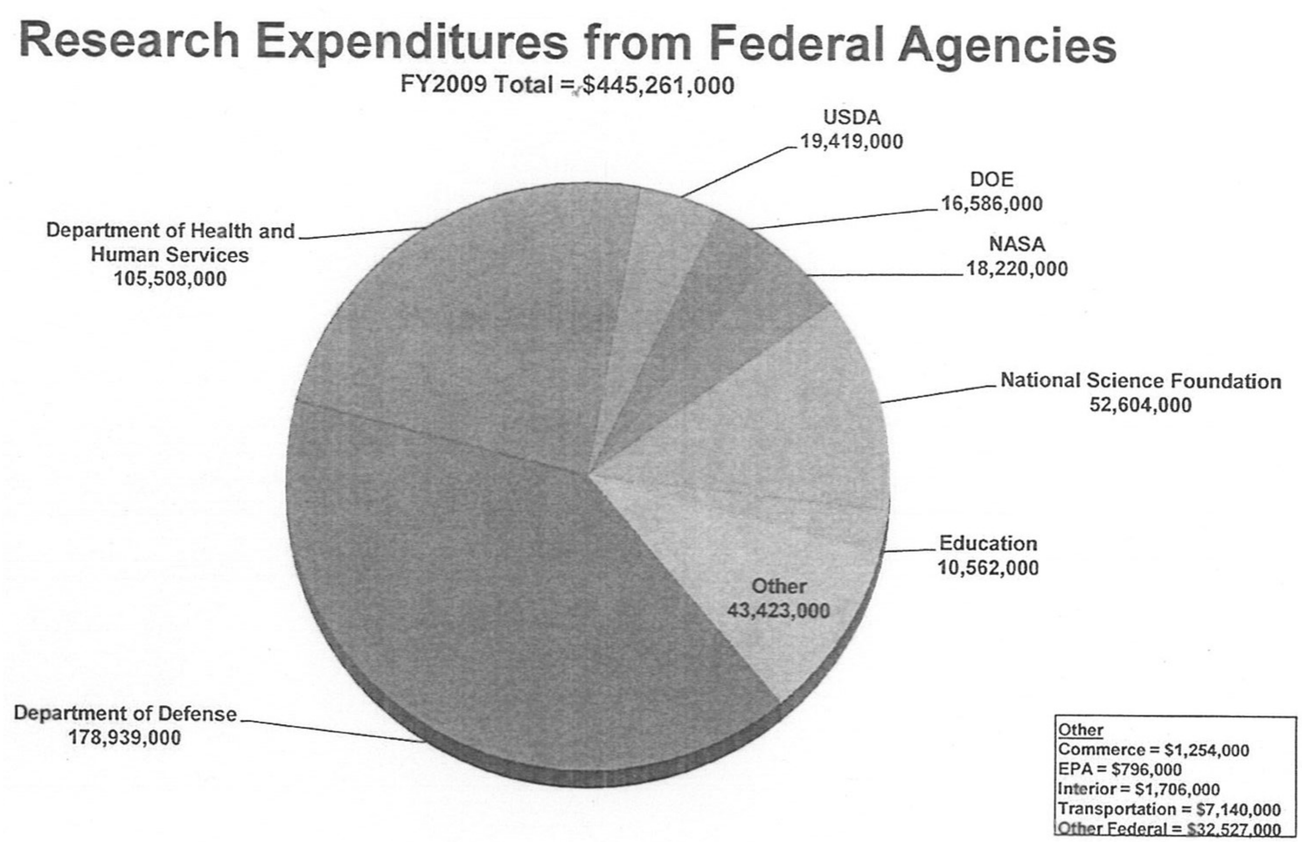
EXPENDITURES ON ORGANIZED RESEARCH

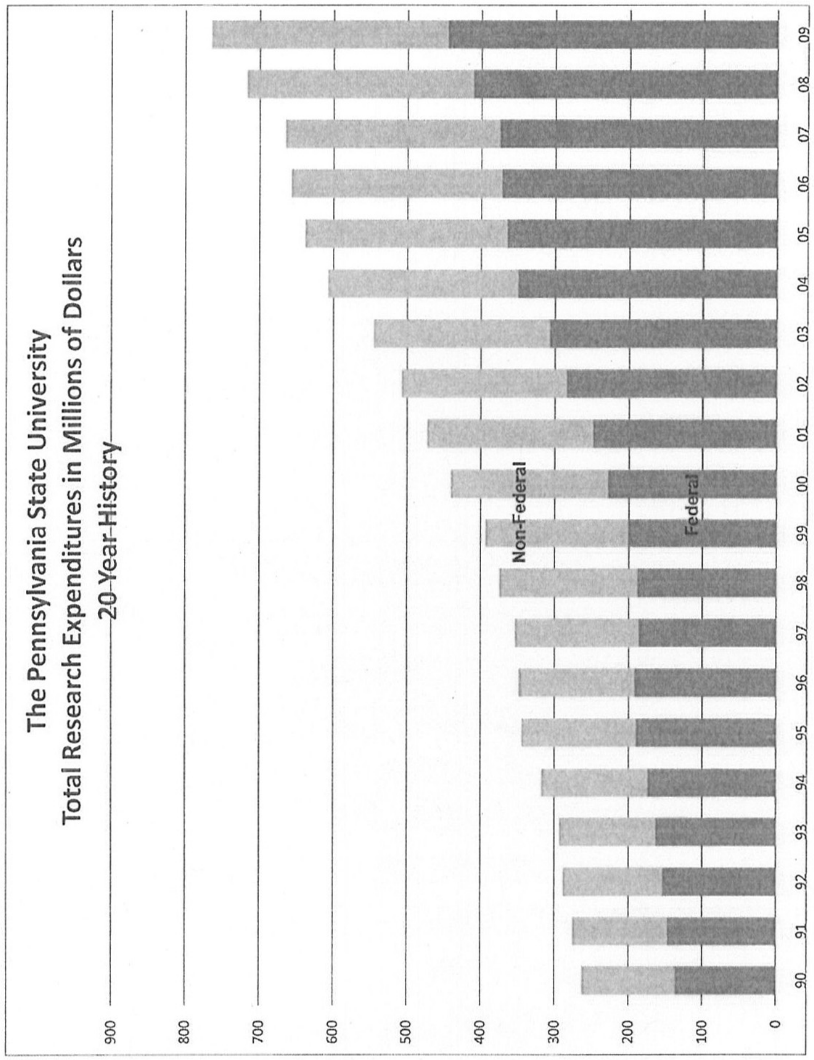
by Source for Fiscal Year 2008-2009



	SOURCE OF FUNDS	AMOUNT THIS YEAR	AMOUNT LAST YEAR
Sponsored Grants & Contracts	Department of Agriculture	$ 12,807,000	$ 11,768,000
	Department of Commerce	$ 1,254,000	$ 1,470,000
	Department of Defense		
	Department of Air Force	$ 6,683,000	$ 7,706,000
	Department of Army	$ 27,755,000	$ 29,793,000
	Department of Navy	$ 141,836,000	$ 128,510,000
	U. S. Marine Corps	$ 2,665,000	$ 4,830,000
	Department of Education	$ 10,562,000	$ 9,605,000
	Department of Energy	$ 16,586,000	$ 14,618,000
	Department of Health & Human Services	$ 105,508,000	$ 98,189,000
	Department of the Interior	$ 1,706,000	$ 1,203,000
	Department of Transportation	$ 7,140,000	$ 5,909,000
	Environmental Protection Agency	$ 796,000	$ 669,000
	National Aeronautics & Space Administration	$ 18,220,000	$ 15,267,000
	National Science Foundation	$ 52,604,000	$ 53,400,000
	Other Federal Agencies	$ 32,527,000	$ 20,338,000
	Subtotal Federal	$ 438,649,000	$ 403,275,000
	Commonwealth of Pennsylvania	$ 40,150,000	$ 42,597,000
	Subtotal Government	$ 478,799,000	$ 445,872,000
	Penn College	$ 1,622,000	$ 1,617,000
	Industry and Private	$ 103,679,000	$ 104,803,000
	Subtotal Non-Government	$ 105,301,000	$ 106,420,000
	Total Sponsored Grants & Contracts	**$ 584,100,000**	**$ 552,292,000**
Federal Appropriations	Agricultural Research	$ 6,612,000	$ 8,169,000
	Total Federal Appropriations	**$ 6,612,000**	**$ 8,169,000**
State Appropriations	Organized Research (Est.)	$ 19,557,000	$ 20,498,000
	Agricultural Research	$ 24,058,000	$ 25,595,000
	Total State Research Appropriations	**$ 43,615,000**	**$ 46,093,000**
	Total External Funds	**$ 634,327,000**	**$ 606,554,000**
	Internal Research and Support	$ 97,987,000	$ 79,401,000
	Research Infrastructure Support	$ 32,723,000	$ 31,289,000
University Funds	**Total University Funds**	**$ 130,710,000**	**$ 110,690,000**
	GRAND TOTAL	**$ 765,037,000**	**$ 717,244,000**

Senior Vice President for Research, Dean of the Graduate School
October 2009


Research Expenditures from Federal Agencies
FY2009 Total = $445,261,000
USDA
19,419,000
DOE
16,586,000
NASA
18,220,000
National Science Foundation
52,604,000
Education
10,562,000
Other
43,423,000
Department of Defense
178,939,000
Department of Health and
Human Services
105,508,000
Other
Commerce = $1,254,000
EPA = $796,000
Interior = $1,706,000
Transportation = $7,140,000
Other Federal = $32,527,000


The Pennsylvania State University
Total Research Expenditures in Millions of Dollars
20-Year-History
Non-Federal
Federal
0
100
200
300
400
500
600
700
800
900
90
91
92
93
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Attachment B

A New Research Business Model: Incentivizing Universities

Introduction

This paper illustrates some of the difficult choices that universities face in order to comply with the current cost policy restrictions of the federal government as expressed by federal agencies and by OMB. Many of these policies were imposed for the purpose of saving taxpayer dollars, while at the same time providing maximum support for research. The paper illustrates that these measures are not the best way to reach the stated goals. Instead of imposing restrictions, we propose that the government look to a new business model, We maintain that it would be preferable to offer incentives to allow the academic community to manage the increasingly rare research finds on terms comparable to those granted to any experienced, cost-conscious and competitive provider of research.

Six examples describe the impact of current regulations, all of which provide short-term cost savings to the federal government, at the risk of long-term damage to the research enterprise. The regulations impose:

Limits on legitimate cost recovery by agency or type of award,

A cap on administrative cost recovery in a time of growing administrative requirements, Lack of commitment to life cycle costs for capital projects and the requirement to invest capital recoveries,

An artificial distinction between internal and external interest costs on borrowed funds, The exclusions of many universities from receiving adequate utility cost reimbursement, Conflicting and duplicative requirements among funding agencies.

Taken either in isolation or as a short-term mandate, any one of these restrictions may seem immaterial, but their cumulative impact is acutely felt in the higher education community. The costs to the federal government are not as immediately evident but nonetheless real. They may be financial, they sometimes represent lost opportunities, i.e. loss of research capacity or they inadvertently encourage less than optimal research decisions. The impact would be no different and as strongly resisted, if these regulations were imposed on any other business entity.

It is true that the government's current costing polices do not deprive universities of the freedom to make choices, but the choices have become increasingly narrow and at times dysfunctional. It should be evident that universities can best serve the nation if they are free to make their best intellectual judgment about the future direction of research. Universities have historically accepted the risk that today's research focus is likely to change tomorrow, if new discoveries redirect the progress of science or if the federal government changes its priorities. The risk, however, is much greater today, because artificial limits and prescriptions have been injected into the basic compliance structure that is the foundation of government research support policy. Cumulatively these prescriptions create financial disincentives that impact program choices and may encourage decisions that are neither in the best interest of taxpayers' nor consistent with government goals and policies in supporting university research.

Situation 1: Limits on legitimate cast recovery by agency or type of award

A tenured professor retires and her 30-year-old laboratory must be renovated to accommodate a new faculty member. In deciding how to allocate the new space, the university has to weigh the risk that a junior faculty's primacy research support may come in the form of awards that do not pay the full, negotiated facilities and administrative (F&A) rate. An example is the NIH career development program, under which F&A recovery is limited to 8%. In establishing this program the government has demonstrated its resolve to support young investigators, recognizing that the nation needs a steady stream of accomplished researchers. However, the government's failure to provide the requisite support costs diminishes the impact of the program. Alternately, a more senior faculty member, whose cutting-edge research is so novel that federal funding has yet to be secured, might claim the newly renovated space. But for how long can the university afford to cost share the F&A costs for his laboratory?

The financial realities of setting up a recent hire to the faculty are large and are real. Renovating space, equipping and running a modem research lab, and providing seed money for new research requires as many institutional resources (research proposal assistance, utilities, administrative support) as providing research space for a more senior colleague. It may turn out that the space is given to an established investigator operating in a mature branch of her field, where F&A costs are provided. Financial considerations, of course, may not be the final determining factor in. academic decisions. Nevertheless, from a strictly "business" perspective, the choice favors the more senior appointment in "safe" and well-funded research areas.

These situations illustrate how academic and financial arguments create difficult trade-offs when important strategic research decisions are made. Some universities have decided to recognize faculty, who are successful grantees and who bring in the full negotiated F&A rate, by awarding them the best research space in newly-renovated buildings. Other universities might consider prioritizing the renovation of buildings that will house successful grant applicants, at the expense of other disciplines that are not as likely to be "funding winners." Without sufficient revenues to support total costs, both direct and indirect, the need quickly arises to subsidize research activity from other sources (primarily from tuition or gifts from private donors).

These cases illustrate how financial disincentives may lead to results that are neither in the best interest of the taxpayers nor consistent with government goals and policies in support of university research.

Situation 2: A cap on administrative cost recovery in a time of growing compliance requirements

The university determines that changes to its oversight requirements for bio-medical research must be substantially enhanced due to much stricter regulation by the federal government. Such enhancements will require the institution to incur additional costs in the hundreds of thousands or even millions of dollars, all directly supportive of research primarily sponsored by federal agencies. Some are the result of new regulations, others are the result of changes in federal interpretation of compliance needs in research areas that develop commensurate with the advance of scientific methods. However, due to the fact that the institution's negotiated F&A rate is already at the 26% administrative cost cap, the government does not provide its fair share of these new compliance costs.

In order to continue the relevant research and to comply with federal regulations, the administrative costs supporting such research must be subsidized by other revenue sources, possibly tuition revenue or private donations or increasingly shrinking state funds. Compliance with these federal mandates is not a matter of choice and "efficiencies" cannot be easily achieved. If no revenue sources are left and if additional subsidies to the research enterprise can no longer be found, the research-intensive universities face even more difficult choices. Their options are reduced to gradual elimination of certain research programs or the even more problematic decision of reducing compliance standards to the required minimum level.

Situation 3: Decreasing pool of investment capital for universities to invest in research facilities

The university determines that a research building dating from the I930s has outlived its usefulness and that it would be most cost-effective to raze the building and to build all new space. However, the common source of funding in the past-tax-exempt bond funding-is now in shorter supply. With the economic downturn of the past few years, the institution's endowment value has declined, thus reducing the level of borrowing capacity available. While the institution has extensive borrowing ability, a significant additional borrowing will likely push its credit rating down a level, thus creating more expensive interest costs. Capital campaigns, although desirable, can only be initiated slowly and have unpredictable outcomes. These realities could force the university to defer a decision, with the result that the building in question will deteriorate further and that current or future research will be negatively impacted.

The federal government has for years failed to include a well-funded facilities support program in the federal agency research program budget. The unfortunate consequence of this has been the increase of earmarks in Congressional appropriations. Also, to date there exists, no federal policy that commits the government to participate in its share of debt service over the life of the loan. It would make good business sense to provide incentives, since the research to be performed in these facilities is in the government's interest. A variety of incentives have been proposed and could include a reasonable facilities funding program placed in the federal budget, offering universities a federal sharing in loans, or a federal loan guarantee program. The common denominator in all these would be removing the uncertainty that universities currently experience under the given federal policy.

Business decisions for the university are further complicated by the federal government's requirement that for every dollar of depreciation recovered on the new building, a dollar must be spent on some future project. This means in effect that the university will never recover the cost of its investment, and may be committed to new construction at times when it is not in a sound financial position to do so.

Situation 4: An artificial distinction between internal and external interest costs on borrowed funds

The university's bond rating is in jeopardy due to depressed financial markets. Because of this, it would be less expensive on a gross basis to allocate internal capital funds to pay for a new science building. However, the university knows that there is no option for recovery from the government of the university's internal cost of capital. Under these circumstances, the university may make a rational business decision to borrow at a higher external rate because it then can recover a fraction of the interest costs from the federal government, thereby lowering its net cost of interest.

It would clearly be in the taxpayers' interest to provide incentives for the university to use its own money, possibly by sharing some of the investment costs, so that the federal contribution does not go to defraying avoidable higher interest costs.

Situation 5: The exclusion of certain universities, from receiving the utility cost adjustment factor

A space vacancy occurs in the cancer research center. The university could make the space available for a number of equally worthy projects. One of them is a large laboratory where the research project requires constant air changes. Unfortunately such a laboratory would entail high energy use. Since the university had not undertaken an energy study prior to 1996, it is now prevented from receiving higher compensation through the F&A rate for higher energy research consumption. When the government put new energy studies on hold in 1996, it promised to develop a fair formula for all academic energy consumers, but has yet failed to do so. As a result, more than one hundred universities are now prevented from recovering the costs for higher energy use which they consume, which they could easily document, and which their peers who had done prior energy studies now enjoy.

For the university faced with this choice, the uncompensated energy costs inject an artificial economic factor into a determination which should be based solely on academic and scientific needs. This may influence the university to make a decision not in the best interests of science.

Situation 6: Regulatory Burden Reinforces Bureaucracy

Universities, like commercial businesses, seek to maximize the use of financial and human resources to meet their strategic objectives. As resources become more constrained, institutions attempt to streamline their efforts, including the maximum use of available technology, to reallocate resources into priority areas. But research universities find it increasingly difficult to reduce the administrative burden of research in order to fund more strategic activities. The following three examples illustrate how federal requirements contribute to high administrative costs, and thereby detract from effective decision-making.

- Each federal agency views itself as unique, operating within its own set of administrative guidelines and regulations. This requires counterpart experts at the university to effectively deal with the day-to-day operations of each respective agency funding.
- New initiatives in the government's administrative processes, such as electronic research administration, have not been coordinated across sponsoring agencies in a way that establishes common standards to assist universities in implementing simple, cost effective solutions. As a result, the same task (i.e., submission of a research proposal) must be accomplished in a variety of different ways.
- Costing regulations became more burdensome and complex in the 1990s, including the requirement to develop and adhere to Cost Accounting Standards Board protocols that are expensive to implement and maintain but often ignored by the cognizant agencies. Significant time and effort that could have been used elsewhere was expended to develop the Disclosure Statements, and continues to be devoted to maintaining them as changes are required to business processes.

A specific example of how such administrative requirements negatively impact the drive towards efficiency is one university's attempt to create a new staff classification for "research faculty. " The sole motivation for this change is to build and strengthen *the university's research capability. In order to create the new position, the institution needs to have a cost recovery model that enables all leave costs to be charged directly to grants and contracts. This requires changes to the written disclosure statement that must be negotiated through the cognizant agency, even though costing practices were recently reviewed in negotiation of the F&A rate. Such requirements delay the implementation process in a way that is difficult to explain to faculty administrators and counter to the shared desire for increased efficiency.*

Conclusion:

These examples illustrate the dangers to the research enterprise when sound business decisions can no longer be reconciled with what appear to be sound research decisions. Unless the government changes some of its policies, it may trigger outcomes that are adverse to its own stated goals: to foster an environment in which the government's academic business partner is empowered to manage itself and the federal investment in research in the most pendent and cost effective manner. For each of the examples cited in this paper, there exist. a number of possible policy solutions. Some are very specific, such as extending the utility cost adjustment factor, and allowing "cost of money" for universities that use their own capital for facilities. Others have broader implications, such as eliminating the administrative cap, or establishing loan guarantee programs for new facilities. Still others would only require adherence to government-stated purposes and principles, such as payment of negotiated F&A rates on all federal awards, and streamlining financial and research administration requirements to eliminate unnecessary processes and to create consistency among sponsoring agencies.

The unique position of universities precludes their being treated as business partners in the same sense as commercial business partners. According to the latest information from NSF, university funds to support research' reached $6.55 billion in 2001, or 20% of total expenditures, As recently as 15 years ago the university share of total expenditures was 10%. Stated differently, for every $1 million of funding received in new awards, a university provides an additional $200,000 of direct and infrastructure costs. This significant investment of funds demonstrates the universities' commitment to support research. Recognizing this, universities must and do take every opportunity to maximize administrative efficiency and reduce costs. However, we believe a comprehensive strategy is needed to address the growing imbalance in support for the university research infrastructure. The government will justifiably expect to get the best results from federally funded research on the most reasonable terms, and with the expectation of cost sharing. But where the government fails to recognize the universities' legitimate business constraints, and the result is increased research cost shifting, it is time for new research business models, which recognize these constraints and design funding programs consistent with them.

Attachment C

Federal Regulatory Changes, Since 1991

These regulations directly affect the conduct and management of research under Federal grants and contracts. The list of current regulations is in chronological order.

Federal Policy for the Protection of **Human Subjects (Common Rule,** 1991)

Nonindigenous **Aquatic Nuisance Prevention & Control** Act of 1990 (Implemented, 1992)

NIH Guidelines for Research Involving **Recombinant DNA** Molecules (1994)

Deemed Exports (1994, EAR & ITAR)

DFARS Interim Export Control Compliance Clauses (July 2008)

Conflict of Interest

Public Health Service/NIH Objectivity in Research (1995)

NSF Financial Disclosure Policy (1995)

Lobbying Disclosure Act of 1995

Cost Accounting Standards (CAS) in OMB Circular A–21 (1995)

Health Insurance Portability & Accountability Act of 1996 **(HIPAA)** Privacy Rule

OMB Elimination of Utility Cost Adjustment (UCA) (1998)

Data Access/**Shelby Amendment** (FY 1999 Omnibus Appropriations Act); related amendments to OMB Circular A–110

Policy on Sharing of **Biomedical Research Resources** (NIH, 1999)

Misconduct in Science (Federalwide Policy, 2000)

NEH, 2001

NSF, 2002

EPA, (Directive, 2003)

Labor, 2004

HHS/PHS, 2005

NASA, 2005

Energy, 2005

Veterans Affairs, 2005

Education, 2005

Transportation, 2005

USDA (Proposed, 2008)

HHS Centers for Medicare and Medicaid Services **(CMS) National Coverage Determination for Routine Clinical Trials** (Clinical Trials Policy), 2000

Executive Order 13224, Blocking Property and Prohibiting Transactions With Persons Who Commit, Threaten to Commit or Support Terrorism (September 2001, also EO 12947, 1995)

Select Agents & Toxins (under CDC and USDA/APHIS) Public Health Security & Bioterrorism Preparedness & Response Act of 2002; companion to the USA PATRIOT Act (2001)

FISMA Federal Information Security Management Act (Title III, E Government Act of 2002) OMB Circular A–130, Management of Federal Information Resources, Appendix III, **Security of Federal Automated Information Systems**

CIPSEA Confidential Information Protection and Statistical Efficiency Act (OMB Implementation Guidance 2007, Title V, E Government Act of 2002)

Federal Policy on Embryonic Stem Cell Research (2003)

Data Sharing Policy (NIH, 2003)

Homeland Security Presidential Directive **(HSPD)–12,** Common Identification Standards for Federal Employees and Contractors (2004)

Higher Education Act, Section 117 **Reporting of Foreign Gifts, Contracts and Relationships** (20 USC 1011f, 2004)

Model Organism Sharing Policy (NIH, 2004)

Constitution & Citizenship Day (2005, Consolidated Appropriations Act FY 2005)

Genomic Inventions Best Practices (2005)

Combating **Trafficking** in Persons (2008)

Code of Business Ethics & Conduct (FAR) 2008

Homeland Security Chemical Facilities Anti-Terrorism Standards (CFATS) 2008

E-Verify 2008

Military Recruiting and ROTC Program Access (2008, Solomon Amendment, National Defense Authorization Act for FY 2005)

Nuclear Regulatory Commission Order Imposing **Fingerprinting and Criminal History Records Check** Requirements for Unescorted Access to Certain Radioactive Materials (Feb. 2008, Section 652, Energy Policy Act of 2005)

National Institutes of Health **Public Access Policy** (2008, Consolidated Appropriations Act of 2008, Division G, Title II Section 218)

Certification of Filing and Payment of Federal Taxes (Labor, HHS, Education and Related Agencies Appropriations Act of 2008, Division G, Title V, Section 523)

Health and Human Services/FDA Clinical Trials Registry **Implementation/Interpretation Changes, Since 1991**

Foreign Nationals (See COGR/AAU/FDP Troublesome Clause Report, 2008 [1])

Publication Restrictions (see COGR/AAU/FDP Troublesome Clauses, 2008)

P.L. 106–107/Grants.gov: Electronic Applications, Financial Reporting Progress Reports, iEdison Invention Reporting, etc. **CCR/DUNS** Registry requirements

Subrecipient Monitoring (OMB Circular A–133, Compliance Supplement)

Changes to A–21 **F&A Proposal Format**

Federal Policy for the Protection of Human Subjects:

- **Federalwide Assurance** (2004), mandatory training
- **IRB Registration** (2008)

Title IX of Education Amendments of 1972: Access to science and math educational programs (2007+)

EPA **Hazardous Waste,** Subpart K (2008)

IRS 990 Reporting

Significant Proposed Changes

Export Controls: Export Administration Regulations (EAR) & International Traffic in Arms Regulations (ITAR) (2003)

Responsible Conduct of Research Training—NSF (America COMPETES Act 2006)

Federal Funding Accountability and Transparency Act **(FFATA) Subrecipient Reporting** (2006)

National Science Advisory Board for Biosafety (NSABB) **Oversight of Dual Use Life Sciences** Research of Concern

Nuclear Regulatory Commission—Considerations concerning the Security and **Continued Use of Cesium-137 Chloride Sources** (July 2008)

USAID **Partners Vetting System** (re: EO 13224 et al. re: terrorist financing)

USDA **Animal Welfare Act, Contingency Planning** (2008)

[1] The Report is available at: *www.cogr.edu/docs/COGRAAUTroublesomeClausesReport.pdf*

Attachment D

New Research Paradigms Call for Regulatory Change

Executive Summary

During recent discussions initiated by the Office of Science and Technology Policy about new research business models, much attention was given to interdisciplinary research activities and the team efforts required to carry out such research. Expanding these thoughts further, this paper offers an analysis of the increased administrative responsibilities that are encountered when research projects scale up to more complex, multi-disciplinary and multi-institutional levels.

Starting with streamlining that would benefit the administration of the basic assistance award, the paper recommends changes that would facilitate business practices commensurate with increasingly complex business relationships. The requested changes in current federal regulations described here are not new, but are gaining greater urgency in order to assure accountability and to reduce the administrative burdens and costs that impact both the government and its awardees as projects scale up.

Although this paper focuses primarily on the government-university relationship, it does not seek to diminish the importance of university-industry collaboration nor does it deny the many beneficial relationships existing between universities and their State agencies. The close nexus between education and research that exists in universities makes them not more important, but certainly different from most other research providers.

Introduction: Premise for research business relationships

The essential premise for a new business relationship between the government and universities is the simple acknowledgment that both parties engage as "business partners". This means, among other things, a recognition of complementary interests in the cost effective administration of awards and the providing of adequate funds to meet the joint expectations for the outcomes of research. These mutual interests exist in both the assistance and the procurement mode because in each both parties provide value. Towards these ends, regulatory requirements that create unnecessary burdens should be removed, and funding for administrative expenditures should be based on a thorough and fair examination of the universities' F&A documentation. The term "rate negotiation" is inappropriate and implies a broken process. Equally important is the avoidance of cost shifting and imposing of caps and other restrictions by the government, which the commercial sector would describe as "price controls". It now appears that not only has the Congress called for new business practices, as evidenced in P.L. 106–107, but that the White House, through the Office of Science and Technology Policy has joined that call for change.

Business Models for the Basic Assistance Award

The simplest research platform is a basic assistance award, which may provide research support of up to $1 million in federal funding. An example of how a new business practice could remove unnecessary regulatory burden for even this simple platform is provided by the proposals of Robert Newton, a former NSF official.

In. the early 1980s, Newton proposed that a faculty's entire research should be considered as one "research program" to be managed as an integrated whole rather than as individually sponsored and managed "research projects". The key prerequisite to aggregation was the concept of "relatedness", which the faculty researcher would be obligated to assert and demonstrate. Once relatedness was established, the researcher should be able to use all sources of funding to charge costs to serve research needs rather than be restricted by individual agency budgets. This concept was one of the motivating factors for forming the Florida Demonstration Project in 1983. It is not yet widely embraced in the Federal Demonstration Partnership of 2003.

Several other unnecessary regulatory impediments to the cost-effective management of research could be similarly eliminated by simple changes to the current requirements. These include flexibility in starting a project, the ability to adjust expenditures according to the needs of the research without having to obtain agency prior approval for each individual action; and the authority to extend the timeframe for expenditures as dictated by progress on the project, without being accused of violating the "expenditure rate".

The value of the business efficiency of such changes was recognized when OMB revised Circular A–110 in the early 1990s. OMB directed federal agencies to adopt a unified position on grant management matters and to provide "expanded authorities" to the grant recipient for management without the need for individual prior agency approval at each step. This recommendation reflected broad public support. Agency implementation however was uneven and even today federal agencies are far from uniform in granting such "expanded authorities" to research universities. In 2000, public comment on the statutory requirements of P.L. 106–107 again indicated overwhelming support for granting expanded management authorities to all funding recipients under all government awards. Until these simple steps are taken to adopt sensible business practices, there is little point in discussing the more complicated issues associated with more complex research and funding efforts.

Recommendation:

- Revise OMB Circular A–110 to direct all federal agencies to grant the "expanded authorities" for grants management in accordance with federal regulations to all research universities.
- Endorse the concept that individual but related research projects by a single investigator can be considered one research program for purposes of management and accountability.
- Rely on business system reviews and project audits at universities rather than prior approvals by individual federal agency staff.

Business Models for Multi-Sponsor, Multi-University Projects

Awards for multi-sponsor, multi-university projects range from $1–5 million dollars. Coordination and leveraging of effort is critically important to their success. It is widely acknowledged that their management is complex because they involve teams of scientists working at different sites and on various aspects of one common research problem. Yet, in most cases, none of the participating universities has enough support to cover more than their minimum share of the administrative burden. Because the federal agencies take a narrow view of the budget categories under OMB Circular A–21, sufficient funds are not provided to support the secretarial and clerical personnel required for such. a sophisticated effort.

Recently, some federal officials seemed to imply that a "new business model" would require that OMB Circular A–21 be withdrawn and fundamentally revised. We do not believe that such drastic cure is required. All that is required to meet research needs is to go back to Circular A–21 in its original form. That would delete a number of requirements which do not add value.

Several other modest changes to OMB Circular A–21 would further advance businesslike management of research. The language of the cost circular needs to be coordinated with the management circular to avoid discrepancies. Universities should be granted use of the cost of money, which other business sectors currently use. University responsibility for monitoring their sub recipient awards must be limited to reasonable procedures focused on scientific program objectives. The government should not expect universities to serve as auditors on one another's projects. This becomes particularly important in multi-campus arrangements, where the designation of subrecipient vs. research partner may not be sufficiently well defined.

Another federal agency practice contrary to sound business principles is that not all federal agencies pay the negotiated F&A rate. They cite various reasons, some programmatic, some historical. This uneven approach to what is intended to be the government-wide rate becomes particularly visible and detrimental in multi-agency awards. The resistance by several agencies to fully fund the negotiated. F&A rates of universities results in extensive under recovery of costs that the science projects can ill afford. Respective data have been provided by the Rand Corporation and more recently by COGR. It would be good business. practice for all agencies to scrub their policies, some of which date from the late 50s, and to eliminate restrictions to full rate reimbursement that have been carried forward without appropriate statutory justification.

Large multi-campus research projects may require institutional cost sharing. The capacity of the participant universities to come up with such funds is dependent on many factors. One might surmise that federal oversight over cost sharing as well as general project administration on multi campus awards would be facilitated by Cost Accounting Standards. However, internal consistency rather than commonality is the major objective of these standards. CAS standards add no value to multi-campus or to single investigator awards. They are duplicative and unnecessary because they reiterate A–21 standards. Doing away with these clearly unnecessary requirements, which the federal government admitted it cannot meet in a timely manner, would result in cost savings both for the government and for the universities that would clearly benefit research. Eliminating CAS standards is overdue.

We recognize that the government has legitimate interests in the establishment of ethics safeguards and multi-disciplinary and multi-campus projects may provide special concerns in this area. A new business model for this platform would benefit particularly from agency implementation of the government-wide misconduct in science policy promulgated in 2000. We also ask that all federal agencies follow the lead of NIH and NSF and develop conflict of interest regulations.

Recommendation:

- Return to the original language of 0MB Circular A–21
- Allow the direct charging of secretarial and clerical staff
- Provide full funding of negotiated university F&A rates
- Reduce subcontract monitoring to reasonable levels
- Issue Government-wide ethics rules
- Rescind the CAS coverage for universities

Business Models for Large Center Awards

Institutions which compete for large awards for Centers or for specialized institutes for up to $15 million must commit substantial infrastructure support, Such support depends largely on available cost sharing resources. The size and complexity of these awards creates a big gap in management and operation between these awards and the single assistance awards. Yet, the same policies govern both. No reasonable business practice would expect to run a multi-million dollar automobile company like a neighborhood small business enterprise. The current restrictions in OMB Circular A–21 make no such distinction and as a result many of the large universities are stretched to the limit of their fund raising capacity for improvements of the infrastructure and for planning needed new facilities.

For such large projects, the recovery of F&A costs is especially significant and consequently agency cognizance becomes a factor. Universities report considerable differences between the two cognizant agencies in their procedures for rate negotiation. There is no basis for two federal agencies to treat universities differently. Good business practices would call for closer coordination between DCAA and DCA, with respect to their audit and their oversight over F&A rate negotiation.

The more one tries to scale up to a new platform, the clearer the impact of the cap on administrative cost will be felt. No other research performer is subject to caps, which were imposed *in addition* to three major revisions of the circular that took place in the 90s. While these OMB revisions provided a clearer definition of cost categories and eliminated "gray" areas, they also hold universities' administrative rates at a level that was below average even at the time it was adopted.

After a decade without adjustment for cost increases, the university community is no longer able to cover the growing gap between regulatory requirements and the restriction in reimbursement. No other business is precluded by the government from recovering its legitimate business-related compliance costs. Since 1992, universities have had to absorb all administrative costs for new requirements and/or for the upgrading of systems that have become necessary in the intervening time. One would expect that it is in the government's own best interest to support universities in their effort to stay competitive and compliant, especially as new security measures become imperative for the nation. The cap needs to be lifted.

These large awards also reinforce the need for government-wide acceptance of regulations governing human subjects, and to overcome the apparent distrust of the "common rule" which leads agencies to establish duplicative reviews of protocols and IRB procedures.

Finally, unnecessary administrative costs could be eliminated simply by the establishment of government-wide payment systems that would replace the labor intensive and outmoded system of grant-specific draw-down by each federal agency.

Recommendations:

- Seek agreement between cognizant agencies
- Implement rate determination, not negotiation
- Remove the administrative cap
- Adopt a uniform government-wide payment systems
- Discourage duplicative administrative reviews

The New Research Business Model in Review

As we propose it, the new business relationship between the government and universities is based primarily on trust. This trust relies on the understanding that it is in the university's own best interest to self regulate and hold costs down but also on the understanding that the government will provide stable funding and that the recovery of costs for facilities and for administrative services will not unexpectedly be capped.

Universities face a growing perception that science can be separated from administration. That is a fallacy. Universities also witness the encroachment of administrative procedures that siphon funds that could otherwise support research or teaching. A new business model would eliminate such duplicative federal requirements.

Recommendation:

- Treat universities as business partners
- Permit performance based budgeting
- Set reasonable audit expectations
- Replace certifications with assurances
- Do not permit budget decisions to drive policy

In this new business environment, the government will not be asked to appropriate more, it will merely be asked to allow universities to use resources the way universities determine necessary to support the mutual goal of obtaining the deliverable of sound scientific research.

In Conclusion

Scaling up to different research platforms entails responsibility for scientific, administrative and financial decisions. It influences decisions regarding the workforce and infrastructure, including space and equipment, and calls for careful coordination between centers at different locations and subject to a variety of administrative regulatory requirements. It reaches into areas of regional and national security and raises fundamental questions regarding how one deals with potential restrictions on foreign scientists, with audit oversight and with the freedom to publish research results.

The key to a successful research business model for increasingly complex projects lies in designing comprehensive but simplified administrative guidance and then permitting universities to take responsibility for management and oversight of the wide range of their projects. We believe that success depends largely on the extent to which the government will grant research universities the flexibility to make sound business decisions on campus, subject to subsequent review and audit by the government.

BIOGRAPHY FOR ALBERT G. HORVATH

Albert G. Horvath is senior vice president for finance and business/treasurer at Penn State effective July 1, 2009. He is responsible for leading the day-to-day management of Finance and Business and the strategic planning process for the unit which has an operating budget of more than $500 million and more than 2,500 employees. He is also responsible for special projects and assignments, including information systems and technology, succession planning, and emergency preparedness.

Al oversees the direct reporting relationships in the areas of auxiliary and business services; corporate controller and controller for the College of Medicine/Milton S. Hershey Medical Center; Office of the Physical Plant; University Budget Office; Office of Investment Management; Commonwealth Operations; University Police; and Human Resources.

Al joined Penn State on June 29, 2007 as vice president for finance and business. He came to Penn State with a wide range of experience in finance and business, much of it in higher education. He has previously served as executive vice president for finance and CFO at Columbia University, where he has been responsible for the financial activities of the university—including its medical center—with a $2.7 billion operating budget. At Columbia, he developed a five-year capital plan and debt strategy and created a procurement organization, was involved with several issues at the medical center, and acted as primary administrative liaison to the audit and finance committees of Columbia's board of trustees. He also served as associate vice president for finance/controller, and later vice president for business and finance and CFO, at The California Institute of Technology; as controller at New York University; and as audit director and assistant vice president for finance at Carnegie Mellon University. He started his career as an auditor with Mellon Bank, before becoming a manager in Mellon's trust and investment department.

A 1981 Penn State graduate with a degree in accounting, I also earned an MBA from Duquesne University in 1985.

Chairman LIPINSKI. Thank you, Mr. Horvath.

Dr. Raymond.

STATEMENT OF DR. JOHN R. RAYMOND, VICE PRESIDENT FOR ACADEMIC AFFAIRS AND PROVOST, MEDICAL UNIVERSITY OF SOUTH CAROLINA, AND CHAIR, STATE OF SOUTH CAROLINA EPSCOR COMMITTEE

Dr. RAYMOND. Mr. Chairman and members of the Subcommittee, thank you very much for allowing me to testify today. The NSF EPSCoR program has a statutory function to strengthen research and education in science and engineering throughout the United States, and to avoid undue concentration of such research and education. This has been accomplished through providing strategic programs and opportunities for EPSCoR participants that stimulates sustainable improvements in their R&D capacity and competitiveness, and to advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity. Twenty-seven states plus Puerto Rico and the U.S. Virgin Islands are currently eligible for NSF EPSCoR support. These 29 jurisdictions comprise 20 percent of the U.S. population, 25 percent of the research in doctoral universities, and 18 percent of our nation's scientists and engineers. NSF EPSCoR funding is awarded through a merit-based peer review process.

EPSCoR has been very beneficial to South Carolina. The Medical University of South Carolina has made relatively modest contributions to the creation of knowledge in science and engineering disciplines. However, with the assistance of programs like NSF EPSCoR, we are now poised to contribute in a substantial and sustainable way to the competitiveness of our Nation.

The current NSF EPSCoR RII grant was awarded to South Carolina in July 2009. This RII has presented us with an exciting opportunity for South Carolina to implement a statewide vision for building a competitive edge in the emerging field of organ printing that can create human organs such as hearts, kidneys and blood vessels. This has ample depth and breadth to bring together faculty and students from nearly all of South Carolina's institutions of higher education to work together toward a common purpose. Furthermore, NSF EPSCoR funds have been leveraged through the recruitment of new professors to the State through the *South Carolina Centers of Economic Excellence Act and the Research Universities Infrastructure Act.*

The NSF RII award provided the impetus for South Carolina and Tennessee to partner on a new NSF EPSCoR cyberinfrastructure award that provides personnel and equipment to facilitate coordination with Clemson's High Performance Computing support staff and with TeraGrid specialists.

Finally, NASA EPSCoR funds have catalyzed connections among South Carolina's researchers and the NASA Jet Propulsion Laboratory to design and test a useful and efficient lunar wheel for use on a small pressurized rover that will enable astronauts to explore the moon.

We believe that the EPSCoR program can be improved. Targeted options continue to be the most viable and effective pathways to develop the scientific infrastructure, talent and critical mass in the EPSCoR states. There should be continued investment in these competitive grant opportunities for states that meet EPSCoR criteria. The current EPSCoR program could be improved by dividing it into research, education and workforce components.

With regard to the entire EPSCoR program, I would suggest that NSF set a goal of doubling the percentage of its funds annually that are awarded to the 27 EPSCoR states and two jurisdictions and slightly less than ten percent of NSF's annual R&RA obligations to 20 percent within ten years. We also need assurances that as the new states are added, the funding needed for them will be requested and appropriated.

EPSCoR states have trained a lot of scientists and engineers over the years, and we need incentives to keep and bring new talent to our state. Physical infrastructure initiatives outside of the EPSCoR program could also be very useful. Cutting-edge facilities, renovations and equipment remain a major obstacle to competitiveness for the EPSCoR states. Our institution has over $100 worth of deferred maintenance in our research facilities. A separate program or a set-aside in existing programs would be very helpful.

Finally, while South Carolina has made impressive progress in cyberinfrastructure, it has not been easy or inexpensive. Many of the EPSCoR states have not been as fortunate as South Carolina and are still lacking the bandwidth systems that will enable the modeling and computer simulations needed for climate change, biomedical and advanced research for visualization.

In closing, we believe the value, effectiveness and sustainability of EPSCoR programs is very clear, both as a catalyst for improving our respective states, and to enhance America's overall competitiveness in the global economy. Again, I thank you for the opportunity to testify today.

[The prepared statement of Dr. Raymond follows:]

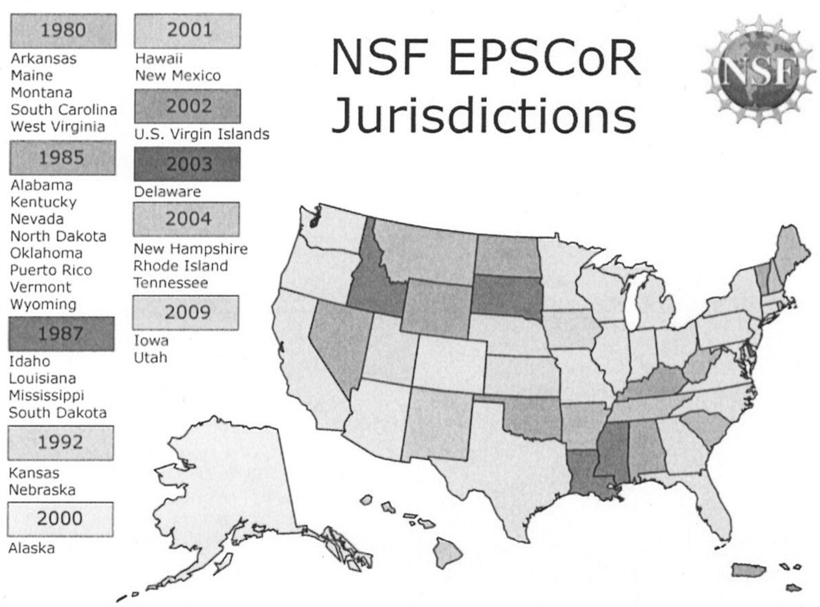
PREPARED STATEMENT OF JOHN R. RAYMOND

Mr. Chairman and Members of the Subcommittee, my name is Dr. John Raymond. I am Vice President for Academic Affairs and Provost at the Medical University of South Carolina. I have also served as Chair of the State of South Carolina Experimental Program to Stimulate Competitive Research (EPSCoR) Committee for the past eight years. Thank you for the opportunity to testify today regarding the research infrastructure needs of our universities and colleges including research facilities and cyber-infrastructure capability, the capacity of the research infrastructure to meet the current and future needs of U.S. scientists and engineers, and the appropriate role of the Federal government in sustaining such infrastructure.

In this testimony, I have been asked to answer questions related to the current National Science Foundation EPSCoR grant awarded to South Carolina. Specifically, I will address EPSCoR's role in facilitating partnerships with state and local governments and the private sector to improve our research infrastructure, its leveraging effect on improving cyber-infrastructure capabilities, and its impact on the Medical University of South Carolina. Secondly, I will describe the state of research infrastructure and research facilities at the Medical University of South Carolina and our unmet research infrastructure needs. Thirdly, I will provide recommendations on how to improve the EPSCoR program based on the findings and recommendations of the EPSCoR Foundation.

Before answering the three specific questions posed to me, it might be useful to provide a brief summary of the EPSCoR program and my university to place my answers into the appropriate context. The National Science Foundation EPSCoR program has a statutory function "to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education." This is accomplished through two goals, which are (1) to provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their R&D capacity and competitiveness; and (2) to advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity. South Carolina is one of the original NSF EPSCoR-eligible states designated in 1980 (please see **Figure 1**). Twenty-nine jurisdictions including twenty-seven states, the Commonwealth of Puerto Rico, and the U.S. Virgin Islands are currently eligible to compete for support through various NSF EPSCoR mechanisms.[1] Those 29 jurisdictions comprise 20 percent of the U.S. population, 25 percent of the research and doctoral universities, and 18 percent of the nation's scientists and engineers. NSF EPSCoR funding is awarded through a rigorous process of merit-based peer-review to ensure quality, accountability and sustainability. Many other federal agencies support programs similar to the NSF EPSCoR program; for example, the National Institutes of Health has a program called the Institutional Development Award (IDeA) program.

Figure 1*. National Science Foundation EPSCoR Jurisdictions*



From http://www.nsf.gov/div/index.jsp?org=EPSC

Founded in 1824, the Medical University of South Carolina is a freestanding academic health science center composed of six health-related colleges (Dental Medicine, Graduate Studies, Health Professions, Medicine, Nursing, Pharmacy). Until recently, our institution made relatively modest contributions to the creation of knowledge in science and engineering disciplines; with the assistance of programs like NSF EPSCoR, we now are poised to contribute in a substantial and sustainable way to the competitiveness of our nation. We were awarded extramural research funding of nearly $218 million in FY 2009–10, of which $140 million was from federal sources, and $103 million from the National Institutes of Health.

[1] Eligible EPSCoR jurisdictions: Alabama, Alaska, Arkansas, Delaware, Hawaii, Idaho, Iowa, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, U.S. Virgin Islands, Utah, Vermont, West Virginia, and Wyoming.

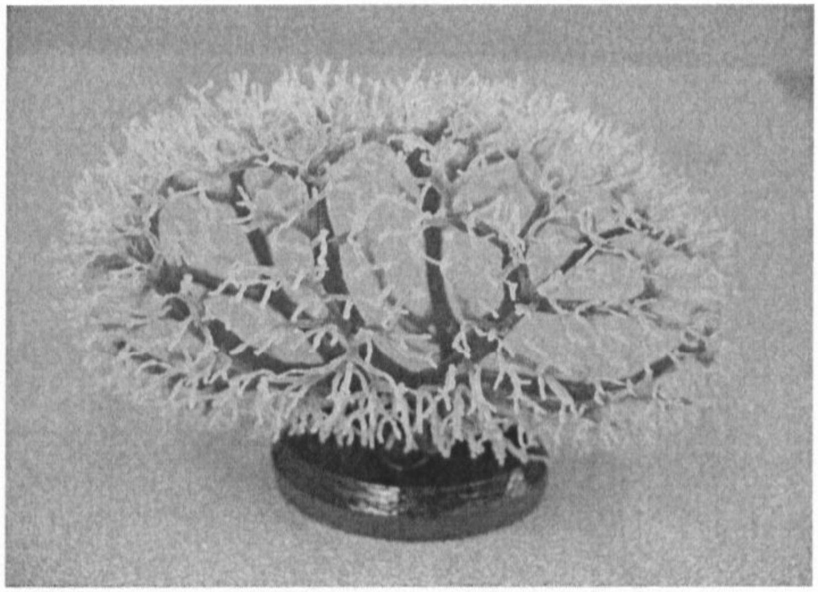
The current NSF EPSCoR Research Infrastructure Improvement (RIO grant was awarded to South Carolina in July 2009. This RII has presented an exciting opportunity for South Carolina to implement a **statewide vision** towards building a competitive edge in the emerging field of "organ printing"—operationally defined as computer-aided, layer-by-layer deposition of biologically relevant material with the purpose of engineering functional tissues and organs. The idea is that we can use cultured cells and supporting materials as "ink" that can be built up using modified ink jet printers and powerful computers to create human organs such as hearts, kidneys, and blood vessels. The patient's own cells (such as fat cells) can be used to make these organs to provide a ready source for transplantation to treat and cure diabetes, kidney failure, heart failure and atherosclerosis. What patient with diabetes wouldn't donate some of their excess fat cells to make a new pancreas to cure their diabetes?

Organ printing poses a grand challenge in terms of engineering and biological principles, and a grand opportunity for South Carolina to contribute to the competitiveness of our country. Currently, the thickness of printed tissue constructs is limited to four cell layers or less due to lack of a blood supply. In order to manufacture more complex organs, one must successfully engineer a vascular supply, which will require a 3–D tree-like network of blood vessels.

The grand vision of this RII has ample depth and breadth to bring together faculty and students from nearly all of South Carolina's institutions of higher education to work toward a common purpose. The 2009 SC NSF EPSCoR RII focuses on a diverse subset of institutions including three research intensive institutions (Clemson University, Medical University of South Carolina, University of South Carolina), three historically black colleges (Claflin University, South Carolina State University, Voorhees College), two other predominately undergraduate institutions (Furman University, USC-Beaufort) and 3 technical colleges (Denmark Technical College, Greenville Technical College, York Technical College). Together we form the SC Alliance for Tissue Biofabrication.

EPSCoR funds were essential for demonstrating the feasibility of using existing rapid prototyping equipment to print an intra-organ vascular tree. Drs. Vladimir Mironov and Roger Markwald at MUSC facilitated the fabrication of a 3–D "plastic" kidney (see **Figure 2**), which was recently printed based on a computer-aided design provided by Prof Nicolas Smith from the University of Oxford (UK) using expertise and facilities at 3–D Systems/York Technical College. This initial success and preliminary data strongly suggest that existing rapid prototyping technology using layer-by-layer addition of building blocks has sufficient resolution for bioprinting a complex branched vascular tree. Rapid prototyping is a rapidly growing, $100 billion/yr industry and 3–D Systems, Inc, located in Rock Hill, SC, is a leading global provider of 3–D printing, rapid prototyping and additive manufacturing products. This is an excellent example of EPSCoR funds being used to catalyze academic-industrial collaborations towards building an advanced biomanufacturing industry in South Carolina.

***Figure 2**. Bioprinted Kidney Vascular Tree Prototype*



The NSF EPSCoR funds have been leveraged through the recruitment of new professors to the state of South Carolina through the Centers of Economic Excellence Act, and the Research Universities Infrastructure Act, two key economic development initiatives passed by the South Carolina Legislature in 2002 and 2004, respectively. Those acts provide state matching funds for recruitment of endowed professors, and for research construction. We have used state funds and private sector matching funds to create multi-institutional Centers of Economic Excellence in Regenerative Medicine, and in Tissue Biofabrication. Several of the professors recruited to these centers have faculty appointments at Clemson, USC and MUSC, thus serving as bridges between our institutions. These new centers will be based in a new 100,000 ft^2 Bioengineering Building, which will be completed in late 2011. This building will house engineers from Clemson and USC, and life scientists from MUSC, working in interdisciplinary teams to address grand challenges like the organ bioprinting project. We also have leveraged the NSF EPSCoR award by developing interdisciplinary educational programs that bring together students and faculty from the technical colleges, historically black serving institutions, four-year and research-intensive institutions.

Finally, the NSF RII award provided the impetus for South Carolina and Tennessee to partner on a new NSF EPSCoR cyberinfrastructure award that provides personnel and equipment to facilitate coordination with Clemson High Performance Computing support staff and TeraGrid specialists. This cyberinfrastructure grant also enables South Carolina institutions to have access to the TeraGrid Kracken system housed at Oak Ridge National Laboratory. This grant, along with a $21 million award from The Duke Endowment and an $8 million award from the Federal Communication Commission, has allowed us to develop a high-speed, high-bandwidth optical and wireless communication grid that spans the state and facilitates competitiveness.

NASA EPSCoR funds have catalyzed connections among Dr. Joshua Summers' team at Clemson, and Michelin, Milliken and the NASA Jet Propulsion Laboratory to design and test a useful and efficient lunar wheel for use on the Small Pressurized Rover that will enable astronauts to explore the moon. The futuristic rover with its "tweels" joined NASA astronauts in President Obama's inaugural parade on Pennsylvania Avenue. The accompanying **Figure 3** shows Dr. Summers and undergraduate student Ms. Samantha Thoe inspecting the metallic prototype.

Figure 3. A "Tweel" Prototype
(Image: Clemson University)

Other federal agency EPSCoR funds have been applied to the areas of energy and alternative fuels. For example, Dr. Terry Tritt's research group at Clemson University has extensive interactions with Oak Ridge National Lab and Savannah River National Lab through the DOE EPSCoR Partnership Program. Dr. Tritt has received international attention for his study of thermoelectric energy, and on materials that can recapture "lost" energy from "wasted" heat.

These are just a few examples of how EPSCoR funds have been used to advance research and science education in South Carolina.

With regard to MUSC's research infrastructure, we have a number of new, state-of-the-art research buildings focusing on childhood diseases, bioengineering and drug discovery and development. We also have a number of aging buildings that will require significant upgrades and renovations to accommodate our expanded scope of research; and new high-end instrumentation to enable our teams to perform the mass spectroscopy, magnetic resonance imaging, high capacity computing, emerging microscopic methods, and interactive teaching, materials sciences, and biofabrication, as well as other emerging methods. We share these needs with many educational institutions, even those in the research powerhouse states. The continued support of EPSCoR programs will be essential for our state, and for institutions like MUSC, to make sustainable contributions to scientific discovery, contemporary science and engineering, education, innovation and the overall competitiveness of our country.

We believe targeted options continue to be the most viable and effective pathways to develop the scientific infrastructure, talent and critical mass in the EPSCoR states. There should be a continued investment in competitive grant opportunities for states meeting EPSCoR criteria. We believe the current EPSCoR program could be improved by dividing it into several components—(1) research and (2) education and workforce: Alternatively, we could simply adopt the NIH dual model of COBREs which are research center development grants, and INBREs which are state network grants to educate and train the next generation of biomedical scientists. This would be a much more direct approach to meeting both research infrastructure and "pipeline" needs. Each component should, of course, be adequately funded at levels similar to those at NIH.

We would appreciate renewed efforts to involve EPSCoR states in the regular NSF programs. This means more representatives from EPSCoR states on the National Science Board, NSF Advisory committees and other relevant "planning" entities; more co-funding especially as the NSF budget is growing, and greater use of mechanisms that will ensure EPSCoR participation in major NSF initiatives. I believe that a few years ago, extra points were awarded for including EPSCoR states in certain applications for large programs. This should be reinstated. Other efforts should be made to assist EPSCoR states in participating in more large-scale NSF efforts such as Science and Technology Centers (STCs), Engineering Research Centers (ERCs), and Materials Research Science and Engineering Centers (MRSECs). Unless that is done, the dollar imbalance between the established states and the EPSCoR states will continue to grow. In this regard, I would suggest that NSF set a goal of doubling the percentage of its funds, annually, that are awarded to the 27 EPSCoR states and 2 jurisdictions—from slightly less than 10% to 20% within ten years. Then, coalesce some of the initiatives recommended above, as well as others gleaned from the broader EPSCoR community, into a "Strategic Implementation Plan" to meet that goal.

We also need assurance that as new states are added, the funding needed for them is requested and appropriated. It costs $5–10 million a year to bring a new state into the EPSCoR program during its first five years and these new EPSCoR states tend to be more competitive than some of the existing ones. Consequently, it is self-defeating to drain resources from one to help the other.

We should look at other mechanisms as well. EPSCoR states have trained a lot of scientists and engineers over the years who, regrettably, have then simply moved to other states. More are staying in our states as we build our infrastructure and attract innovative companies. We need incentives to keep and bring new talent to our states. Physical infrastructure initiatives outside of the EPSCoR program could also be useful. Renovations and' equipment remains a major obstacle to competitiveness for the EPSCoR states. Cutting edge facilities, renovations and equipment remain a major obstacle to competitiveness for the EPSCoR states. A separate program or a set aside in existing programs would be helpful.

Physical infrastructure initiatives outside of EPSCoR or in addition to the existing EPSCoR program are essential. That is your focus today. The EPSCoR states unquestionably and unequivocally require such investments. Construction of scientific facilities, renovations and equipment remain a major obstacle to competitiveness in the EPSCoR states.

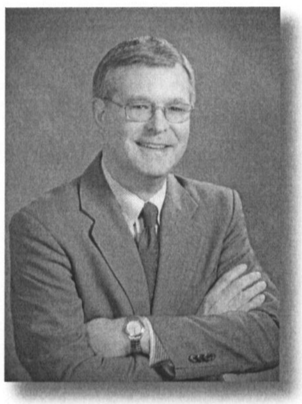
Finally, while South Carolina has made impressive progress in cyberinfrastructure, it has not been easy or inexpensive. Many of the EPSCoR states have not been as fortunate and many are still lacking the bandwidth and support systems that will enable modeling and simulations needed for climate change, biomedical and advanced research and for visualization.

We thank this subcommittee for its ongoing support of our states and for the wisdom to invest in programs that engage the populace of all of our states in building science and engineering capabilities that will broaden the base of talent and the capacity for innovation throughout the United States. We believe in the value, effectiveness and sustainability of EPSCoR programs—both as a catalyst for improving our respective states and to enhance America's competitiveness in the global economy.

In closing, I thank you for the opportunity to address the Subcommittee today.

Biography for John R. Raymond

MUSC
MEDICAL UNIVERSITY
of SOUTH CAROLINA



John R. Raymond, Sr., M.D.
DCI Professor of Medicine
Vice President for Academic Affairs and Provost
Medical University of South Carolina

John R. Raymond, Sr., M.D., is Vice President for Academic Affairs and Provost at the Medical University of South Carolina. Dr. Raymond is a practicing Nephrologist who plays active roles in clinical care, teaching, faculty mentorship and research. He earned a B.S. in Psychology (cum laude) from the Ohio State University in 1978, and an M.D. (cum laude) from Ohio State University in 1982. He performed internship, residency, chief residency and nephrology fellowship training at Duke University Medical Center and the Durham VA Medical Center. He performed laboratory training at Duke under the supervision of Dr. Robert Lefkowitz. After completing his training, he joined the faculty at Duke, where he rose through the ranks to attain tenure. He joined the faculty at MUSC in 1996 as the Dialysis Clinics, Incorporated (DCI) Professor of Medicine. Dr. Raymond served as Associate Chief of Staff for Research at the Ralph H. Johnson VA Medical Center from 1998 to 2002. He assumed the position of Associate Provost for Research at MUSC in October 2001, and served as Interim Vice President for Academic Affairs and Provost from July 2002 to January 2003 when he was appointed Vice President for Academic Affairs and Provost.

Dr. Raymond is active as a clinician-educator and mentor, and has been a physician in the Department of Veterans Affairs for 24 years. He maintains a well-funded research laboratory, focusing on basic mechanisms of kidney cell function. He has published over 100 full-length manuscripts and has received as a principal investigator or primary mentor over $25 million of competitive extramural funding from the National Institutes of Health, Department of Veterans Affairs and various foundations. He also has received and additional $13 million of construction funding in his role as an institutional official. Active in peer review, Dr. Raymond has served on numerous study sections for the NIH, VA, American Heart Association, National Kidney Foundation and other organizations, and provided editorial services to many peer reviewed journals. Dr. Raymond was inducted into the Alpha Omega Alpha Medical Honor Society, the American Society for Clinical Investigation and the Association of American Physicians. He holds fellowships from the American Society of Nephrology, The American Heart Association and the American College of Physicians. Dr. Raymond is a resident of Mount Pleasant, South Carolina.

REV: 07/09; JS

Chairman LIPINSKI. Thank you, Dr. Raymond.

Now I will recognize Dr. Dunning.

STATEMENT OF DR. THOM H. DUNNING, JR., DIRECTOR OF THE NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Dr. DUNNING. Mr. Chairman, thank you for the opportunity to address the Subcommittee on Research and Science Education.

Before I start, I would like to take this opportunity to thank Representative Ehlers for his service to the Nation's science and educational enterprise. We all have greatly benefited from your dedication to advancing science and engineering, and we thank you.

Now let me return to the topic at hand, the state of cyberinfrastructure in the United States. To ensure that we are all on the same page, I would like to note that cyberinfrastructure consists of computing systems, and consists of data sources, data storage systems, visualization environments all linked by high-speed networks, knitted together by software and enabled by expert support staff. Cyberinfrastructure allows us to make discoveries and innovations not otherwise possible, and as such, it is now a critical part of the Nation's research infrastructure.

Given the time constraints, I will focus my comments mainly on the high-performance computing, or HPC, aspect of cyberinfrastructure including the University of Illinois's Blue Waters, which, when it comes online in 2011, will be the most powerful computer in the Nation for open scientific research, and in fact, it will likely be the most powerful computer in the world for such research. This extraordinary computer will be capable of sustaining a million billion arithmetic operations per second, have more than one petabyte of memory, a million times what you have in your PC, more than 10 petabytes of online disc and 500 petabytes, or half an exabyte, of archival storage.

National resources like Blue Waters are not the result of one organization's work. This computer reflects a model, in fact, of a university-state-federal-industry partnership founded on a 24-year relationship between the University of Illinois at Urbana-Champaign, the State of Illinois and the National Science Foundation. In the specific case of Blue Waters, the State of Illinois built the national petascale computing facility and provided I-wire connectivity to connect that facility to the national research networks. The University of Illinois is buying the archive system and networking gear and investing in software for Blue Waters. NSF is buying the computing system and funding its operation and maintenance. And finally, IBM, which is the computer vendor for Blue Waters, is working closely with the university to ensure that Blue Waters delivers maximum value to the scientific community.

In this regard, I do have one concern. Continuing progress requires that industry be researching, developing and producing high-end computers for scientific research, and I am very concerned at the drop-off in companies investing in this particular area, especially in the highest end.

Let me now make four comments on the status of cyberinfrastructure for high-performance computing and what is needed for this cyberinfrastructure to be effectively and efficiently used for discovery and innovation. First, let me note that the deployment of fast high-end computing systems by NSF has been very successful, providing extraordinary value to the scientific community, but what has been lacking is the investment in user support. Even scientists experienced with high-performance computing require assistance to use systems at the leading edge, and as we have found at NSCA and other sites, researchers in a growing number of other fields are finding high-performance computing critical to meeting their particular goals. Expert support is required to bring them into the fold.

A second concern about NSF's HPC program is the frequency of competitions associated with the deployment of these resources. Competition is good, but when you are building infrastructure, completeness, robustness and continuity are also critical. Too-frequent competitions make it difficult to attract high-quality staff, result in discontinuities and inefficiencies in support service and are a drain on valuable staff support time. To be blunt, the current model is unsustainable and a task force currently advising NSF on future HPC strategies will recommend longer term, more stable funding, coupled with rigorous reviews to ensure quality.

A third concern is the balance between investments in hardware and software. Scientists and engineers certainly need access to ever more powerful computers, but science and engineering applications must be carefully designed to fully exploit the capabilities of the high-performance computing systems available. New tools and approaches are needed to help scientists develop applications for Blue Waters and the even bigger computers that will come next. This is a major area for NSF investment and will require significant collaboration between NSF directorates and offices on developing a new generation of science and engineering applications as well as a robust and complete HPC software stack.

A fourth area of concern, not just for HPC but also for cyberinfrastructure in general, is networking. While the United States may appear to be in good shape on the surface, this smooth surface hides a number of issues. Scientists are choosing not to undertake some activities because they know those activities will stress the networks. Data volumes are rapidly increasing and will overwhelm current capacities in the next few years.

And finally, as mentioned by Dr. Raymond, networking capabilities are not evenly distributed. Many universities may not be able to benefit from the major advances being made in data-intensive science.

To tackle some of these current and upcoming challenges in networking, NSF must do more. One key area of need is to interconnect NSF's major research facilities, instruments and computers. A potential model for this is the Department of Energy's ESNET, which is a high-performance network being built to connect major Office of Science research facilities. Another key area, and one that is specific to NSF, is the need to enhance the ability of university researchers to connect to NSF's major facilities, the so-called end-to-end problem. All of the concerns I have raised are driven by the need to tackle not only existing problems, but to prepare for future opportunities such as the coming revolution in data-driven discovery.

One of the most exciting advances in science and engineering is the increasing digitization of observational science, from astronomy to biology to environmental science. Advanced sensor arrays, micro-scopes and automated sequencers, and telescopes are allowing us to produce huge quantities of meaningful data. At NSF, this can clearly be seen in its large MREFC projects. To build the cyberinfrastructure for these projects, we need to share and reutilize software, whenever possible, that is both costly to build and maintain. Such coordination is not easy with independent projects, and the lack of continuity at supercomputing centers leads to their under utilization by these major data-driven discovery projects.

I would like to conclude with a brief word about education and cyberinfrastructure. Two key questions that we have are: what does the next generation of scientists and engineers need to know about cyberinfrastructure, and second, how can we modify the curriculum and courses to provide the needed knowledge? NSF with its broad mandate in science and engineering, research and education is well suited to explore the options and serve as a catalyst for the needed changes at universities.

This concludes my verbal remarks. Thank you for the opportunity to testify before you today, and I am more than happy to answer any questions you may have.

[The prepared statement of Dr. Dunning follows:]

PREPARED STATEMENT OF THOM H. DUNNING, JR.

What Is Cyberinfrastructure?

Cyberinfrastructure, n., *cyberinfrastructure consists of computing systems, data sources and data storage systems, visualization environments, and support staff, all linked by high speed networks to make discoveries and innovations not otherwise possible.*

Over the past quarter century, computing has become an integral part of the fabric of experimental and theoretical science. All but the simplest laboratory experiments are performed under computer control, the data is analyzed using software running on a personal computer or small compute cluster, and the results compared with the latest theories through computational simulations on high performance computers. The use of computing technology is now spreading to the observational sciences, which are being revolutionized by the advent of powerful new sensors that can detect and record a wide range of physical, chemical and biological phenomena-from massive digital detectors in a new generation of telescopes to sensor arrays for characterizing ecological and geological areas and new advanced sequencing instruments for genomics research.

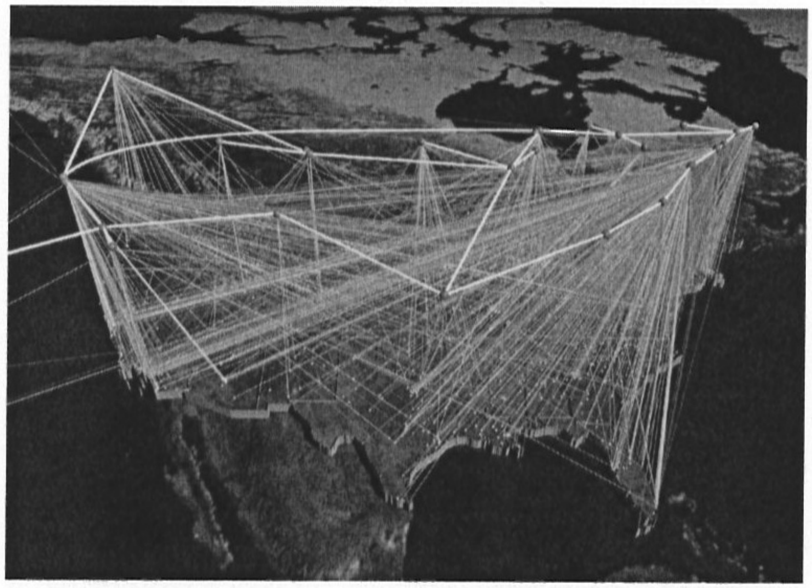


Figure 1. Cyberinfrastructure is a networked collection of computer systems, data sources and stores, and visualization systems linked by a software infrastructure that integrates these systems into a unique and powerful research capability.

Research Advances Enabled by Cyberinfrastructure

Three major modes of scientific discovery are enabled by cyberinfrastructure: computational modeling and simulation, data-driven discovery, and, increasingly, the coupling of these two modes. To address the questions posed by the Subcommittee, I will discuss the cyberinfrastructure needs of these three modes of scientific discovery and then provide an analysis of the status of the existing cyberinfrastructure. To begin, let us briefly review the science and engineering advances made possible by cyberinfrastructure.

Computational Modeling and Simulation. In computational modeling and simulation, scientists develop a mathematical model of the phenomena of interest, e.g., the chemical and physical processes involved in an internal combustion engine or the processes involved in the prediction of weather, and then use high performance computers to solve the resulting equations. For most phenomena of interest, the equations are very complex and, so, the power of computational modeling and simulation grows with increases in computing power. As computing systems have progressed from the megaflops era in the 1970s to the petaflops era of today, our ability to accurately simulate a broad range of biological, chemical, physical and, even, social phenomena has grown dramatically.

- The Southern California Earthquake Center seeks to develop a predictive understanding of earthquake processes aimed at providing society with improved understanding of seismic hazards. In partnership with earthquake engineers, SCEC researchers are developing the ability to conduct end-to-end simulations ["rupture to rafters") to extend this improved understanding of seismic hazards to an improved understanding of earthquake risks and risk mitigation strategies.
- Researchers at the University of Illinois at Urbana-Champaign are using computational simulations to obtain a detailed understanding of the functioning of the ribosome, the large cellular machine responsible for synthesizing proteins in our cells, as well understanding the mechanism used by the

poliovirus to gain entry into our cells. The former will enhance our fundamental understanding of cell biology, while the latter may lead to the development of better anti-viral drugs.

- A team from Michigan State University and the University of California, San Diego are studying the formation of the first galaxies. Based on a fundamental understanding of the physical processes and the initial conditions that led to the formation of the first stars, powerful numerical simulations are helping astrophysicists understand how and when the very first sources of light formed.

All of these simulations are numerical- and data-intensive and can only be performed on the most powerful computers available.

Data-driven Discovery. In data-driven discovery, scientists gather information from various data sources, e.g., a large digitally-enabled telescope, an array of environmental sensors, or "gangs" of genome sequencers, and then analyze the resulting mass of data usingsophisticated mathematical procedures seeking patterns, information and understanding. Data-driven discovery requires an extensive cyberinfrastructure that supports data collection and transport to storage sites, followed by data cataloging, integration and analysis (including visualization). Often, the cataloged data becomes a resource for a large research community. Depending on the quantities of data involved as well as the mathematical demands of the analysis, data-driven discovery may require extensive computing resources as well as large data storage facilities.

- The Ocean Observatory Initiative is constructing an integrated observatory network to provide the oceanographic research and education community with: (i) a cabled network of monitoring devices on the sea floor spanning important geological and oceanographic features, (ii) an array of relocatable deep-sea buoys that can be deployed in harsh environments, and (iii) construction of new facilities or enhancements to existing facilities leading to an expanded network of coastal observatories. The OOI will provide earth and ocean scientists with unique opportunities to study multiple, interrelated processes over timescales ranging from seconds to decades; to conduct comparative studies of regional processes and spatial characteristics; and to map whole-earth and basin scale structures.[1]
- The Large Synoptic Survey Telescope (LSST) is unlike other ground-based telescopes. It is a wide-field survey telescope and camera that can image the entire sky in just three nights, providing a time history of celestial events. Using an 8.4-meter ground-based telescope, the LSST will, for the first time, produce a wide-field astronomical survey of our universe. Its 3 gigapixel camera—the world's largest digital camera—will provide digital imaging of faint astronomical objects. The LSST will provide unprecedented three-dimensional maps of the mass distribution in the universe, in addition to the traditional images of luminous stars and galaxies, These maps will be used to better understand the nature of the mysterious dark energy that is driving the accelerating expansion of the universe. In addition, the LSST will also provide a comprehensive census of our solar system, including potentially hazardous near-Earth asteroids

Data-driven Computational Modeling and Simulation. There are increasing opportunities for linking data-driven discovery with computational modeling and simulation. For example, in the NSF-funded LEAD project (Linked Environments for Atmospheric Discovery),[2] one of the goals is to gather and analyze the data from a distributed array of Doppler radars to determine, *in real time,* when atmospheric conditions are ripe for the formation of a tornado and then launch computational simulations to determine the likely path and intensity of the tornado. Such opportunities will grow in the future as sources of sensed data become more widespread.

Development of a National Cyberinfrastructure

In recognition of the increasing importance of research cyberinfrastructure, the National Science Foundation recently issued a Dear Colleague Letter on "Cyberinfrastructure Framework for 21st Century Science and Engineering." This letter stated that it was imperative for NSF to develop a long term vision for the nation's cyberinfrastructure that covered the following critical areas:

1. Cyberinfrastructure for:

[1] See: *http://www.oceanleadership.org/programs-and-partnerships/ocean-observing/.*
[2] See: *https://portal.leadproject.org/gridsphere/gridsphere.*

a. High end computational, data, visualization and sensor-based systems and the associated user support for transformative science.
b. NSF's large-scale collaborative research facilities and projects, integrated with that of other federal agencies and international organizations.

2. Linkage of this cyberinfrastructure into campuses (including government and businesses) accompanied by programs that support integrated, widely dispersed, broadly based activities and resources.
3. Education and outreach to help develop computational science- and technology-savvy researchers and workforce.

This letter was signed by all of the Assistant Directors at NSF as well as the directors of many major NSF programs.

The development of a national cyberinfrastructure for research poses many unique challenges for NSF. Cyberinfrastructure is very different from physical infrastructure such as a laboratory building. Computing and related technologies are still rapidly advancing—computing power doubles every two years, disk capacity increases even more rapidly, 60% per year. The software that ties all of the infrastructure elements together to create a unique research capability has to be revised in response to these changes in technology. Finally, the use of cyberinfrastructure is still in its infancy—high quality support staff are needed to ensure that the U.S. research community can take advantage of the new capabilities provided by cyberinfrastructure. This close coupling of hardware, software, and expertise with a rapidly changing technology base is unparalleled in other types of infrastructure.

Cyberinfrastructure must also be funded through different mechanisms. Infrastructure must be sustained over long periods of time to be useful to researchers, and it cannot be sustained through a series of short term, loosely integrated projects. Like an interstate highway, cyberinfrastructure must provide a smooth, continuous path from one point to another. On the other hand, cyberinfrastructure must also evolve as computing technology advances; otherwise, it will rapidly become outdated. So, there must be flexibility in how the funding is used in long term cyberinfrastructure projects. Finally, cyberinfrastructure is expensive, both in terms of the hardware that must be deployed, the software that must be developed and maintained, and the support staff that are critical for its efficient functioning. It is important to avoid duplication and leverage existing capabilities and resources whenever possible.

The NSF-wide Advisory Committee for Cyberinfrastructure has begun work on the development of the new cyberinfrastructure framework outlined in the Dear Colleague letter,[3] establishing six Task Forces:

Campus Bridging	High Performance Computing
Data	Software and Tools
Grand Challenges	Work Force Development

The Task Forces involve distinguished scientists and engineers from across the nation as well as NSF program officers. Although the Task Forces are in the early stages of their work, they have already held a number of meetings and teleconferences to explore and discuss new concepts and strategies for developing a comprehensive national cyberinfrastructure. I am participating in three of these Task Forces: Grand Challenges, Software and Tools, and High Performance Computing and have colleagues who are involved in the other three Task Forces. This testimony provides a prologue to the work of the six NSF Task Forces.

Before moving on, I should note that NSF is not the only federal agency that supports cyberinfrastructure in the nation's universities. The Office of Science in the U.S. Department of Energy (DOE–SC) also funds cyberinfrastructure for university researchers. DOE–SC has a well defined, long term plan to provide computational, data and communications resources for laboratory and academic researchers based on the identified needs of its major research programs. However, with the exception of the INCITE program,[4] DOE–SC's cyberinfrastructure is closely tied to its mission needs, serving only those laboratories and universities deemed critical to that mission. The National Institutes of Health (NIH) supports a number of cyberinfrastructure-related software development efforts in its biomedical research programs but, by and large, depends on agencies such as NSF as well as the academic institutions that it supports to provide much of its cyberinfrastructure, especially the hardware. However, biomedical research is approaching a tipping point-the amount of data being accumulated in NIH's research programs will soon far ex-

[3] See: *https://nsf.sharepointspace.com/acci_public/default.aspx.*
[4] See: *http://www.er.doe.gov/ascr/incite/index.html.*

ceed that which can be stored, managed and analyzed by the other agencies and institutions. NIH has several strategic planning activities underway to identify the best path forward. Whatever the outcome of these planning activities, meeting the growing computing and data needs of NIH's intramural and extramural research programs will surely require substantial increases in NIH's cyberinfrastructure investments.

High Performance Computing

As noted earlier, advances in computational modeling and simulation are driven by increases in computing power. Over the past few decades, increases in computing power have largely been driven by Moore's Law, with a doubling in computing power occurring every 18–24 months. Thus, the end of the 1980s saw the deployment of computers capable of performing a billion arithmetic operations per second.[5] Ten years later, computing technology had advanced to the point that it was possible to perform a trillion arithmetic operations per second. In 2008, computers capable of a quadrillion operations per second were deployed. It is expected that exascale computers, 1,000 times more powerful than petascale computers, will arrive in another eight years, although many hardware and software challenges must first be overcome.

The National Science Foundation (NSF) and the Office of Science in the U.S. Department of Energy (DOE–SC) have committed to providing high performance computing resources for open scientific and engineering research, including for researchers who are funded by other government agencies. DOE–SC is funding several major computing centers in support of its energy and environmental missions as well as its broader national science mission: its flagship facility at Lawrence Berkeley National Laboratory and its leadership computing facilities at Oak Ridge National Laboratory and Argonne National Laboratory. NSF funds large national computing facilities at the Texas Advanced Computing Center and University of Tennessee/Oak Ridge National Laboratory and its largest national facility at the University of Illinois at Urbana-Champaign. Although I am familiar with DOE's computing program, I will only discuss NSF's program here since NSF's programs are most relevant to the Subcommittee's charge. However, DOE–SC's contributions to the national cyberinfrastructure should be kept in mind.

Cyberinfrastructure for High Performance Computing. NSF's high performance computing plan for 2006–10 was outlined in the document "Cyberinfrastructure Vision for 21st Century Discovery" (March 2007). The report recognized the need, first articulated in the Branscomb report,[6] for a broad range of computing resources, from leadership-class national computing resources to university high performance computers and the compute/data clusters and workstations used by small research groups-the so-called Branscomb pyramid.[7] The report stated NSF's intent to fund the highest performance computing systems, the so-called Track 1 and Track 2 systems, as national resources. It envisioned that, in the 2006–10 time frame, Track 2 systems would provide 500+ teraflops (TF) of peak computing power and a Track 1 system would provide a sustained performance approaching 1 petaflop (PF) on a broad range of science and engineering applications.[8]

NSF awarded funding for Track 2 systems to the Texas Advanced Computing Center (TACC) in 2006 (Sun system with a peak performance of 579 TF) and the University of Tennessee/Oak Ridge National Laboratory in 2007 (Cray system with a peak performance of 1,028 TF). NSF announced the award of a Track 2 system to Pittsburgh Supercomputing Center in 2008. Unfortunately, the downturn in the economy led to the demise of the selected computer vendor, Silicon Graphics, Inc., which was acquired by Rackable Systems. Rackable Systems subsequently changed its name to SGI but cancelled the on-going contract negotiations with PSC. So, a third Track 2 system has not been deployed, despite clear evidence of a need for additional computing resources in the national allocation process run by NSF.

[5] A typical arithmetic operation is the multiplication of two 14-digit numbers to yield a 14-digit result.

[6] "From Desktop to Teratlop: Exploiting the U.S. Lead in High Performance Computing," NSF Blue Ribbon Panel on High Performance Computing, Lewis Branscomb (chairman), NSF 93–205, August 1993.

[7] NSF supports the acquisition of computer systems at the lower levels of the Branscomb pyramid through many other programs, e.g., the Major Research Instrumentation (MRI) program. See: *http://nsf.gov/pubs/2010/nsf10529/nsf10529.htm.*

[8] The peak performance of a computer system is the theoretical limit of its computing capability; it can never be achieved. The sustained performance of a computer is the performance that is actually achieved on a given science or engineering application. Although peak performance is used as a proxy for sustained performance, the correlation can be very weak.

To complement the Track 2 systems, NSF has also deployed a number of experimental and specialized computing systems to serve the nation's scientists and engineers, These include the many-core system deployed at the University of Illinois at Urbana-Champaign and another under development at the Georgia Institute of Technology, the data system being deployed at the San Diego Supercomputing Center, the experimental grid test-bed system at Indiana University, and the visualization systems at the University of Tennessee/Oak Ridge National Laboratory and the Texas Advanced Computing Center.

In August 2007, NSF announced that it had selected the University of Illinois at Urbana-Champaign and its National Center for Supercomputing Applications (NCSA), IBM Corporation, and the Great Lakes Consortium for Petascale Computation to develop and deploy the Track 1 system called Blue Waters[9] by July 1, 2011. Blue Waters is based on the most advanced technologies under development at IBM. These technologies are embodied in PERCS (Productive, Easy-to-Use, Reliable Computing System), which IBM is developing with funding from DARPA's High Productivity Computing Systems (HPCS) program. Blue Waters will be the first production deployment of PERCS and will be a truly extraordinary resource for science and engineering research.

Blue Waters will have more than 300,000 compute cores, 1 petabyte of main memory, 10 petabytes of user disk storage, and 500 petabytes of archival storage. It will have an innovative low latency, high bandwidth communications network that will facilitate scaling to large numbers of compute cores, and an I/O subsystem that will enable the solution of the most challenging data-intensive problems. With a peak performance of approximately 10 petaflops, performance analyses indicate that Blue Waters will sustain 1 petaflops or more on a broad range of science and engineering applications.

The breakthroughs enabled by the extraordinary computing capabilities of Blue Waters will revolutionize many areas of science and engineering. In the past two years, NSF has awarded allocations of time or provisional allocations of time to eighteen (18) research teams from thirty (30) institutions across the country, with more to follow in future years. Research to be carried out on Blue Waters covers all areas of science and engineering from astronomy through biology, chemistry and materials science to geosciences and social and behavioral sciences.

The Blue Waters Project is based on a 24-year partnership between the state of Illinois, the University of Illinois at Urbana-Champaign, and the National Science Foundation. To ensure the success of the Blue Waters Project, the state of Illinois agreed to provide a new state-of-the-art, energy efficient facility to house Blue Waters. In addition, the University of Illinois at Urbana-Champaign is making substantial investments in the development of software for Blue Waters—collaborating with IBM and the Great Lakes Consortium to: (i) enhance the systems software for Blue Waters, (ii) develop software and tools to facilitate the development of science and engineering applications for Blue Waters, and (id) aid scientists and engineers in rewriting their applications to obtain maximum performance on Blue Waters. In addition, previous investments by the state of Illinois in I–WIRE,[10] a high performance communications infrastructure connecting the major research universities and laboratories in Illinois, provides the transport mechanism for connecting Blue Waters to national research and education networks.

Status of High Performance Computing Cyberinfrastructure. I will discuss the status of computer hardware and software for high performance computing separately as the issues are distinct, if interconnected.

Computer Hardware. NSF has been successful in deploying new computing systems that are delivering extraordinary value for the U.S. research community—*the first system delivered to TACC exceeded the total computing capacity of NSF's TeraGrid by a factor of more than five.* However, the focus of these acquisitions was on the delivery of raw computing cycles and the funding available to provide support for the users of these new high performance computer systems was limited, This is unfortunate because this approach favors those scientists and engineers who are already using supercomputers and need little assistance, while our experience at NCSA and that at many other centers indicates there is a growing need for high performance computing resources in almost all fields of science and engineering. Without adequate user support, it will be difficult for these new researchers to make effective use of the available resources. High quality support staff is one of the most valuable resources in NSF's supercomputing centers and a fully funded user support program is needed.

[9] See: *http://www.ncsa.illinois.edu/BlueWaters.*
[10] See: *http://www.iwire.org/.*

Both the Track 1 and Track 2 awards were made through open competitions that included the existing centers as well as many new entrants. The outcome of these competitions is that the two Track 2 awards went to new centers—the Texas Advanced Computing Center and University of Tennessee/Oak Ridge National Laboratory. This is not necessarily bad, although it represents a lost of significant capability at San Diego Supercomputer Center and Pittsburgh Supercomputing Center. At this point the long term impact of the loss of funding on SDSC and PSC is unknown, but the potential loss of expertise at these sites is of great concern to the computational science and engineering research community.

It should also be noted that the prospect of continual competitions has a corrosive effect on the staff at the centers—it is not only difficult to hire quality staff with funding that only lasts for 4–5 years, but enormous amounts of staff time have to be dedicated to preparing for the competitions, rather than assisting researchers. The advantages of competition must be carefully balanced against those of stability in NSF's supercomputing centers program.

The above problems have been extensively discussed by the Task Force on High Performance Computing. It is clear that stability and sustainability are critical if NSF's supercomputing centers are to attract high quality staff who can advance the use of high performance computing across the frontiers of science and engineering. Increased stability of the supercomputing centers that NSF supports, coupled with a rigorous review process to ensure operational quality, will certainly be one of the major recommendations from the Task Force. For additional thoughts on this topic, see the published comments by Larry Smarr [11] and Sid Karin,[12] the founding directors of NCSA and SDSC, respectively.

Computer Software. During my two years as Assistant Director for Scientific Simulation in DOE's Office of Science, I played a central role in crafting its *Scientific Discovery through Advanced Computing* (SciDAC) program. This program highlighted the intimate connection between hardware and software and sought to advance computational modeling and simulation through balanced investments in these two areas. Experiences from this program, as well as DOE's ASCI program clearly show that advancing our ability to model complex natural systems requires as much, if not more, investment in software than in hardware.

This problem is actually more acute now than when the SciDAC program was initiated. Since 2004, because of rapidly increasing thermal loads, the speed of a single compute core has not increased. Instead, computer vendors are adding additional cores to the chips and running the chips at lower speeds (to reduce the heat load). As a result, most laptops now use at least dual-core chips and quad-core chips are found in large compute servers, with eight-core chips now available from Intel and IBM. This trend has two major impacts:

1. Science and Engineering Applications. In the future, increases in the performance of computational modeling and simulation codes will only be achieved through the use of larger and larger number of processors. Although this "scalability" problem has been with us for nearly twenty years, for much of that time its impact was not felt because of the dramatic increases in the performance of single cores—a factor of two orders of magnitude from 1989 to 2004. With single core performance now stalled, computational scientists and engineers must confront the scalability problem head on.

   The need for ever more scalability has increased the difficulty of developing science and engineering applications for high performance computers. At the heart of the problem is algorithms that scale well to large numbers of compute cores. This problem can only be solved through inspired research. But, even given the appropriate algorithms developing science and engineering applications for computers with hundreds of thousands of compute cores, hundreds of terabytes of memory and tens of petabytes of disk storage is challenging, The software must be written, debugged, optimized and, to the extent possible, made resilient to computer faults (e.g., the loss of a compute core)—none of which is easy or straightforward. Progress will require the creation of new software development tools or the revision of existing tools (compilers, debuggers, libraries, performance analysis tools, etc.) and inte-

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[11] "The Good, the Bad and the Ugly: Reflections on the NSF Supercomputer Center Program," Larry Smarr, HPCWire, January 4, 2010 *(http://www.hpcwire.com/features/The-Good-the-Bad-and-the-Ugly-Reflections-on-the-NSF-Supercomputer-Center-Program-80658282.html).*

[12] "Thoughts, Observations, Beliefs & Opinions About the NSF Supercomputer Centers," Sidney Karin, HPCWire, January 28, 2010 *(http://www.hpcwire.com/features/Thoughts-Observations-Beliefs-Opinions-About-the-NSF-Supercomputer-Centers-82972987.html).*

gration of these tools into a robust, easy-to-use application development environment.

2. Computing System Software. Although computer companies provide the base computing system software for high performance computers, enhancements to this base software can greatly facilitate operation, control and use of the system. This problem is becoming more acute as the computer systems become larger and more complex. Recently, a large international group of computer and computational scientists has come together to discuss plans for the development of software for petascale and exascale computers.[13] They are exploring how laboratories, universities, and vendors can work together to coordinate the development of a robust, full featured software stack for petascale and -beyond computers.

The development of high performance computing software—science and engineering applications and computing systems software—is a topic that is being heavily discussed in several NSF Task Forces (Grand Challenges, Software and Tools, High Performance Computing, and Data). What is clear is that the current approach to developing a high performance computing software stack is too fragmented. The Task Forces have noted the need for long term, multi-level efforts in high performance computing software that involves all of NSF's directorates and the Office of Cyberinfrastructure. A partnership between OCI and the Computer & Information Science & Engineering directorate would help create software to manage, control and operate petascale and beyond computers as well as the new tools and software development environment needed to develop science and engineering applications for these computers. A partnership between OCI and the other directorates at NSF would foster the development of a new generation of science and engineering applications that can take full advantage of the power of petascale and beyond computers and realize the promise of these extraordinary resources for advancing science and engineering. Such partnerships already exist, e.g., the *Accelerating Discovery in Science and Engineering through Petascale Simulations and Analysis* (PetaApps, NSF 08–592) program, but they could be substantially strengthened.

High Performance Computer Vendors. There is one last concern that deserves to be mentioned—the dwindling number of supercomputer vendors in the U.S. just a few years ago, five companies were involved in the development and deployment of supercomputers: IBM, Cray, Sun, SGI and Hewlett-Packard. Sun has now been subsumed by Oracle and SGI has been taken over by Rackable Systems. Although the long term consequences of these actions are not yet known, it is unlikely that Oracle and Rackable Systems/SGI will have as strong an interest in supercomputing as the original companies. Of the remaining companies, only IBM and Cray are actively involved in research and development on supercomputing. Although you would have to talk with these companies to better understand the issues surrounding this situation, it is clear than the supercomputing industry in the U.S. is not as healthy as it was just a few years ago.

Advanced Information Systems

One of the most exciting research advances in science and engineering in the past decade is the digitization of observational science. Fields as disparate as astronomy, biology and environmental science are being revolutionized by the use of digital technologies: digital detectors like those in digital cameras in astronomy, highly automated sequencers in biology, and sensor arrays in environmental science. Data-driven discovery requires sophisticated, advanced information systems to collect, transport, store, manage, integrate and analyze these increasingly large amounts of invaluable data. The knowledge gained from data-driven discovery is already transforming our understanding of many natural phenomena and the future is full of promise.

National Observatories. National astronomy observatories are major investments in the NSF research portfolio. At the leading edge of this portfolio are the latest additions to the NSF's list of approved major research equipment and facilities: the Atacama Large Millimeter Array[14] (ALMA) and the Advanced Technology Solar Telescope[15] (ATST). In addition, two other observatories are in the planning phases: the Giant Segmented Mirror Telescope[16] (GSMT), which will operate in the ultraviolet to the mid-infrared with unprecedented resolution and sensitivity, and

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[13] See *http://www.exascale.org/iesp/Main_Page.*

[14] See: *http://www.almaobservatory.org/.*

[15] See: *http://atst.nso.edu/.*

[16] See: *http://www.gsmt.noao.edu/.*

the Large-aperture Synoptic Survey Telescope[17] (LSST), which will be able to image faint astronomical objects across the sky, including objects that change or move.

NCSA is heavily involved in the LSST project and has been designated as the main storage and distribution site for all of the data produced by the telescope's 3.2 gigapixel camera. The data challenges to be faced by the LSST are typical of next generation optical telescopes, although the data-processing needs of the Square Kilometer Array (SKA) radio-telescope will dwarf those of the LSST. The LSST will produce more than 15 terabytes of data per night, yielding several petabytes of data per year, and 200 petabytes over its lifetime. This data rate, when combined with the need for real-time analysis to identify and characterize changing or moving objects as well as traditional data mining on petabyte-size data sets, requires a new approach to data management, automated processing, and analysis. Although the telescope will not see first light until 2014, NCSA is already working with other partners in the LSST project to design the cyberinfrastructure needed to meet these challenges.

Several national-scale environmental observatories are also major initiatives in the current NSF research and development portfolio. These are represented by the Ocean Observatory Initiative[18] (001), which is leading the way in this space, along with the National Ecological Observatory Network[19] (NEON), and the WATERS Network.[20] Ecological observatories have been in existence for many years with one of the oldest large-scale observatories being the Long-Term Ecological Research Network,[21] although the grand challenges being addressed and the level of integration required for the new observatories far exceeds those of earlier observatories.

Environmental science often depends upon observations from multiple observatories not only of the same type but also complementary observatories. For instance researching the effects of climate change on a terrestrial species might include temperature, rainfall and other traditional measurements from the region being studied, but it might also include ocean temperature, and tidal and current flow data that may directly or indirectly influence the region, and it may also include weather patterns and pollution counts, all of which may be derived from observatories geographically far away that are owned and operated by other organizations. The ability to interact with and integrate data from multiple observatories that cross scientific, geographical, and administrative domains is an increasing requirement for environmental scientists today and presents a number of additional challenges with respect to coordination, standardization, and long term support for deployed cyberinfrastructure.

Environmental observatories share many of the same general needs with other science domains including data storage and management, application codes, workflow systems to coordinate their research activities, and collaboration tools. However, it is the challenge of supporting potentially thousands of highly variable *in situ* sensors along with the need to manage and share them across vast geographical distances and administrative boundaries that makes environmental observatories unique.

The proposed Genome 10K project[22] is an example of the future of genomic research. The authors of this project, which includes scientists from across the world, are proposing to dramatically increase the number of vertebrate genomes available to the research community. This is made possible by a dramatic drop in sequencing costs coupled with a corresponding increase in computing capability. The Genome 10K Community of Scientists propose to assemble and sequence a collection of some 16,203 representative vertebrate species spanning evolutionary diversity across living mammals, birds, non-avian reptiles, amphibians, and fishes. This will allow scientists, for the first time ever, to carry out a comprehensive studies of vertebrate evolution. Just as computers enabled the assembly and annotation of the human genome, supercomputers will be required to manage and analyze massive quantities of genomic data to achieve the goals of the Genome 10K project.

Status of Cyberinfrastructure for Data-driven Discovery. The development of cyberinfrastructure for data-driven discovery is in its infancy. Within NSF, most of the activity in this area is being driven by large Major Research Equipment & Facilities Construction (MREFC) projects. Each of these projects is developing the cyberinfrastructure needed to accomplish its mission, relying to some extent on the

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[17] See: *http://www.lsst.org/lsst.*

[18] See: *http://www.oceanleadership.org/programs-and-partnerships/ocean-observing/ooi/.*

[19] See: *http://www.neoninc.org/.*

[20] See: *http://www.watersnet.org/.*

[21] See: *http://www.lternetedu/.*

[22] "Genome 10K: A Proposal to Obtain Whole-Genome Sequences for 10,000 Vertebrate Species," Journal of Heredity, November 6, 2009.

cyberinfrastructure developed in other projects but often redeveloping cyberinfrastructure capabilities in slightly different guises. Since one of the major issues associated with cyberinfrastructure is the ongoing support and maintenance costs associated with the software, sharing cyberinfrastructure software, wherever feasible, will help keep these costs under control.

More recently, NSF has created major programs that are focused largely on the development of the cyberinfrastructure needed to support data-driven discovery. These include the iPlant Collaborative,[23] a project aimed at developing cyberinfrastructure to address a number of grand challenges in plant biology (Genotype to Phentotype in Complex Environments, Tree of Life for Plant Sciences, etc.), and DataNet (NSF 07–601), which consists of several projects designed to explore different approaches to organizing, managing and preserving the data being created in scientific and engineering research.

One of the major cyberinfrastructure requirements for data-driven discovery is the availability of the required data storage capacity, computing resources and associated software. Although these needs could often be met by augmenting the resources available at the NSF-funded supercomputing centers, most major data-driven discovery projects, which usually have lifetimes measured in decades, are reluctant to use the centers because of their uncertain future (current Track 2 grants are only for four years and funding for the Track 1 system expires in 2016). This is a lost opportunity for leveraging the expertise at and cost efficiency of the supercomputing centers.

Networking

To first order, the cyberinfrastructure most needed by universities to participate in or benefit from NSF's high performance computing and data-driven discovery projects is adequate network bandwidth linking them to the relevant project sites. The nation's major research universities are partners in Internet2, which provides a national high performance network. In addition, the National LambdaRail, which is also owned by the U.S. research and education community, provides a testbed for research in the development and use of communication technologies. However, this does not mean that all universities and colleges have access to network bandwidth adequate for their participation in or interaction with the big computing and data projects, an imbalance that will become more acute as the data volumes increase.

As comfortable as the situation may be now,[24] at least for the nation's major research universities, the volume of data that will be generated over the next few years in high performance computing and data-driven discovery will far outstrip the capacities of the current networks. For example, many simulations on Blue Waters will generate multiple terabyte data sets with the total amount of data generated in a given project being measured in petabytes. Although NCSA can provide connectivity to Chicago at 100–400 gigabits per second (Gbps), the national networks passing through Chicago (or any other U.S. city for that matter) do not have the capacity to deliver these data streams to the researchers' home institutions. Separate from the capacity issue, the underlying communication architecture, services and networking technologies required by data intensive science are very different from those that support common consumer services. Common carriers have shown little interest in meeting the specialized requirements of scientific research communities.

In this regard it is worthwhile to note the DOE–SC's ESnet is a welcome exception. ESnet connects more than 40 sites across the nation, including all of DOE–SC's major experimental and computing facilities. DOE–SC's new Science Data Network, which is a part of ESnet, provides services that are specifically targeted for data-intensive science. The SDN circuits provide a wealth of services that are invaluable to scientists who need reliable, high performance, end-to-end connections between two or more sites. ESnet received funding under the American Recovery and Renewal Act to develop and deploy a 100 Gbps network linking its open supercomputing centers in California, Illinois and Tennessee. This is the first step toward DOE–SC's vision of a 1 terabit per second (Tops) network linking its major facilities.

Although communications bandwidth. is critical to participating in high performance computing and data-driven discovery, the TeraGrid's Campus Champions pro-

[23] See *http://www.iplantcollaborative.org/*.

[24] Some scientists note that the current "favorable" situation is deceptive. Because of bandwidth limitations, they note that many scientists are simply avoiding research practices that would stress the current networks.

gram [25] has shown that access to local expertise is also critical. This program supports individuals on university campuses who are knowledgeable about the TeraGrid and who can help faculty and students apply for and make use of the resources and services available through the TeraGrid. Such programs are likely to be just as important for data-driven discovery as for high performance computing.

Status of Networking. NSF was one of the pioneers in establishing a national networking infrastructure, e.g., NSFnet and Mosaic (the first web browser, which was created at NCSA). However, its networking infrastructure support programs were eliminated several years ago. So, the nation's scientists and engineers must rely on commercial providers, research and education network providers such as Internet 2 and National LambdaRail, and state governments for their communications needs. To date, these entities have been able to provide the bandwidth and connectivity needed by researchers.24 However, with the major new data-intensive research resources coming on line, this will no longer be adequate.

Another major problem is that, to date, there has been little focus on improving end-to-end networking capabilities, i.e., providing high performance connections between the researcher's desktop or local compute/data cluster and large computing and data sites. Even if it appears that there is adequate network bandwidth between these two end points, a bottleneck, often, but not always, on the researcher's campus dramatically limits the network performance. We need to have a better understanding of the issues affecting end-to-end performance to enable researchers to interact with their ongoing research activities at the major facilities.

There are steps that NSF could take to ensure that researchers in U.S. universities have the networking capacity and policies needed to support their research. NSF could begin by developing a high performance network connecting all of their major research facilities, observatories, and supercomputing centers, interconnecting this network with those serving other major federal research facilities, e.g., ESnet, as needed by the academic research community. There are many advantages that will accrue from connecting NSF's large experimental and observational facilities with its computing and data facilities, especially if the future of these centers were secure. In addition, NSF could undertake pilot projects to obtain a better understanding of the problems limiting high performance end-to-end connections between researchers/small research groups and its major research facilities. This would require close collaboration between groups providing national networking resources and campuses providing the "last mile" connection.

Education

I would be remiss if I did not include a section on education in responding to the Subcommittee's request for information on the state of cyberinfrastructure at U.S. universities. Although not a part of the cyberinfrastructure per se, our ability to advance science and engineering using the national cyberinfrastructure requires a new generation of scientists and engineers who can contribute to and understand the use of the basic technologies involved in cyberinfrastructure and computational science and engineering and who can collaborate with colleagues in other fields to take full advantage of the extraordinary capabilities provided by this infrastructure. We need to define the core competencies important for the next generation of scientists and engineers, followed by the development of implementation plan(s) to affect the needed curriculum and course changes.

The curriculum and course changes required to educate the next generation of research leaders is not obvious. Many schools have established graduate programs in computational science and engineering that supplement study in a discipline with courses in ,computer science and engineering and applied mathematics; see, e.g., the Graduate Program in Computational Science and Engineering at the University of Illinois at Urbana-Champaign.[26] Such programs are invaluable in preparing students for future careers in computing- and data-intensive fields. But are they sufficient? And what about undergraduate education? At the rate that analog science is becoming digital science, what do we need to teach all undergraduates in science and engineering about computing and related technologies to prepare them for life and work in the 21st century. Through its investments in research and education, NSF can serve as a catalyst for this transformation.

In the Blue Waters Project, we are pursuing this goal through the *Virtual School of Computational Science and Engineering,*[27] headed by Professor Sharon Glotzer at the University of Michigan. The Virtual School brings together faculty across the

[25] See: *https://www.teragrid.org/web/eot/campus_champions.*
[26] See: *http://www.cse.illinois.edu/.*
[27] See: *http://www.greatlakesconsortium.org/education/VirtualSchool/.*

universities in the Great Lakes Consortium for Petascale Computation to address the unique opportunities and challenges associated with petascale computing and petascale computing-enabled science and engineering. The *Virtual School* supports the creation and integration of courses and curricula that are tailored to the educational needs of 21st Century scientists and engineers, delivered using 21st century instructional technologies. Although the *Virtual School* is initially targeting graduate-level education, efforts in undergraduate education will follow.

BIOGRAPHY FOR THOM H. DUNNING, JR.

In December 2004 Thom H. Dunning, Jr. was appointed director of the National Center for Supercomputing Applications and Distinguished Chair for Research Excellence in the Department of Chemistry at the University of Illinois at Urbana-Champaign. He was formerly director of the Joint Institute for Computational Sciences, Distinguished Professor of Chemistry and Chemical Engineering at the University of Tennessee, and Distinguished Scientist in Computing and Computational Sciences at Oak Ridge National Laboratory. Before taking that position, Dr. Dunning was responsible for supercomputing and networking for the University of North Carolina System and a professor of chemistry at the University of North Carolina at Chapel Hill.

Dr. Dunning was Assistant Director for Scientific Simulation in the Office of Science at the U.S. Department of Energy in 1999-2001, on leave from Pacific Northwest National Laboratory. In that position, he was instrumental in creating DOE's scientific computing program, *Scientific Discovery through Advanced Computing*. Dr. Dunning joined PNNL as Associate Director for Theory, Modeling & Simulation in the Environmental Molecular Sciences Laboratory in August 1989. In EMSL, he established a world-class research program in theoretical and computational molecular science and founded the Molecular Science Computing Facility. In February 1994, Dr. Dunning was appointed Director of the Environmental Molecular Sciences Laboratory. As Director, he oversaw the construction of laboratory as well as the development of its research instruments and scientific research programs—a $230 million project—for DOE. In October 1997, Dr. Dunning accomplishments were recognized by his appointment as the first Battelle Fellow at PNNL, thereby establishing the highest scientific and engineering position in the Laboratory.

Dr. Dunning has authored nearly 150 scientific publications on topics ranging from advanced techniques for molecular calculations to computational studies of the spectroscopy of high power lasers and the chemical reactions involved in combustion. Five of his papers are "Citation Classics" with over 1,000 citations each (one has nearly 10,000 citations). He has organized symposia and workshops for the National Research Council, the American Chemical Society, the U.S. Department of Energy, the National Science Foundation, and many other organizations. Dr. Dunning was the scientific leader of DOE's first "Grand Challenge" in computational chemistry, which, along with the EMSL Project, led to the development of NWCHEM, a computational chemistry code for massively parallel computers that has dramatically extended the range and accuracy of molecular calculations. At Illinois, Dr. Dunning is leading the Blue Waters Project, a project partially funded by the National Science Foundation to acquire and deploy a *sustained* petascale computing system.

Dr. Dunning is a member of the American Chemical Society, and a Fellow of the American Physical Society and of the American Association for the Advancement of Science. He has served on numerous national advisory committees, including NRC's AFOSR Chemistry Review Committee (1987-1990), NSF's Advisory Committee for Chemistry (1991-3), and DOE's Council on Chemical Sciences (1996-9). He was the founding vice-chair of NRC's Chemical Sciences Roundtable (1996-1999) and organized its first two workshops. In April 1997, Dr. Dunning received DOE's E. O. Lawrence Award for "seminal contributions to the development and application of theoretical and computational chemistry" and, in February 2001, he was presented with DOE's Distinguished Associate Award for his research, management, and leadership in the chemical, molecular, and computational sciences for the Department.

Dr. Dunning received his B.S. in Chemistry in 1965 from the University of Missouri-Rolla and his Ph.D. in Chemical Physics from the California Institute of Technology in 1970. He was awarded a Woodrow Wilson Fellowship in 1965-66 and a National Science Foundation Fellowship in 1966-9. Previous positions include group leader of the Theoretical and Computational Chemistry Group at Argonne National Laboratory (1978-1989) and staff member and Associate Group Leader of the Laser Theory Group at Los Alamos National Laboratory (1973-78). These positions were preceded by postdoctoral appointments at the California Institute of Technology (1971-3) and Battelle Memorial Institute (1970-1).

Chairman LIPINSKI. Thank you, Dr. Dunning.

I would like to thank all the witnesses for their testimony. It is good to see especially with the rescheduled hearing that we have a pretty good turnout here. This is something that I think is very important to discuss since it is really key to figuring out what is best for our competitiveness, where to invest, although there are always tradeoffs that need to be made in talking about bringing back a program that was ended. I think it does require a lot of thought, so we will move on to questioning right now, and as is my tradition, I will leave myself to last on my side, so I will begin by recognizing Dr. Baird for five minutes, and I want to ask members to try to keep it down to the five minutes to at least get us through the first round of questions. I will be tight in trying to keep it to that. Dr. Baird

Mr. BAIRD. Thank you, Mr. Chairman. I want to begin by echoing the accolades for our good friend and colleague, Dr. Ehlers. He served this committee and this country extraordinarily well, and it has been a privilege to serve with him. As I have said when people speak about my retirement, I am not dead yet, so I am sure, Vernon, the rest of us have a lot of good work to do but, Vern, thank you for your work.

Thanks to the witnesses for their great comments and for your service to your schools and communities. I am very troubled by this issue of the infrastructure deficit that you talked about. Dr. Tolbert, you mentioned it; Dr. Raymond and Mr. Horvath, and then Dr. Dunning talked about sort of a different kind. There is one kind of deficit which seems to be the maintenance backlog, what are we doing to keep our existing facilities up to date, and then Dr. Dunning talked about the ability to keep up with what is happening in the other direction. Let me start with this maintenance issue. Dr. Tolbert, I think you said a $100 million deficit in some fashion. Can you elaborate on that a little bit?

Dr. TOLBERT. I think you may be referring to the $200 million building renewal——

Mr. BAIRD. I have cut your deficit in half. That is the kind of effective legislation I——

Dr. TOLBERT. Thank you very much. The $200 million number is actually a lower limit. It is actually much more than that. The State of Arizona owns the buildings, but it is up to the universities to keep them in shape and actually to try to keep them upgraded so that they are appropriate for the research in the fields they were built for. As state funds coming to the university have declined and private funding is scarce, this has become a real issue. In particular, donors are interested in funding new buildings when they have the funds. Right now isn't a good time for that. But when they have the funds, they are interested in new buildings. It is very hard to keep our older buildings in good working order. It is a little bit like the Nation's highway system. We built a lot of great universities some decades ago and now many of our science buildings are deteriorating.

Mr. BAIRD. That is why I asked. I actually serve on the Highway Transportation Committee as well, and we talk a lot about the fiscal deficit in this country. It is about $1.3 trillion per year. There is an existing infrastructure deficit exceed $1 trillion in highway, roads, et cetera, and now we are hearing about academic buildings.

Dr. Raymond, you talked about a pretty large number in your case as well. What is your situation?

Dr. RAYMOND. Our situation is very similar to the University of Arizona. The $100 million number that I gave you would be required to bring our buildings up to the minimum standards. If we brought them up to good standards, it would be closer to $200 million. The State of South Carolina provides a lump-sum appropriation to our university, which primarily is used to pay the light bills and salaries of support staff. There is very little left at the end of the day to take care of these older buildings, and we rely heavily on clinical revenue from our hospital, which obviously is diminishing these days, and from philanthropy to try to keep those buildings in good shape.

Mr. BAIRD. Mr. Horvath, do you want to comment from your institution's perspective?

Mr. HORVATH. Sure. It is similar to the other two institutional examples. We have an overall facility deficit across the university of about $1 billion, and if you look at our annual capital plan, about 50 percent of the funding that we are investing in facilities and infrastructure is really being targeted to try to reduce that deferred maintenance backlog, and roughly 40 to 50 percent of that total relates to research, buildings and facilities which tend to be more intensive from a cost perspective.

Mr. BAIRD. These are three of our major universities in the country and we are hearing now of deficits well exceeding $1 billion from just three universities. Nationwide, this has got to be a serious problem, and you know, at a time when people are saying, well, we have got to cut taxes, et cetera, et cetera, there are going to be consequences, presumably for the quality of education received by your students and the competitiveness of their academic and intellectual products, I am guessing.

Dr. Dunning, you are looking at it from the other side. One of the things this committee and others are worried about is the lag in U.S. competitiveness in other areas. If we don't make the investments, what happens to our supercomputer competitiveness?

Dr. DUNNING. Well, it is clearly going to decline if we don't make these types of investments. We see a resurgence of interest in high-performance computing and supercomputing across the world. The European Union has outlined a very aggressive program for building its supercomputing capability. The Japanese have long been in the game. But now we are also seeing significant advances in China and in other countries. So this is clearly an area in which competitiveness—although we are in a good position at the current time, competitiveness is something that will be challenging to maintain.

Mr. BAIRD. Thank you, Mr. Chairman. Thanks to the witnesses.

Chairman LIPINSKI. Thank you, Dr. Baird. That is a very good way to start us out here, and I will recognize Dr. Ehlers for five minutes.

Mr. EHLERS. Thank you, Mr. Chairman, and I would also like to point out that Dr. Baird is not running for reelection either, so the message is clear.

I appreciate your kind words for me, Dr. Dunning. I hope you feel that because we are both leaving, there is such a great need here for scientists that you will run for the Congress this fall and perhaps all of you carry that message back to your home institutions.

Mr. BAIRD. Talk to me before you embark on that.

Mr. EHLERS. But we desperately need more scientific and engineering talent in the Congress. We have most of it right here.

Dr. Dunning, I just wanted to point out another dimension. A computer scientist in my district who teaches at the institution I used to teach at has come to see me and is very concerned about the declining enrollments in computer science nationwide, and in fact introduced a resolution to declare a week to emphasize computer science throughout the Nation and so forth. The professor who talked to me had very good statistics about what has been happening in declining enrollment but particularly what is happening in high schools; that they are now getting away from the subject, not getting students excited about computer science and all the issues related to it, and that doesn't necessarily even mean just programming or development, it means everything. And I am just wondering if you have encountered the same situation in your facility.

Dr. DUNNING. We have certainly seen that same situation. In fact, when we talk to our industrial partners—NCSA has a very large industrial partners program—one of their concerns is about the ability to really be able to recruit the type of workforce that they are going to need in the future where high-performance computing has become a way of designing, for example, the next generation of products, products that reduce the environmental impact or can be done in a timely fashion. So we certainly see it at the university. We do see that it is slowing, which I think is good. One of the things that I think actually we find is an attractant to students interested in computer science is the applications of computer science. Many of them come in thinking of only a small number of applications of computer science, but basically what they aren't realizing is, all of science is open to a computer scientist, ranging all the way from astrophysics to zoology if they want to understand how they take the skills they learn as a computer scientist and really participate in this new era of digital science.

Mr. EHLERS. Thank you for those comments. That reinforces what I have been told and what I have been trying to change here, and I hope you can get the rest of the computer science world excited about this.

Dr. DUNNING. So do we.

Mr. EHLERS. That may be one of my retirement projects.

Dr. DUNNING. Good.

Mr. EHLERS. Thank you. I yield back.

Chairman LIPINSKI. Thank you, Dr. Ehlers.

I will now recognize Ms. Fudge.

Ms. FUDGE. Thank you, Mr. Chairman, and thank all of you for being here.

I represent northeast Ohio. We have one of the largest research institutions, Case Western Reserve University, and over the years Case has found time and found a way to work more collaboratively with our large research hospitals, the Cleveland Clinic and university hospitals in particular, and so just understanding how we function in our area. My question to any of the panel members is that certainly we all recognize that states are struggling and the current economy is really not very good, but the fact is that many states began divesting in higher education long before the economic downturn, and industry as a whole invests very little in higher education and university research, even though both the states and industry rely very heavily on strong universities for their own growth and success. I just want to know from you or hear from you what you are doing as a university community to lobby your states, your local industry and some public support to sustain your investments in higher education that will benefit all of us. Anyone? Dr. Tolbert, thank you.

Dr. TOLBERT. Thank you very much, Congresswoman Fudge, for your question. This is a really important role that I think we all play. Certainly in my role at the University of Arizona as a senior administrator, I must be making that kind of argument all the time, both to the state and locally, actually, to local government as well, and also to the private sector. We are working hard to broaden and deepen our relationships with the largest corporations that we work with. We have a huge Raytheon presence in Tucson. Raytheon Missile Systems is based in Tucson and the University of Arizona provides more Raytheon employees than any other university in the country. That is really important to us, and we are trying to find ways that we can increase the benefit to both by increasing the number of internships, for example, available to our students and so on.

But the argument that has to be made, I think, is, importantly, not one about short-term gain only. It is that this is a long process we are engaged in. We need long-term relationships with the private sector. We need the state to understand our long-term needs and not to say that we can enhance economic development tomorrow, but that if we want Arizona to pull itself out of this deep, deep economic slump, we must have research universities doing research but also educating students in a research-oriented environment.

Ms. FUDGE. Thank you.

Dr. Raymond, in your testimony you mentioned that there are certain initiatives that the State of South Carolina has done to expand state research capabilities. Can any of the other witnesses talk about how their universities are linking research investments to regional economic goals? And I am taking this line because I went to Ohio State University, which is a very well known research institution as well, but we have them all over the country, and certainly if their reliance is going to be on us, we can't do all of them. So what we are doing as a community is to try to find other sources, but as well as to collaborate more, because I think that is where we are all going to have to be heading. Anyone? Dr. Raymond, if you would like to expand, or someone else on the panel?

Dr. RAYMOND. Thank you. By the way, I was born in Akron and went to Ohio State.

Ms. FUDGE. All right. I knew there was something I liked about you.

Dr. RAYMOND. South Carolina is trying to build critical mass through a collaboration between the four largest hospital systems in the state and the three research-intensive universities, Clemson, USC and MUSC, in which we all put at least $2 million a year into joint initiatives and recruitment of endowed professors to the state. This interdigitates well with the State of South Carolina's investment through the Centers of Economic Excellence program, that provides matching dollars for recruitment of new talent to the State of South Carolina. So we have really worked very well together. This initiative now is in its fifth year and it has spawned patient safety initiatives, public-private partnerships and partnerships with large pharmaceutical companies and device makers that wouldn't otherwise be interested in dealing with one of our universities, but the power of having a $10 billion budget and 40,000 employees can convince them that we are good partners.

Ms. FUDGE. Thank you very much. Yes, Dr. Horvath.

Mr. HORVATH. One of the things that I would point out just recently that we were successful with was the achievement of a grant through the Recovery Act that is going to enable us to be part of a 19-institution consortium in Pennsylvania to really expand and add robustness to our computing networks throughout the State of Pennsylvania. It is a large-scale project. There is private money that will be involved in that and it is really, I think, one of the indications of a new way in which we are going to have to collaborate across institutions to make some of the needs or address some of the needs that we have in our states and locally.

Ms. FUDGE. Thank you, Mr. Chairman. I yield back.

Chairman LIPINSKI. Thank you, Ms. Fudge.

I will recognize Ms. Johnson.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and let me express my appreciation to Dr. Ehlers. I hate to see Dr. Ehlers retire. He has been a friend of mine on this committee now for as long as he has been here, and I have relied heavily on your knowledge. What I would like to ask of the distinguished witnesses—and thank you for being here—are you seeing any more student readiness as a research university? That is number one. And then, we have some major research departments, and I don't know how well they coordinate—NIH, the National Science Foundation, Department of Defense, Energy, Ag, Education. Is there enough collaboration between them to maximize research dollars?

Dr. TOLBERT. I will answer your first question, and then I would also like to say something about your second question, Congresswoman. The first question had to do with readiness. We do not see improving readiness. In fact, we are having to put in place or deciding to put in place a lot of sort of one-on-one assistance to students to try to help students who really aren't quite ready to find their way into the university but also we are greatly growing our relationship with the community colleges in the state so that we can do two-plus-two programs that help with readiness.

And the other question?

Ms. JOHNSON. The other question is, we have major research departments here and some of it could overlap or some could be in coordination with medical schools and others, and I wonder if there is enough collaboration between these departments to maximize what dollars we do have for research.

Dr. TOLBERT. I think that is an extremely good question because the NIH has done something interesting. They have several programs working across institutes within the NIH. I am a neuroscientist. My funding has almost all been through the NIH. And that is I think working very well for NIH. Is there enough coordination across agencies? I am sure we would all argue no. It is very difficult but more coordination would be better. And one of the things that I suggested was a committee be appointed that would look across federal agencies at this issue of funding of research infrastructure for just that reason.

Ms. JOHNSON. Thank you.

Anyone else?

Dr. DUNNING. Let me take a slightly different tack on your question, and that is readiness of graduate students to participate in research that is heavily involved in computing, and I would say again, we are not properly educating the next generation of scientists and engineers to really understand the major role that computing and information science is going to play in their careers, especially when you consider that their careers are going to last 30 to 40 years into the future.

Ms. JOHNSON. Thank you very much, Mr. Chairman.

Chairman LIPINSKI. Thank you, Ms. Johnson.

I will now recognize myself for five minutes. I think we had very good questions so far. I wanted to follow up a little bit on some of the questions and answers. All of you talked about what really is the deficit in terms of the infrastructure right now, and we know that a lot of the university laboratories and other research facilities were built 30 or more years ago, even before some of the requirements of modern science and engineering researchers were even thought of. Two questions that I want to ask related to that. The first is for all of you. Do you find it difficult to compete for faculty and graduate students because of the infrastructure or lack of infrastructure that you have? Whoever wants to offer. Dr. Tolbert.

Dr. TOLBERT. Thank you very much, Mr. Chairman. That is such an interesting question. What we find is that in the areas in which we have built recent research buildings, or research laboratories when in older buildings, we are much more competitive. Of course, we have put the dollars into areas where we wanted to grow, but for instance, we have a life sciences building that is doing a wonderful job for us of attracting new faculty and also very good undergraduate and graduate students. So as we put facilities in place, I think I can argue pretty strongly that we find that we are more competitive, not only in bringing people but in keeping them, which is also a very important issue.

Chairman LIPINSKI. Anyone else want to take a stab at that? Dr. Raymond.

Dr. RAYMOND. Well, I would echo our experience. When we have put up new buildings for our health professions, the quality of students and faculty that we are able to attract and retain goes up enormously. So if you superimpose that on our background, I would say that we probably are having difficulty recruiting top talent to some of the buildings and facilities that maybe aren't as up to date.

Chairman LIPINSKI. I had a dual listening session last week in northern California with a number of universities, and one thing that they had mentioned and I had raised earlier was losing out to other countries. Have you seen, especially graduate students who come from other countries, a greater likelihood that they return to their home country than, say, was the case five, ten years ago? Dr. Raymond?

Dr. RAYMOND. I recently completed a trip to Shanghai and Guangzhou, China. We have a partner university there, Zhejiana University, and we have post-docs and faculty members who have been at our institution for 5 to 20 years who are now returning to China because they find that the facilities are as good or better than we have here and there is a lot of investment by the local government and the federal government in startup companies and in providing them with opportunities for entrepreneurship. So we have a very tangible loss in our own institution to China.

Chairman LIPINSKI. Anyone else? Dr. Dunning?

Dr. DUNNING. Yes, another comment related to that is that the Chinese government is in the process of establishing three to five major supercomputing centers which are going to be partnerships between the provinces in China. And the federal government in China, and this clearly is attracting recent graduates and more senior professors back to China to participate in this effort.

Chairman LIPINSKI. One thing that, certainly, as we look to the future and competitiveness, one thing that people often say to me is, well, we still have the greatest universities in the world in this country, and it certainly is a concern if we see that starting to go away and lose our competitiveness there.

One other thing I wanted to—the second part I wanted to put out there is, are we losing productivity in our research because of the facilities? We talked about, and I mentioned at the beginning, there is a tradeoff. We would all love to fund this infrastructure but we know that there is not unlimited dollars, and I realize that, and I know bringing up the possibility of reauthorizing ARI would raise this issue but I wanted to do it. Is there a problem and do you see a potential problem, do you see it happening already of losing how productive the research is? We just keep putting the funding into research, and if we don't have the facilities, are we losing out on the value of that money? Mr. Horvath?

Mr. HORVATH. In older facilities that have more substantial needs, essentially what happens is, band-aids are applied rather than, perhaps, more fundamental changes or upgrades being made to building infrastructure or the specific instrumentation or equipment in a particular lab. I think if we had the flexibility and ability to make more fundamental investments in those types of facilities, I think we would see greater productivity and better cost efficiency as a result of being able to do those things.

Chairman LIPINSKI. Dr. Raymond, did you——

Dr. RAYMOND. Yes. Thank you, Mr. Chairman. We just did a study on a research facility, a very simple metric, dollars per square foot of federal grants earned by our faculty, and it is no coincidence that the newer and more modern buildings are populated by faculty that are more productive. And furthermore, to operate the buildings costs a lot more for the older facilities so our investment is not getting the same kind of returns in the older facilities that it is in the newer facilities, both in terms of faculty productivity and in terms of the cost to keep those buildings operating.

Chairman LIPINSKI. Dr. Tolbert.

Dr. TOLBERT. We found exactly the same thing. I would just like to echo what Dr. Raymond said, same statistics.

Chairman LIPINSKI. Thank you. With that, I will yield back my time. Dr. Ehlers, do you have further questions? I will yield five minutes to Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chairman. I just want to clear up a few questions that I have.

Mr. Horvath, in your testimony you had a list of federal regulatory and legislative changes that you say directly affect the conduct and management of research under federal grants and contracts, and some of them are self-evident but you mentioned the Lobbying Disclosure Act and a section of the Higher Education Act relating to the reporting of foreign gifts, contracts and relationships. I am curious, how do those impede your efforts?

Mr. HORVATH. I think they were all essentially listed to provide some background to how the regulatory environment has changed in which universities have to operate, and those changes have occurred since the imposition of the indirect cost cap, the 26 percent administrative cap back in 1991. All of those things have come together to create greater complexity and encouraged us to add processes and staff to be able to respond to those things. So I think the point of that was to say that the regulatory environment has become much more complex in an era when we are constrained in terms of the amount of costs that we can recover to respond to those.

Mr. EHLERS. Now, is it because the researchers have to take time from their research to meet their requirements or because your office is burdened with having to respond?

Mr. HORVATH. It is basically the administrative responsibilities that faculty, for example, now have to shoulder as a result of some of those new requirements, are not able to be recovered and take some of their time away from conducting research in their laboratories.

Mr. EHLERS. Thank you.

Then Dr. Raymond, you got the NSF research infrastructure improvement grant. That sounds very exciting. What is the value of the grant, and I am wondering how the money will be distributed. You mentioned it expands on the contribution of the non-research but I would like to see you expand on the contribution of the non-research incentive intensive institutions, the smaller universities, community colleges, minority institutions. I have often wondered how we could develop an effective method of doing that nationwide. Could you give me a little background on that, please?

Mr. RAYMOND. I would love to have the opportunity to update you in three or four years when we can actually measure outcomes, but for the first time we have the senior research universities willing to sit at the same table with community colleges, technical colleges and four-year institutions to develop an overall plan to address the deficiencies in the pipeline for STEM disciplines in our universities, and they are also now reaching out to K–12 in the state, so I hope that this provided the seed corn, so to speak, to really have a good outcome.

Mr. EHLERS. Thank you. I yield back, Mr. Chairman.

Chairman LIPINSKI. Thank you, Dr. Ehlers. I was just discussing the timing of the grant announcements from the Recovery and Reinvestment Act, and I know that is going to be relatively soon. Have your universities applied for grants? Dr. Tolbert?

Dr. TOLBERT. Thank you, Mr. Chairman. We have never seen so much grant-writing activity as we have seen in the last year. In fact, it has been a huge burden on our sponsored projects office, which reports to me, another one of these hidden costs. People have been working nights and weekends to handle all the grant proposal activity that has happened. We have won $83 million in Recovery Act funds, and the reporting now of the activities also is another hidden cost, administrative cost. We are delighted to have those funds. Most of the funds are for research projects. About $6 million of that is for infrastructure, buildings and equipment, but most of it is for the direct costs of research. Our faculty are delighted, but the research reporting requirement on my office is now huge. That is the downside of being very successful. We are delighted with the Recovery Act.

Chairman LIPINSKI. In terms of the research infrastructure grants, we are supposed to hear soon on a lot of those. Some of those will have to wait until September. Mr. Horvath?

Mr. HORVATH. We have submitted applications for grants on two specific facilities. One is the renovation of one of our health and human development buildings, and the second for biological research lab and building, and we are hoping to hear positive news sometime in the next few days or few weeks.

Chairman LIPINSKI. Dr. Tolbert?

Dr. TOLBERT. And we have learned that we will be getting an NIH grant for $15 million for a research support building in the new arm of our college of medicine in Phoenix.

Chairman LIPINSKI. Dr. Raymond?

Dr. RAYMOND. We have also recently learned that we received an $8 million grant to substantially renovate an older facility on campus to bring the microbiology and immunology labs up to speed. One of the problems we had in the building, it is humid in Charleston and we were having difficulty maintaining positive air pressure so there was mold growing in some of the micro and immuno labs so you can't do bacteriology research with fungus growing in there, so this will help us to bring our facilities up to snuff.

Chairman LIPINSKI. Thank you. I just wanted to conclude, I want to ask Dr. Dunning a couple things. How much does the NCSA spend helping its user community?

Dr. DUNNING. I would say on the average probably around $4 to $5 million a year. That is primarily staff time. I must say not all of that is funded by the National Science Foundation, however; a good portion of that is funded by the State of Illinois and the University of Illinois.

Chairman LIPINSKI. Do you think there should be more funding to help users?

Dr. DUNNING. We are seeing large growth in the number of communities that need high-performance computing to be able to move into the new areas they want to go into and to solve the types of problems that they are encountering. I think the only way to successfully move those communities in that direction is through strong user support.

Chairman LIPINSKI. I have heard that there are issues in terms of being able to—people who can really use those facilities being able to understand how they can use them, the ability to—not even having the knowledge of what is possible to do and how to do it. Do you find that?

Dr. DUNNING. Some of the communities are coming from a very low base. One of the environmental communities we worked with a couple of years ago was using Excel spreadsheets as the means of storing and analyzing all of their data. That works for a while, but when you start accumulating the quantities of data that these environmental groups are now talking about being able to gather by the sensor arrays and other devices that they have, that won't work in the future, and so there is a tremendous education and training aspect that goes along with the user support. One of the things that we find really critical for our user support is to have a staff member that actually has some training in either that area or related areas, so he understands the scientific objectives and techniques that community is using, because the more you know about the community, the better you're able to move them down the pipeline toward being able to use these much larger computing systems.

Chairman LIPINSKI. Thank you. I will yield back. Dr. Ehlers, any more questions, closing comments?

Mr. EHLERS. I have taken too much time already.

Chairman LIPINSKI. I want to thank all of our witnesses for testifying before the Subcommittee today. The record will remain open for two weeks for additional statements from the Members and for answers to any follow-up questions the Committee may ask of the witnesses.

Again, I thank the witnesses all for their testimony. Certainly as we move forward with NSF reauthorization, with America COMPETES reauthorization, I welcome any more comments that you have. Your input is critical if we are going to do this right, and we are really going to make sure we are putting our resources in the best possible place for our universities, for research and for our competitiveness.

With that, the witnesses are excused and the hearing is now adjourned.

[Whereupon, at 3:27 p.m., the Subcommittee was adjourned.]

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