THE FUTURE OF MANUFACTURING: WHAT IS THE ROLE OF THE FEDERAL GOVERNMENT IN SUPPORTING INNOVATION BY U.S. MANUFACTURERS?

HEARING

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

MARCH 17, 2010

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THE FUTURE OF MANUFACTURING: WHAT IS THE ROLE OF THE FEDERAL GOVERNMENT IN SUPPORTING INNOVATION BY U.S. MANUFACTURERS?

WEDNESDAY, MARCH 17, 2010

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

The Committee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bart Gordon [Chairman of the Committee] presiding.

BART GORDON, TENNESSEE
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Hearing on

The Future of Manufacturing:
What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?

March 17, 2010
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witness List

Dr. Susan Smyth
Director of Manufacturing Systems Research, GM R&D
and Chief Scientist for Manufacturing
General Motors Company

Dr. Len Sauers
Vice President of Global Sustainability
Procter & Gamble

Mr. Debtosh Chakrabarti
President and Chief Operating Officer
PMC Group Inc.

Dr. Mark Tuominen
Director
National Nanomanufacturing Network

Mr. Wayne Crews
Vice President for Policy and Director of Technology Studies
Competitive Enterprise Institute

HEARING CHARTER

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY

The Future of Manufacturing: What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?

WEDNESDAY, MARCH 17, 2010
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Wednesday, March 17, 2010, the House Committee on Science and Technology will hold a hearing to receive testimony on the need for U.S. manufacturers to adopt innovative technologies and processes in order to remain globally competitive, and to determine the appropriate role for the Federal Government in supporting efforts by U.S. manufacturers to innovate.

2. Witnesses

- **Dr. Susan Smyth**, Director of Manufacturing, GM R&D, and Chief Scientist for Manufacturing, General Motors Company
- **Dr. Len Sauers**, Vice President, Global Sustainability, Procter & Gamble
- **Mr. Debtosh Chakrabarti**, President and Chief Operating Officer, PMC Group Inc.
- **Dr. Mark Tuominen**, Director, National Nanomanufacturing Network
- **Mr. Wayne Crews**, Vice President for Policy and Director of Technology Studies, Competitive Enterprise Institute

3. Background

The manufacturing sector plays a critical role in the U.S. economy. According to the Manufacturing Institute, in 2008, the manufacturing sector generated $1.64 trillion worth of goods and, if it were a country by itself, would have ranked as the eighth largest economy in the world.[1] The manufacturing sector accounted for nearly 57 percent of total U.S. exports in 2008, and employed nearly 12 million people last year.[2]

However, manufacturing is no longer as dominant a sector of the U.S. economy as it has been in the past. In 2008, manufacturing represented 12 percent of GDP, which is a significant decline from nearly 30 percent in the early 1950s.[3] In addition, between 2000 and 2007, the U.S. global market share of manufactured exports fell from 19 percent to 14 percent. During that same period, the Chinese share of global exports rose from seven percent to 17 percent.[4]

In recent years, several key reports have argued that innovation—both in terms of the processes being used and the products being produced—is one key to preserving, and perhaps even growing, the manufacturing sector in the U.S.

- In its recent annual report entitled *Innovation and Product Development in the 21st Century*, the Manufacturing Extension Partnership Advisory Committee included a recommendation to manufacturers to "innovate constantly to adapt to economic and technological changes." The Advisory Committee noted that leading manufacturing firms continue to innovate their way

[1] *The Facts About Modern Manufacturing, 8th Edition* (Manufacturing Institute, 2009)
[2] *The Facts About Modern Manufacturing, 8th Edition*
[3] *Innovation and Product Development in the 21st Century* (Hollings Manufacturing Extension Partnership Advisory Board, February 2010)
[4] *The Facts About Modern Manufacturing, 8th Edition*

through economic and technological shocks and disruptions, and even use them to their advantage.[5]

- The Interagency Working Group on Manufacturing R & D made the following observation in *Manufacturing the Future: Federal Priorities for Manufacturing R & D*: "There is strong consensus in industry, academia, and government that the future competitiveness of U.S. manufacturing—and all that it underpins—will be determined, in large part, by research, innovation, and how quickly firms and industries can apply and incorporate new technologies into high value-added products and high-efficiency processes."[6]
- In *The Innovation Imperative in Manufacturing. How the United States Can Restore Its Edge*, the Boston Consulting Group and the Manufacturing Institute at the National Association of Manufacturers concluded: "With high-quality inexpensive products flooding the market from every corner of the globe, competing on cost alone is a losing battle for most U.S.-based manufacturers . . . . To stay in the game, companies in the United States must differentiate themselves through innovation: new products and services, new ways of working, new ways of going to market."[7]

4. Overview

National Science Foundation

The National Science Foundation (NSF) supports fundamental manufacturing research. This work is done primarily through the Division of Civil, Mechanical, and Manufacturing Innovation (CMMI) in the Engineering Directorate. The budget request for CMMI for Fiscal Year 2011 is $206.5 million, an increase of 9.8 percent over the Fiscal Year 2010 enacted level.

The Division is divided into four program clusters, including an Advanced Manufacturing cluster. The cluster supports fundamental research leading to transformative advances in manufacturing technologies in the following areas:

- The *Manufacturing and Construction Machines and Equipment Program* supports fundamental research leading to improved machines and applications for manufacturing.
- The *Materials Processing and Manufacturing Program* supports fundamental research on the interrelationship of materials processing, structure, performance and process control. Analytical, experimental, and numerical studies are supported covering processing methods such as molding, forging, casting, welding, hydroforming, composite layup, and other materials processing approaches.
- The *Manufacturing Enterprise Systems Program* supports research on design, planning, and control of operations in manufacturing enterprises. Research is supported that impacts the analytical and computational techniques relevant to extended operations and that offer the prospect of implementable solutions.
- The *Nanomanufacturing Program* supports research and education on manufacturing at the nanoscale, and the transfer of research results in nanoscience and nanotechnology to industrial applications.

  NSF supports four Nano Science and Engineering Centers that focus on nanomanufacturing: the Center for Hierarchical Manufacturing at the University of Massachusetts, the Center for Scalable and Integrated Nanomanufacturing at the University of California at Berkeley, the Center for High-Rate Nanomanufacturing at Northeastern, and the Center for Nano-Chemical-Electrical-Mechanical Manufacturing Systems at the University of Illinois at Urbana-Champaign.

  NSF also supports the National Nanomanufacturing Network, which includes the four Nano Science and Engineering Centers and other academic, government, and industry partners. The Network is focused on facilitating and expediting the transition of nanotechnologies from core research and breakthroughs in the laboratory to production manufacturing.

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[5] *Innovation and Product Development in the 21st Century*

[6] *Manufacturing the Future: Federal Priorities for Manufacturing R & D* (Interagency Working Group on Manufacturing R & D, Committee on Technology, National Science and Technology Council, March 2008)

[7] *The Innovation Imperative in Manufacturing: How the United States Can Restore Its Edge* (The Boston Consulting Group & The Manufacturing Institute, March 2009)

Finally, NSF hosts and sponsors workshops on manufacturing. For example, in 2009, NSF hosted workshops on energy manufacturing, additive manufacturing, and nanomanufacturing.

National Institute of Standards and Technology

Manufacturing Engineering Laboratory

Through its Manufacturing Engineering Laboratory (MEL), the National Institute of Standards and Technology (NIST) promotes innovation and the competitiveness of U.S. manufacturing through measurement science, measurement services, and technical contributions to standards. MEL has a budget of approximately $43 million and a staff of 250 scientists and engineers, support personnel, craftsmen, technicians, and visiting scientists.

MEL is comprised of the following five divisions:

- The *Precision Engineering Division* conducts research in dimensional measurements, develops new measurement methods, provides measurement services, develops national and international artifact and documentary standards, and disseminates the resulting technology and length-based standards.
- The *Manufacturing Metrology Division* develops methods, models, sensors, and data to improve metrology, machines, and processes and provides services in mechanical metrology, machine metrology, process metrology, and sensor integration.
- The *Intelligent Systems Division* develops measurement and interoperability standards to enhance manufacturing robotics and automation equipment and the underlying industrial control systems.
- The *Manufacturing Systems Integration Division* develops and applies measurements and standards that advance information-based manufacturing technology.
- The *Fabrication Technology Division* provides instrument and specialized fabrication support for NIST researchers and serves as a testbed for many NIST/MEL programs.

MEL also hosts workshops on manufacturing. For example, last year, MEL hosted workshops entitled "National Workshop on Challenges to Innovation in Advanced Manufacturing: Industry Drivers and R & D Needs" and "Workshop on Sustainable Manufacturing: Metrics, Standards, and Infrastructure".

Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP) program at NIST is a network of 59 centers located in every State and Puerto Rico, providing a range of services to small and medium-sized manufacturers. The MEP centers advise businesses in a variety of areas, including lean manufacturing techniques. The Fiscal Year 2011 budget request for MEP includes a request for $4.64 million to expedite and facilitate adoption of technological innovations by smaller U.S. manufacturers, especially clean technologies and processes that improve manufacturers' competitive position.

Technology Innovation Program

The Technology Innovation Program (TIP) at NIST was created in 2007 through the *America COMPETES Act* (P.L. 110–69). Its purpose is to support, promote, and accelerate innovation in the United States by funding high-risk, high-reward research in areas of critical need. In Fiscal Year 2009, manufacturing was one of two areas of critical national need for which TIP proposals were solicited. The TIP manufacturing solicitation emphasized: (1) process scale-up, integration, and design for advanced materials; and (2) predictive modeling for advanced materials and materials processing. TIP announced more than $40 million in funding for manufacturing-related projects in Fiscal Year 2009.

Small Business Innovation Research and Small Business Technology Transfer

Executive Order 13329 ("Encouraging Innovation in Manufacturing ") was signed on February 24, 2004. It ordered the head of each executive branch department or agency with one or more Small Business Innovation Research (SBIR) programs or one or more Small Business Technology Transfer (STTR) programs to give high priority within such programs to manufacturing-related research and development to advance innovation in manufacturing.

In Fiscal Year 2009, about 100 of the 320 SBIR/STTR awards made at NSF had a major manufacturing innovation component. At the same time, in Fiscal Year

2009, more than 40% of SBIR/STTR awards at NIST had implications for manufacturing.

Sustainable Manufacturing

There are several Federal Government programs focused on sustainable manufacturing, also known as green manufacturing. The Department of Commerce defines sustainable manufacturing as "the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers." [8]

NIST's ***Manufacturing Engineering Lab*** conducts research in the area of green manufacturing. In fact, in its Fiscal Year 2011 budget request, NIST is requesting $10 million in additional funding (for a total of $16.4 million) for Green Manufacturing and Construction programs. According to the budget request, the funding will be used in part to develop an information infrastructure, based on open standards, to communicate critical sustainability information efficiently among suppliers, customers, and regulators and to identify and disseminate bestpractice methods, processes, and assessment tools for sustainable manufacturing in key industrial sectors.

At the Department of Energy, the Office of Energy Efficiency and Renewable Energy's ***Industrial Technologies Program*** partners with U.S. industry to carry out research, development, and demonstration of next-generation manufacturing technologies to reduce the use of energy by the U.S. industrial sector. The program supports research and development of new energy efficient technologies, supports commercialization of emerging technologies, and provides plants with access to proven technologies, energy assessments, software tools and other resources.

The budget request for Fiscal Year 2011 for the Industrial Technologies Program is $100 million, a $4 million increase over the Fiscal Year 2010 enacted level. The request includes $10 million in funding for a new Manufacturing Energy Systems program focused on enhancing the competitiveness of America's manufacturers through the rapid innovation of new products and processes that significantly reduce manufacturing energy intensity and carbon emissions. According to the budget request, the program will be anchored at two premier universities and will serve as knowledge development and dissemination centers organized around distinct manufacturing areas with critical technical needs.

There are also several multi-agency efforts focused on sustainable manufacturing. These include the ***Green Suppliers Network***, which is a collaborative venture among industry, the Environmental Protection Agency, and NIST's Manufacturing Extension Partnership. The program works with large manufacturers to engage their small- and medium-sized suppliers in low-cost technical reviews that focus on process improvement and waste minimization. The technical reviews, which are conducted by NIST, combine "lean and clean" manufacturing techniques to assist manufacturers in increasing energy efficiency, identifying cost-saving opportunities, and optimizing resources to eliminate waste within their manufacturing processes.

In addition, five Federal agencies—NIST (through the Manufacturing Extension Partnership), the Department of Energy (through the Industrial Technologies Program), the Environmental Protection Agency, the Department of Labor, and the Small Business Administration—participate in the ***E3: Economy, Energy and Environment*** program. Federal and local resources are combined to conduct assessments and gap analyses of company manufacturing processes, the results of which are used to develop comprehensive improvement plans on behalf of and in collaboration with the participating communities. The goals of the program, which operates under the umbrella of the Green Suppliers Network, include making manufacturing plants more energy efficient and cost effective; reducing the environmental impact of manufacturing plants through green manufacturing practices and improvements; improving regional economies by retaining jobs in more competitive companies and positioning them for growth and job creation in emerging green industries; and assisting manufacturers in growing and succeeding in a sustainable business environment.

Coordination of Federal Manufacturing R & D

In January of 2004, the Department of Commerce released a report entitled *Manufacturing in America: A Comprehensive Strategy to Address the Challenges to U.S. Manufacturers*. One of the report's recommendations was the establishment of an interagency working group within the National Science and Technology Council (NSTC) to serve as a forum for developing consensus and resolving issues associated

[8] *How Does Commerce define Sustainable Manufacturing?* (*http://www.ita.doc.gov/competitiveness/sustainablemanufacturing/how_doc_defines_SM.asp.*)

with manufacturing research and development policy, programs, and budget guidance and direction. Shortly thereafter, the Interagency Working Group (IWG) on Manufacturing Research and Development was established under the NSTC with the chartered goal of identifying and integrating requirements, conducting joint program planning, and developing joint strategies for the manufacturing research and development programs conducted by the Federal Government.

In March of 2008, the IWG produced a report entitled *Manufacturing the Future: Federal Priorities for Manufacturing R & D*, which identified three technology areas as areas of opportunity for Federal manufacturing research and development: manufacturing r & d for hydrogen technologies, nanomanufacturing, and intelligent and integrated manufacturing.

The charter for the IWG expired in March of 2009. Since the expiration of its charter, the IWG has not been active as a formal entity within the NSTC.

Administration's Framework for Revitalizing American Manufacturing

In December of 2009, the Executive Office of the President released *A Framework for Revitalizing American Manufacturing*. The Framework included seven areas of focus, with a commitment to take specific actions in each area. One of the framework's areas of focus is "invest[ment] in the creation of new technologies and business practices." Action items relating to this area of focus include:

- Doubling r & d budgets of key science agencies;
- Improving coordination of manufacturing-related r & d;
- Exploring new options to stimulate innovations and technological breakthroughs, such as prizes and reverse auctions;
- Making the research and experimentation tax credit permanent;
- Spurring innovation in manufacturing by increasing the Technology Innovation Program;
- Pursuing structural reforms that support innovation and production, such as public-private partnerships, providing anti-trust waivers for certain types of private cooperation, and using the Federal Government's coordinating abilities to overcome information problems and match innovators and markets;
- Protecting intellectual property rights;
- Doubling the Manufacturing Extension Partnership;
- Streamlining and enhancing delivery of government services to business; and
- Creating an Office of Innovation and Entrepreneurship and a National Advisory Council on Innovation in the Department of Commerce

Other areas of focus in the framework included: (1) providing workers with the opportunity to obtain the skills necessary to be highly productive; (2) developing stable and efficient capital markets for business investment; (3) helping communities and workers transition to a better future; (4) investing in an advanced transportation infrastructure; (5) ensuring market access and a level playing field; and (6) improving the business climate.

5. Overarching Questions

- Are the Federal Government's current manufacturing research and development programs sufficient?
- Are there areas of research and development related to manufacturing that are not being addressed by the Federal Government that should be addressed?
- What is the current role of the manufacturing industry in shaping the Federal manufacturing research and development agenda? Are Federal program focused on manufacturing research and development responsive to the needs of the manufacturing industry? If not, why not?
- Are the technologies and processes developed through federally-funded manufacturing research and development programs being utilized by manufacturers? If not, why not?
- Are Federal programs focused on manufacturing research and development duplicative? If so, is there a need for better coordination and prioritization of Federal manufacturing research and development?
- Broadly speaking, what obstacles currently exist to manufacturers adopting innovative technologies and processes? Is there anything more that the Fed-

eral Government should be doing, or could be doing, to help manufacturers adopt these technologies and processes?

Chairman GORDON. The Committee will come to order.

I want to thank everyone for being here today for this important hearing on innovation in manufacturing.

Let me also make a quick announcement, and that is that we are expecting to have votes at 11:00 today, which in the world around here means that we really don't have to leave until about 11:10 or so. So I would—for the convenience of the witnesses, we have your written statement. We are going to try to move things along. If there are Members that feel a need, then we will stay or come back, whatever might be. We just don't want to put you out. I should also tell all of you that there are several meetings, as you can imagine, going on at the same time, and so we will have some Members coming in and coming out but we have staff on both sides that are also here.

So there is a perception out there that the U.S. manufacturing sector is on its last legs. The truth is, however, that the manufacturing sector in the United States is alive and well, and continues to be an important part of our economy. Each year, the U.S. manufacturing sector generates more than $1.5 trillion worth of goods, accounts for more than half of the total U.S. exports, and employs millions of people.

Nevertheless, it is true that the manufacturing sector in the United States is not as strong and vibrant as it once was. There is a strong case to be made that, in order to avoid further decline, we need to take action now to preserve, and perhaps even grow, the U.S. manufacturing sector for the future.

A variety of factors have likely contributed to the decline in U.S. manufacturing, including global competition. Be that as it may, our manufacturers cannot and should not compete with other countries on labor costs alone. In order to stay competitive, the U.S. manufacturers will need to be leaner and more efficient, and make better products faster. To accomplish this, we will need to develop new manufacturing technologies and cutting-edge processes. We will also need to ensure that mechanisms are in place to take those technologies and processes from the lab to the manufacturing plant.

U.S. manufacturers should also be at the forefront when it comes to producing new and innovative, high-value-added products. If we want to position our manufacturers to make the next big things of the future, we need to make certain that they have the ability to do so quickly and efficiently.

At the same time, the ability of U.S. manufacturers to innovate and remain competitive is largely dependent on a flexible, skilled workforce. The manufacturing plant of today is not the manufacturing plant of the past. Today's manufacturing is a high-technology activity, requiring a workforce with scientific and technical skills. Unfortunately, despite this need, U.S. manufacturers are experiencing a lack of skilled workers at all levels. This Committee is committed to doing what it takes to ensure that businesses in the United States, including manufacturers, have access to workers they need to get the job done.

In today's hearing, we will focus on what more the Federal Government should do, if anything, to help U.S. manufacturers innovate. It is my expectation that what we learn today will help in-

form the reauthorization of the *America COMPETES Act*, which the Committee is currently working towards.

I am confident that our witnesses will be able to offer us unique perspectives on this issue, and I want to thank all of you for being here and look forward to your testimony.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Good morning. I want to thank everyone for being here today for this important hearing on innovation in manufacturing.

There is a perception out there that the U.S. manufacturing sector is on its last legs. The truth is, however, that the manufacturing sector in the U.S. is alive and well, and continues to be an important part of our economy. Each year, the U.S. manufacturing sector generates more than $1.5 trillion worth of goods, accounts for more than half of total U.S. exports, and employs millions of people.

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A variety of factors have likely contributed to the decline in U.S. manufacturing, including global competition. Be that as it may, our manufacturers cannot—and should not—compete with other countries on labor costs alone. In order to stay competitive, U.S. manufacturers will need to be leaner and more efficient, and make better products faster. To accomplish this, we will need to develop new manufacturing technologies and cutting-edge processes. We will also need to ensure that mechanisms are in place to take those technologies and processes from the lab to the manufacturing plant.

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In today's hearing, we will focus on what more the Federal Government should be doing, if anything, to help U.S. manufacturers innovate. It is my expectation that what we learn today will help inform the reauthorization of the *America COMPETES Act*, which the Committee is. currently working towards.

I am confident that our witnesses will be able to offer us unique perspectives on this issue. I want to thank all of you for being here. I look forward to your testimony.

Chairman GORDON. Now the Chair recognizes Mr. Hall for an opening statement.

Mr. HALL. Thank you, Mr. Chairman, and I am very interested to hear what our witnesses have to say, so I will try to be brief, as you have been.

This is another hearing geared toward the reauthorization of the *America COMPETES Act*, and let me reiterate that all of us recognize the magnitude and importance a robust Federal research and development enterprise has on our economy, our national security and our ability to be globally competitive. However, we also need to understand our current economic realities. Unfortunately, instead of being responsive to concerns and working to reduce regulatory burdens on manufacturing, we are heading in the wrong direction. Cap-and-trade is a prime example of this. It would add an unprecedented combination of energy taxes and regulatory require-

ments on the manufacturing sector that would obviously pressure businesses to shift capital and jobs away from important areas such as R&D, and it could be argued that some of our economic woes are a result of manufacturers not unlike the ones before us today being overregulated and forced to take their business outside of the United States, costing Americans their jobs. I am sure the same is true for U.S. manufacturing R&D efforts as well.

With specific regard to the R&D jurisdiction of this committee when it comes to manufacturing, I am particularly struck by a statement provided by the National Petroleum Refineries Association that states, "With increasing regulations, many companies have been forced to decrease their R&D budgets and shift their resources to regulatory compliance." Mr. Chairman, I ask unanimous consent that their written statement be made a part of the record.[1]

Chairman GORDON. Without objection.

Mr. HALL. And I yield back my time. Thank you, sir.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF REPRESENTATIVE RALPH M. HALL

Thank you Chairman Gordon for calling this hearing to examine whether there is an appropriate role for the Federal Government in supporting U.S. manufacturing innovation, and if so, what that role is.

I am very interested to hear what our witnesses have to say today, so I will be very brief. As this is another hearing geared towards the reauthorization of the *America COMPETES Act*, let me reiterate that all of us recognize the magnitude of importance that a robust Federal research and development enterprise has on our economy, our national security, and our ability to be globally competitive; however, we also need to understand our current economic reality.

It could be argued that some of our economic woes are a result of manufacturers, not unlike the ones before us today, being overregulated and forced to take their business outside of the United States, costing everyday Americans their jobs. I'm sure the same is true for U.S. manufacturing R&D efforts, as well. With specific regard to the R&D jurisdiction of this Committee when it comes to manufacturing, I am particularly struck by a statement provided by the National Petroleum Refiners Association that states, "With increasing regulations, many companies have been forced to decrease their R&D budgets and shift their resources to regulatory compliance." (Mr. Chairman, I ask unanimous consent that their written statement be made part of the record.)

In addition, I am also eager to hear how the billions of dollars the Federal Government has invested in GM is helping them spur innovation and technology in their manufacturing, but perhaps that's best left for questioning.

So, with that, I welcome our witnesses to the hearing, and I look forward to receiving your testimony.

Chairman GORDON. 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 Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good morning. Thank you, Mr. Chairman, for holding today's hearing on opportunities for innovation in the U.S. manufacturing industry and the role of the Federal Government in keeping manufacturers competitive in the future.

As a member of the Congressional Manufacturing Caucus, I have consistently supported our manufacturing industry, the backbone of the American economy. For centuries, the U.S. has been the world leader in manufacturing, and the American workforce has been the most competitive and innovative in the world. However, in recent years, we have seen this leadership position begin to slip as low-cost products manufactured overseas have flooded our markets. Constant innovation and rapid

[1] Written statement is located in Appendix 2.

application of new technologies and techniques are vital to maintain our competitiveness and ensure the future of American manufacturing.

We have seen first-hand the effectiveness of innovation in the manufacturing sector through programs like the Manufacturing Extension Partnerships (MEP) and the Technology Innovation Program (TIP). First, MEP provides technical assistance to help small and medium size manufacturers modernize and innovate. I have heard directly from my constituents about the positive impact MEPs have had on their businesses. I would like to hear from our witnesses how we can continue to improve the MEP. In particular, I am interested in how we can link these partnerships to community colleges.

Second, TIP supports and funds high-risk, high-reward research on critical issues for the manufacturing sector. While the results of this research will impact manufacturers of all sizes around the country, one challenge facing the manufacturing industry is attracting students and researchers to manufacturing sciences and careers in manufacturing. I am interested to hear from our witnesses what options they see for attracting more students to this important sector of our economy.

I welcome our witnesses, and I look forward to their testimony.

At this time I would like to introduce our witnesses. First, Dr. Susan Smyth is the Director of Manufacturing Systems Research and Chief Manufacturing Scientist for Manufacturing for General Motors Company. Dr. Len Sauers is the Vice President of Global Sustainability for Procter and Gamble. Dr. Debtosh Chakrabarti is the President and Chief Operating Officer for PMC Group Incorporated. Dr. Mark Tuominen is the Director of the National Nanomanufacturing Network, and Dr. Wayne Crews is the Vice President for Policy and Director of Technology Studies at the Competitiveness Enterprise Institute.

As our witnesses should know, we try to keep our testimony to around five minutes. Your written testimony will be included in the record for the hearing, and when all of you have completed your spoken testimony, we will begin questions. Each Member will then have five minutes to question the panel.

So Dr. Smyth, please begin your testimony.

STATEMENT OF SUSAN SMYTH, DIRECTOR OF MANUFACTURING SYSTEMS RESEARCH, GM R&D AND CHIEF SCIENTIST FOR MANUFACTURING, GENERAL MOTORS COMPANY

Dr. SMYTH. Mr. Chairman and Committee members, thank you for the opportunity to testify on behalf of General Motors. I am Susan Smyth, Director of General Motors' Manufacturing Systems Research Lab, and I lead worldwide research and development efforts in support of advanced manufacturing. I am pleased to be able to speak to you today about advanced manufacturing and the important role the National Institute of Standards and Technology, NIST, and other Federal agencies play in support of this vital area of national interest. I also look forward to discussing some of the challenges associated with advanced manufacturing and suggesting areas where we can strengthen collaboration.

Automotive manufacturing is one area where we have significant opportunity to expand U.S. competitiveness and stimulate economic development and grow jobs. Chrysler, Ford and General Motors together account for 110,000 U.S. manufacturing jobs and support three million additional jobs located in all 50 of the United States. Our three companies annually invest $10 billion in U.S. plants and equipment, and in 2008 we purchased $100 billion of U.S. auto

parts, materials and services. We also spent $12 billion on engineering and research and development.

The United States, along with the rest of the world, is working to reinvent manufacturing to ensure competitiveness, improve efficiency, and increase energy and environmental stewardship, and I would like to highlight a few projects that show the strength of these private-public manufacturing partnerships.

NIST/MEL: The Manufacturing Engineering Laboratory at NIST promotes competitiveness in key manufacturing-related areas such as robotics, virtual manufacturing, green manufacturing and nanotechnologies. In addition, the NIST lab derives standards that are key to the adoption of efficient, safe and repeatable processes. As just one example of the power of partnering, NIST worked with General Motors, Ford and Chrysler through the United States Council for Automotive Research, USCAR, to develop standards for certification of wireless technologies. These standards have increased OEM [Original Equipment Manufacturer] productivity and lowered our costs because now we can buy off-the-shelf certified products and know they will work for a specified function as opposed to testing them all ourselves. The NIST–USCAR collaboration resulted in the growth of new jobs in a network of small local companies which now certify all these network devices that they conform to industry standards.

Many national labs, including NIST, have an influence on manufacturing. However, MEL stands alone as an organization that has the core technical skills, profound knowledge of manufacturing processes and a passion for manufacturing. Although MEL is an effective organization focused on customer needs, the structure in which it resides is not optimal, and the percentage of resources that are dedicated to manufacturing are a very small part of the overall NIST budget.

We greatly appreciate working with NIST, but we believe the NIST charter should be revisited to allow a more equal footing between small and large business. The rationale for this request is that the challenges we are facing today are system-level challenges. Two examples are vehicle electrification, which is nothing less than the reinvention of the automobile, and the drive towards sustainable manufacturing. Technology solutions that will help us meet these challenges need to be driven by balanced effort of small and large companies, to better leverage the speed of the small and the system integration perspective of the large.

DOE: The Department of Energy has been supporting crucial research and helping build manufacturing capability on batteries, motors, and other electric vehicle technologies through FreedomCAR and the Fuel Partnerships. GM is grateful for the stimulus grants that we received to help us open our new battery manufacturing plant in Brownstown, Michigan, and our electric drive production center in White Marsh, Maryland. These two facilities will provide us with valuable learning and allow us to more rapidly move down the cost curve on these technologies, enabling us to get to higher production volumes.

NASA: NASA [National Aeronautics and Space Administration] has recently been an important partner on the manufacturing front for us. Together we were able to develop and build Robonaut2—or

R2 for short—a faster, more dexterous, more technologically advanced robot. This new generation of robot is able to use its hands to do work beyond the scope of any existing humanoid robot and can do it safely side by side with people, which is the key to our robotic strategy of humans working in harmony and enabled, not replaced, by robots.

As I have mentioned, other countries see the value of robotic technology and they have made it a national priority. We need to adopt similar industrial priorities in this and other important areas of manufacturing.

In conclusion, General Motors would ask the Committee to focus on the following: first, the creation of a cross-agency forum with a charter to align large-scale manufacturing, driving collaborative prioritization of key technologies by industry and government. Second, sufficient funding to allow the United States to compete with efforts in other countries. And third, reframing the goals and scope of advanced manufacturing in the national labs from the point where the technology metrics are met for the product, to the point where high-volume production is possible. General Motors welcomes initiatives like these, as well as government, public, private and cross-industry partnerships to accelerate those technology developments and early commercialization.

Thank you for the opportunity to testify today. I look forward to your questions.

[The prepared statement of Dr. Smyth follows:]

PREPARED STATEMENT OF SUSAN SMYTH

Mr. Chairman and Committee Members, thank you for the opportunity to testify on behalf of General Motors. I am Susan Smyth, Director of GM's Manufacturing Systems Research Laboratory. I lead GM's worldwide R&D efforts in support of advanced manufacturing processes and systems. While this past year has been one of unprecedented challenge and change at General Motors, in the wake of the bankruptcy, we are a smaller, leaner company that is even more focused on advanced technology.

I am pleased to be able to speak to you today about advanced manufacturing and the important role the National Institute of Standards and Technology (NIST) and other Federal agencies play in support of this vital area of national interest. I also look forward to discussing some of the challenges associated with advanced manufacturing and suggesting areas where we can strengthen collaboration, especially in manufacturing R&D.

This is an important time in the history of the automobile industry. As we have seen recently, the world in which we live and do business in is changing. Automotive technology is rapidly advancing, presenting challenges and opportunities with high levels of risk to both the industry and the manufacturing base of entire nations.

Automotive manufacturing is one arena where we have significant opportunity to expand U.S. competitiveness and stimulate economic development and jobs growth. Chrysler, Ford, and General Motors together account for 110,000 U.S. manufacturing jobs and support three million additional jobs located in all 50 states. Our three companies annually invest $10 billion in U.S. plants and equipment. We also spend $12 billion on engineering and R&D, which is helping to drive a resurgence in American manufacturing.

This starts with the supplier community, which we know you care greatly about. We are currently updating the figures for 2009, but for 2008 the three domestic manufacturers purchased over $100 billion in U.S. auto parts, materials, and services. Every dollar spent in the manufacturing sector generates an additional $1.36 in economic activity. This represents a greater return than in any other sector.

The U.S., along with the rest of the world, is working to reinvent manufacturing to ensure competitiveness, improve efficiency, and increase energy and environmental stewardship. I would like to highlight a few projects that show the strength of private/public manufacturing partnerships.

NIST/MEL

NIST's Manufacturing Engineering Laboratory (MEL) promotes competitiveness in key manufacturing-related areas such as robotics, virtual, green, and nano technologies. In addition, the NIST lab drives standards that are key to adoption of efficient, safe, and repeatable processes. As just one example of the power of partnering, NIST worked with GM, Ford, and Chrysler through the United States Council for Automotive Research (USCAR) to develop the standards for certification of wireless technologies such as the Ethernet, DeviceNet, and ControlNet.

These standards have increased OEM productivity and lowered cost because now we can buy off-the-shelf certified products and know they will work for the specified function. As companies strive to become leaner and compete in a global market, we cannot afford to waste our technical resources on non-core business. This NIST–USCAR collaboration has resulted in the growth of new jobs in a network of small local companies, which now certify that all these network devices conform to the new industry standards.

Many national labs, including NIST, have an influence on manufacturing technology. However, MEL stands alone as an organization having core technical skills, profound knowledge of the manufacturing domain, and a passion for manufacturing. Although MEL is a highly effective organization, well focused on customer needs, the structure in which it resides is not optimal. The percentage of resources dedicated to manufacturing remains a small part of the overall NIST budget.

We greatly appreciate working with NIST, but we believe the NIST charter should be revisited to allow a more equal footing between small and large business. The rationale for this request is that many of the challenges we are facing today are "systems-level" problems. Two examples are vehicle electrification—which is nothing less than the reinvention of the automobile—and the drive towards sustainable manufacturing. Technology solutions to enable us to meet these challenges need to be driven by a more nuanced mix of effort among small and large companies, to better leverage the speed of the small and the system-integration perspective of the large.

Another positive interaction between GM and MEL has been in the area of virtual manufacturing, which allows us to design and validate processes and tools in a computer prior to physically building a plant or product. In virtual manufacturing, we can mathematically model the form, fit, and function of manufacturing processes. It is a technology lever that we use to drive costs down and quality up, and we currently have active programs linking GM, USCAR, NIST, and several universities. One such research program, led by the University of Iowa, is linked with the Virtual Soldier, which will create a digital human to design safer and more ergonomically acceptable manufacturing processes.

DOE

The Department of Energy has been supporting crucial research and helping build manufacturing capability on batteries, motors, and other electric vehicle technologies through the FreedomCAR and Fuel Partnership. GM is grateful for the Stimulus grants we received to help us open our new battery manufacturing plant in Brownstown Township, Michigan and our electric drive production center in White Marsh, Maryland.

These two facilities are among the first advanced battery and electric motor manufacturing plants in the United States to be operated by a major auto company. They will provide us with valuable learnings and allow us to more rapidly move down the cost curve on these technologies—thus enabling us to get to higher production volumes, which is where these technologies start to have real-world impacts on petroleum consumption and greenhouse gas emissions.

Lightweight materials is another area where there has been great success with government-industry collaboration. Our collaboration with DOE through USCAR has led to introduction of more high-strength steels, aluminum and magnesium alloys, composites, and associated processes. These collaborative efforts have led to reduced material and energy requirements and lower material scrap rates in our plants.

To build on this progress, we support the creation of the Automotive Manufacturing Energy Reduction Partnership, which has been jointly mapped out by DOE and USCAR. Although yet to be funded, this partnership is intended to be a means to grow jobs by creating a more energy-efficient and, therefore, more competitive auto industry and supply base while simultaneously meeting the national objective of energy use reduction. We also feel that potential partnerships between the automotive and defense sectors in energy and materials research could produce synergistic results for both business sectors.

NASA

NASA has also been an important partner on manufacturing R&D. Recently, NASA and GM announced our advanced robotics partnership to accelerate development of the next generation of dexterous robots for use in both the automotive and aerospace industries.

Together, we were able to develop and build Robonaut2—or R2 for short—a faster, more dexterous, and more technologically advanced robot. This new generation is able to use its hands to do work beyond the scope of existing humanoid robots, and it can safely do it side-by-side with people, which is the key to our robotic strategy of humans working in harmony and enabled not replaced by robots.

This partnership should interest the Committee for two reasons. First, the GM NASA partnership was a new business model for conducting high-end research with embedded personnel beyond the traditional sabbatical model. It is critical for both NASA and GM, as the joint learnings from the program help move robotics to the next level. For GM, we see the collaboration leading to development of assembly processes that integrate robotic technology with people. This has the potential to improve manufacturing processes, increase flexibility, and enhance the safety of the production environment. GM is also actively looking for ways to apply the robotics, controls, sensor, and vision technologies developed as part of this collaboration to leading-edge advanced vehicle safety systems.

Second, robotics is a central element of competitiveness in advanced manufacturing. The creation of the "roadmap for U.S. Robotics" was stimulated by the bipartisan Congressional Caucus on Robotics. It states that "Led by Japan, Korea, and the European Union, the rest of the world has recognized the irrefutable need to advance robotics technology and have made research investment commitments totally over a billion dollars, while the U.S. investment in robotics technology (outside unmanned systems for defense) remains practically non-existing."

This new segment in robotics is estimated to double the current $25-billion U.S.-based robotics industry (direct revenue, plus auxiliary automation equipment, castings, etc.) with many applications in the assembly area of manufacturing processes over the next 5–10 years.

The opportunity to create manufacturing jobs with this new type of robot can be extrapolated from the success of the medical robot industry. Since the inception of this business at the beginning of the decade, the annual growth rate has exceeded 30 percent and is estimated to reach revenue levels of $2.8 billion by 2011.

As I have mentioned, other countries also see the value of robotics technology and have made it a national priority. What this means is that government and business are working together in a highly collaborative way to ensure that the technology moves from research to commercial implementation quickly. We are starting to see similar support in other areas of advanced manufacturing, such as radio frequency identification in Korea, lightweight materials and processes in China to name but two.

We need to adopt similar industrial priorities in other important areas of advanced manufacturing to ensure that the U.S. remains or becomes competitive and that jobs remain on shore. We can build on the successes that I have already outlined by:

- Providing more funding to the NIST Manufacturing Engineering Laboratory to grow its ability to manage important new projects and provide oversight for strengthened collaboration.
- Modifying the industrial technical program (ITP) charter of engagement with NIST to better engage large business on complex systems-level issues, and encourage technical transfer without significant royalty clauses, which impede commercialization and the creation of jobs in spinoff businesses.
- Creating a cross-agency forum to create and manage a national agenda for manufacturing technology. This forum could identify key technology goals and metrics and orchestrate collaboration to better leverage resources and eliminate redundant efforts.
- Nurturing the creation of product and manufacturing technologies related to the electrification of the vehicle. We need to develop a successful U.S. manufacturing base for this new breed of automobile. We also need to invent manufacturing systems capable of delivering automotive quality for new electric vehicle components at volume rates. As an example, we require technology for non-destructive evaluation during battery manufacturing processes and reversible joining processes that would enable remanufacturing, and repurposing of used automotive batteries for stationary power storage applications.

As we look to the future, we need to focus our collective attention on technologies that enhance our virtual and flexible manufacturing capabilities *at a project level*. Areas such as robotics, virtual manufacturing, and sustainability are key technology areas of focus for our business, and we would ask for additional development funding to:

- Develop the manufacturing aspects of batteries, fuel cells, electric motors, and power electronic components, including real-time quality processes.
- Support technology that creates flexible systems and facilities, which will enable more consumer custom-ordering using efficient manufacturing processes that can quickly respond to changing customer demand.
- Drive other cross-industry improvements such as those needed in the field of virtual manufacturing. Here, the development of standards would enable better communication between IT systems and help alleviate the unending challenge of system interoperability—expanding, for example, on some of the award-winning work in ISO STEP Standards for the exchange of product model data that was carried out by the NIST MEL lab.
- In the virtual arena, we also need to create linkages between different virtual tools. This would enable a more efficient use of the software products that we have today, e.g., such as the development of automatic meshing capabilities.
- Finally, continuous support for technology is required to enable energy-efficient and environmentally neutral manufacturing processes.

Rethinking the Goal Line

Beyond funding, we may need to revise how we think about the meaning of success in automotive technology R&D. In addition to technical success, we also need to address how we take innovation to commercial scale and high rates of adoption.

Just as with any other advanced technology, there are three phases involved in adoption of advanced manufacturing technologies. These include innovation, demonstration, and commercial implementation. Moving through the three phases required to commercialize new technologies is a particularly difficult challenge in the auto industry because of the long time horizons and high capital cost. This is a challenge that urgently needs to be addressed because of the magnitude and importance of the dual societal objectives of energy reduction and jobs creation.

Historically, the U.S. has emphasized R&D discovery, but in order for innovation to be implemented (and have a meaningful impact on challenges such as petroleum consumption and greenhouse gas emissions), funding and collaboration must continue on to the next level, which is scale production. Many new ideas can be managed on small production lines, but the challenge of scaling to large and fast output rates cannot be overlooked. In order to be relevant to these great societal challenges, we need to ensure that government R&D programs are focused on ways to provide high-quality assembly, non-destructive evaluation, and high rates of repeatability at large volumes. Currently, the U.S. focus is on the first phase of innovation, which is essential but not sufficient because we must also give priority to demonstration and technical inventions required to enable high-volume, high-speed production.

Some countries have a different approach and focus support on development of the linkage to business. Germany, for example, has invested in a technology transfer infrastructure, i.e., the Fraunhofer Institutes, and also mandates that engineering academics spend a significant time in industry. China has a government-directed agenda and a strong focus on advanced manufacturing. Japan has a culture of OEMs and suppliers collaborating through government-funded initiatives. All of these countries have advanced manufacturing strategies, collaboration models, and a funding charter that extends beyond technical innovation.

Conclusion

In summary, General Motors asks the committee to focus on the following:

- First, collaborative prioritization of key technologies by industry and government. These priorities should include robotics and other flexible manufacturing enablers, virtual manufacturing, and green manufacturing, and manufacturing of key electric drive components, including batteries, fuel cells, motors, and power electronics.
- Second: Increased funding for the NIST Manufacturing Engineering Laboratory (MEL) to support these priorities.
- Third: The creation of a cross-agency forum with a charter to align with large-scale manufacturing R&D and with sufficient funding to compete with efforts in other countries.

- Fourth: Congressional consideration of DOE funding for the proposed Automotive Manufacturing Energy Reduction Partnership, which will be focused on enhancing the competitiveness and energy-efficiency of the U.S. auto industry and supply base.
- Fifth: Reframing the goals and priorities for advanced technology vehicle manufacturing at DOE, NIST, etc., from the point where technology metrics are met to the point where high-volume production is possible.

General Motors welcomes initiatives like these as well as government, public/private, and cross-industry partnerships to accelerate both technology development and early commercialization.

Thank you for the opportunity to testify today. I look forward to your questions.

BIOGRAPHY FOR SUSAN SMYTH

Susan Smyth is the Chief Scientist for Global Manufacturing at General Motors and the Director of the GM R&D Manufacturing Systems Research Lab. In this capacity, she directs the creation of GM's global advanced manufacturing strategies and oversees innovation and implementation of GM's advanced manufacturing portfolio. Susan is recognized as one of GM's key strategic technology leaders inside and outside General Motors. She chairs the Technology Leadership Council for Manufacturing at USCAR, the preeminent technical organization for pre-competitive automotive technology. She is a member of Northwestern's Master of Manufacturing Management executive governance Council at the Kellogg School of Management. Furthermore, she is an executive advisor to the Tennenbaum Institute at Georgia Tech.

In her role as Chief Manufacturing Scientist, she has aggressively grown GM's global collaboration footprint in the US, Europe, Israel, Korea, and China. She is the co-Director of Collaborative Research Labs at University of Michigan, MIT, and Shanghai Jiao-Tong University. These collaborations have yielded internal and external recognitions. Susan's teams have garnered an unprecedented number of Boss Kettering Awards, GM's highest corporate innovation prize, numerous McCuen Innovation Awards, and the 2009 Korean Presidents Award for Technology.

Prior to this assignment, Smyth was Global Math Process Leader for Manufacturing Engineering, responsible for developing and implementing math-based strategies for GM Manufacturing, driving towards a completely virtually integrated manufacturing system design. This resulted in significant advances in quality, throughput, maintenance enabling world class product launches.

Susan began her career with General Motors as a Senior Project Engineer with the advanced engineering staff. Since then she has held a variety of leadership positions in strategic business planning, advanced engineering, manufacturing and quality. She holds a Bachelor of Science degree in Physics, Masters of Science in Optoelectronics and Information Technology, and a Ph.D. in Physics.

Chairman GORDON. And Dr. Sauers, you are recognized.

STATEMENT OF LEN SAUERS, VICE PRESIDENT OF GLOBAL SUSTAINABILITY, PROCTER AND GAMBLE

Dr. SAUERS. Chairman Gordon, Ranking Member Hall and distinguished Members of the Committee, thank you for inviting me to testify today. My name is Len Sauers. I am the Vice President for Global Sustainability at the Procter and Gamble Company. I lead P&G's overall program in this area.

P&G manufactures and markets a broad range of consumer products: beauty, health and wellness, and home care products in the United States and globally. We have operated in the United States for more than 170 years. As a major American manufacturer, we are fully committed to innovate and invest in the United States.

While our business is robust, much of our future growth is tied to serving the world's consumers, 95 percent of whom reside outside the United States. Emerging markets are an engine of growth for P&G and are also critical to P&G's employment in the United States. One of five P&G jobs in the United States supports our

global business, and our business has a multiplier effect, supporting 1.5 million jobs in our U.S. and global supply chain and another 100,000 jobs in our go-to-market distribution and merchandiser network.

P&G has historically viewed sustainability as largely a corporate responsibility. As a large multinational company, we believe being socially and environmentally responsible are simply the right things to do. However, more recently, there has been greater attention placed on sustainability by consumers, governments and NGOs. Due to this greater attention, we believe that sustainability can move beyond just being a responsibility to also being an opportunity to build our business.

To leverage this opportunity, we recently developed a renewed program in environmental sustainability with strategies and goals that are focused in two areas: improving the environmental profile of our products, and improving the environmental profile of our operations. Please let me make a few comments on both, starting first with our products.

In order to improve the environmental profile of their products, a consumer products company must clearly understand their consumer. Relative to sustainability, we find that only a small percentage of consumers are willing to accept tradeoffs such as increase in price or a decrease in performance in order to purchase a product that claims to be environmentally sustainable. We find that the vast majority of consumers, over 70 percent, will buy a sustainable product but only if all their other needs of cost and performance are met. The challenge for P&G is to develop products that enable consumers to be sustainable, but for which there are no tradeoffs, and this represents a huge challenge for our R&D community.

An example of one such product which I brought today that we recently developed and is on the market is Tide Cold Water, which is a laundry detergent specially designed to provide the same performance in cold water that consumers see in hot or cold. The environmental benefits of such a product are enormous. If every household in the United States that used hot water today switched to cold water for laundry, the energy savings would be 70 to 90 billion kilowatt-hours per year, which is three percent of the Nation's total household energy. It would reduce carbon dioxide emissions by 34 million metric tons, which is about seven percent of the U.S.'s Kyoto target. This is just one example of a sustainable product we have developed, and we have committed to develop and market at least $50 billion in sales of these products like this over the next several years.

Innovation is critical to accomplishing this and our other business goals. As such, we have invested over $2 billion in R&D annually. We have 24 innovation centers on four continents with over 9,000 people in our R&D facility. Over 1,000 Ph.D.s represent more than 120 scientific disciplines and hold over 35,000 patents globally. To meet the continued challenges we face in our product innovation and operational improvements, we have identified five areas of opportunity where the Federal Government can be helpful.

First, the government needs to drive research in the area of renewable energy, to develop more cost-effective alternatives and a grid that can deliver the renewable energy to manufacturers. Sec-

ond, the *America COMPETES Act* needs to be reauthorized, which will lead to the creation of new markets and technologies. I would like to thank you, Mr. Chairman, and Ranking Member Hall, for your prior support of this program. Third, there is a need to continue to focus on STEM [science, technology, engineering, and mathematics] education and training. The skills are needed so that we can attract and build the best and brightest U.S. workforce. There is a need to increase the collaborative government-industry innovation through the national labs. P&G has a successful partnership with Los Alamos National Lab where a comprehensive approach was developed to reduce the cost of our equipment failures in operations. And finally, the best way to preserve and create U.S. manufacturing jobs and promote innovation in the United States is through sound and predictable policies, legislation and regulation that foster a competitive manufacturing environment. Innovation cannot move forward without a science-based framework.

Thank you again for the opportunity to testify today and share with you the importance of sustainable innovation at Procter and Gamble.

[The prepared statement of Dr. Sauers follows:]

PREPARED STATEMENT OF LEN SAUERS

Introduction

Chairman Gordon, Ranking Member Hall and distinguish members of the Committee, thank you for inviting me to testify on "The Future of Manufacturing: What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?"

I am the Vice President, Global Sustainability at Procter & Gamble. I am responsible for the company's sustainability efforts. Four billion times a day, P&G brands touch the lives of people around the world. The company has one of the strongest portfolios of trusted, quality, leadership brands, including Pampers, Tide, Pantene, Duracell, Olay, Gillette, and Braun. The P&G community includes approximately 135,000 employees working in about 80 countries worldwide.

I want to thank you Mr. Chairman and Ranking Member Hall for champion roles in supporting the *America COMPETES Act*, authorizing Federal funding for basic R&D and science, technology, engineering, and mathematics (STEM) education which creates the opportunity for P&G to find future skills to effectively innovate. P&G is a member of the Task Force on American Innovation, whose mission it is to support basic research in the physical sciences and engineering.

Innovation is P&G's lifeblood. When we look at innovation we are faced with three critical questions:

- How can we put consumer-driven innovation at the center of everything we do?
- How can we use innovation as a competitive advantage?
- How can we manage the risks of innovation?

P&G invests over $2 billion in innovation annually. We have 24 innovation centers on 4 continents with over 9000 people in our R&D facilities. Over 1000 Ph.D.s represent more than 120 scientific disciplines and hold over 35,000 patents globally.

A few years ago, we set a goal for innovation, moving to an open innovation model. Our goal was that 50% of all initiatives needed to have at least one significant external partner. We wanted to "turbo-charge" our innovation capacity. We built the capability to reach nearly 2 million researchers, entrepreneurs and companies doing work in areas relevant to our businesses. Today, we've met and exceeded our 50% goal and we are now building the next generation of our "connect and develop" capability.

Another key component of our innovation model is to develop an understanding of the consumer. Since 2001, we have spent over $3 billion, more then double the industry average, to learn about the consumer. This leads us to breakthrough innovation, where we have delivered 110 new initiatives in the last 14 years that have made the Information Resources, Inc (IRI) Pacesetter's top 25 list. In 2008, P&G

had 5 of the top 10 product launches in the U.S. and 10 of the top 25. We are expecting similar results when IRI announces their 2009 Pacesetter list.

At P&G, we focus our sustainability efforts to innovate improvements that matter to the consumer, making the most meaningful impact possible. Our commitment begins with our Purpose, Values, and Principles, where sustainability is embedded, and manifests itself in a systemic and long term approach. We strive to make our actions matter. We pursue our sustainability goals with the aim of improving quality of life now and for generations to come. In 2007, we established five sustainability strategies and goals for 2012. In March, 2009 we increased our goals to reflect our progress and to demonstrate our ongoing commitment to sustainable, responsible growth. Our five sustainability strategies are:

- Products—delight the consumer with sustainable innovations that improve the environmental profile of our products.
- Operations—Improve the environmental profile of P&G's own operations.
- Social Responsibility—Improve children's lives through P&G's social responsibility programs.
- Employees—Engage and equip all P&Gers to build sustainability thinking and practices into their everyday work.
- Shape the future by working transparently with our stakeholders to enable continued freedom to innovate in a responsible way.

Sustainable Product Innovation

Our goal is to develop and market at least $50 billion in cumulative sales of "sustainable innovation products" which are products with a significantly reduced (> 10%) environmental footprint versus previous or alternative products. We combine two key strengths—consumer understanding and science to deliver sustainable innovations that do not require trade-offs in performance or value.

One example is helping consumers save energy and reduce their own Green House Gas emissions through the development of sustainable products. We developed Tide Coldwater, a new product technology which focused on cold water-washing, which delivers the same cleaning performance consumers expect from hot-water washing. If every household in the United States used cold water for laundry, the energy savings would be 70–90 billion kilowatt hours per year which is 3% of the total nation's household energy consumption while reducing CO_2 emissions by 34 million metric tons per year, which is about 7% of the US's Kyoto target.

In 2007, we began to convert our North American liquid laundry detergent portfolio to a 2X concentrated formulation. This innovation created the following benefits: less water (saving 500 million liters a year); reduced CO_2 emissions by more than 100,000 metric tons a year; reduced the amount of packaging materials by 15,000 metric tons per year; and reduced the number of truck loads by 40,000 per year.

And through our open innovation model, we partnered with one of our suppliers, which led to the development of a new polymer to be used in our powdered laundry detergent, which reduces surfactant levels while improving product performance.

Sustainable Operational Improvement

We continue to drive conservation efforts in manufacturing. Between raw materials and the creation of a product, we strive to reduce waste, water, energy and CO_2 through systematic conservation efforts. We apply smart eco-design through innovative construction process improvements. And we re-use where feasible giving new life to what was once waste. We have expanded our work from a focus on the core of our manufacturing operations to a holistic end to end view of opportunities.

Our goal is to deliver an additional 20% reduction (per unit of production) in CO_2 emissions, energy consumption, water consumption and disposed waste from P&G plants, leading to a total reduction over the decade of at least 50%.

We are proactively putting green technologies including solar, wind and geothermal in our plants where it makes good business sense. Examples of successful initiatives include the installation of a roof-mounted photovoltaic solar energy system at our Oxnard, CA facility which is projected to produce more than 1.9 million kilowatt hours during the first year of operation. Over 20 years, this system is estimated to product enough electricity to power over 3,200 homes for a year. Heat exchange units that capture heat for reuse at our paper plant in Mehoopany, PA reduces carbon emissions by 13,600 metric tons per year and the energy savings will be greater than the per-site energy consumption at 80% of our other facilities around the world. Finally we have designed eco efficiencies at our new paper plant facility being built in Box Elder County, Utah.

For decades, P&G has transported product in "multi-modal" fashion that is using multiple forms of transport. But today, we are shifting toward "intermodal" transportation, which uses shipping containers that transfer smoothly from one mode to another. An intermodal approach optimizes the transportation process. A transportation program in North America, P&G's first to incorporate an intermodal component has reduced transportation costs and improved sustainability, saving 11 million liters of diesel fuel annually.

Opportunities for the Federal Government to Enhance Manufacturing Innovation

We have identified five areas where the role of the U.S. Government is critical to innovation and manufacturing:

1. The government needs to drive research in the area of renewable energy to develop more alternatives and a grid that can deliver the renewable energy sources to manufacturers.
2. "The *America COMPETES Act*" needs to be reauthorized which will lead to the creation of new markets and technologies.
3. There is a need to continue to focus on STEM education and training. These skills are needed so that we can attract and build the best and brightest workforce. One of the top 3 skill sets that we seek for management positions are undergraduate engineers. For our plant technician roles we are looking for demonstrated technical and leadership skills, ideally through trade schools and two year colleges.
4. There is a need to increase the collaborative government/industry innovation through the National Labs. P&G has a successful partnership with Los Alamos National Lab (LANL) where a comprehensive approach was developed to reduce operating costs and minimizing capital expenditures by predicting, preventing, and reducing equipment failures in our manufacturing operations.
5. Finally, the best way to preserve and create U.S. manufacturing jobs and innovation in the U.S. is through sound and predictable policies, legislation and regulation that will foster a competitive manufacturing environment. Innovation can not move forward without a science based regulatory framework in place. If not handled with care, the cumulative effect of new legislation and regulation will result in added cost, regulatory burden and less rather than more flexibility for business.

Conclusion

Chairman Gordon, Ranking Member Hall and other members of the Committee, thank you for the opportunity to testify today and share with you the importance sustainable innovation is to Procter & Gamble (*www.pginnovation.com*). There is definitely a role for the Federal Government to ensure that the necessary skills and technologies are being developed to help manufacturers like P&G. We are supportive of the efforts to sustain Federal R&D funding through the reauthorization of America's Compete for NSF, NIST, and DoE Office of Science and enhancing STEM education because the ability for us to continue to reduce our environmental footprint of our products and our operations depends on the skills of the future.

BIOGRAPHY FOR LEN SAUERS

Len Sauers

Vice President, Global Sustainability, P&G

Len is Vice President for Global Sustainability at P&G. Based in Cincinnati, Ohio, he leads the company's overall sustainability efforts. He works closely with P&G's executive leadership to develop and then ensure the company delivers its short and long-term sustainability goals.

Len is a 23-year veteran of P&G with broad-reaching experience in human safety, regulatory affairs, and environmental science.

Len is a 23-year veteran of P&G with broad-reaching experience in human safety, regulatory affairs, and environmental science. In addition to his Global Sustainability leadership role, Len also leads the Human and Environmental Safety, Regulatory Affairs, and Corporate Biotechnology organizations worldwide. These groups are responsible for conducting human and environmental risk assessments for new products and ingredients, ensuring regulatory compliance, and conducting upstream basic research.

With a doctorate in Toxicology, Len maintains ties with academia through teaching arrangements in Ohio and West Virginia. He is co-author of Toxicology of the Immune System – A Human Approach and has written numerous journal articles, textbook chapters, and scientific abstracts. He is a Diplomate, American Board of Toxicology, and holds degrees from University of Delaware, University of San Francisco, and West Virginia University.Prior to joining P&G, Len served in the US Army as part of the Medical Research and Development Command. He was stationed at the Letterman Army Institute of Research in San Francisco.

Len lives in Cincinnati with his wife and two children. He serves on the boards of the Cincinnati Zoo and Botanical Gardens and the regional blood bank.

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Chairman GORDON. Thank you, Dr. Sauers.
And now Mr. Chakrabarti.

STATEMENT OF DEBTOSH CHAKRABARTI, PRESIDENT AND CHIEF OPERATING OFFICER, PMC GROUP INC.

Mr. CHAKRABARTI. Mr. Chairman, Ranking Member Hall, Members of the Committee, on behalf of myself and PMC Group, I thank you for the opportunity to testify today on the important subject of the future of U.S. manufacturing.

PMC is a growth-oriented global chemicals company dedicated to innovative solutions to everyday needs. Our company was built on

a model of growth through innovation while promoting social good. We are dedicated to sustainability. Over half of our raw materials are derived from renewable sources.

In our Nation's history, Federal Government programs for scientific research and development have yielded the seeds of tremendous advances in the private sector. We must now refocus our research efforts to the most important and promising areas of growth, and invest in transitioning these technologies into private-sector manufacturing growth and competitiveness.

From PMC's genesis in 1994 to the present, as a rapidly growing manufacturer, we have experienced the challenges that come with growth and implemented workable solutions. This journey of ours gives us a fresh and real perspective on the issues facing U.S. manufacturers.

The chemical manufacturing industry is one of the most important sectors of the U.S. economy. The chemical industry employs in excess of 840,000 employees with hourly earnings 22 percent greater than the private-sector average. When you include indirect employment, the industry is responsible for more than 5.4 million jobs.

Despite its importance to the economy, the chemical industry continues to face challenges. Efficiency and improving manufacturing technologies are spreading across the globe, rapidly reducing the productivity advantage that once compensated for higher costs in the United States. Lower barriers to the flow of investment capital have led to newer, more efficient manufacturing plant investments to be installed elsewhere in the world. The gaps to our leadership are shrinking. Innovation must lead the pathway to the future if we are to maintain our leadership position.

The U.S. chemical industry is in need of growth revival. We believe that two of the most important challenges facing our Nation today are how to increase the number of good, high-paying jobs, and how to reduce the dependence of our Nation on foreign oil. We believe that increased development and production of chemicals based on renewable sources is a viable and sustainable pathway to further both of these objectives, while at the same time reducing our Nation's carbon footprint.

Replacement of crude oil by renewable feedstocks through the chemical supply chain is a "real and now" possibility. By virtue of their higher value, downstream chemicals from renewable sources can rapidly lead to the reduction of imported crude oil and increased job creation. However, the renewable chemicals industry faces challenges to get off the ground, and these challenges lie primarily in the development and commercialization phase.

We believe that there should be three critical pillars to the development of a sustainable, renewable chemicals industry. First, we must promote the development of new chemical products based on renewable sources. Sustainable efforts by private industry in this type of research should be supported by the government through funding research programs for renewable chemicals specifically, introducing jump-starting legislation that calls for replacing petroleum-based chemicals in certain end uses and funding the development of pragmatic standard methodologies to support the growth of these products.

Second, we must promote investment in transforming existing facilities to produce renewable chemicals. The access to commercialization-phase investment capital, especially for small- and medium-sized enterprises, is a significant challenge to the early stages of transformation. We can promote this transformation through grants for transformation of existing facilities for manufacture of renewable chemicals, incentives for private investment in the production of renewable chemicals, supporting small- and medium-sized enterprises through capital access programs, and through the development of a one-stop-shopping approach to government support programs, and elevating renewable chemicals to an important position in the Nation's agenda, similar to biofuels.

Finally, we must maintain and extend our productivity leadership through retrofitting existing facilities with productivity improvement control and measurement systems, and improving the access to best practices in manufacturing for small and medium enterprises. The government can support these efforts through the National Institute of Standards and Technology by way of funding programs for manufacturers to upgrade productivity-improving technologies, funding research in new productivity improvement systems, and leveraging the existing efforts of the Manufacturing Extension Partnership to assist small- and medium-sized manufacturers in implementing best practices and productivity.

At PMC, renewable chemicals are a substantial part of our growth strategy. We have committed to this strategy because we believe that it is a sustainable pathway for manufacturing growth. The challenge that we face, along with other U.S. manufacturers, is in accelerating the commercialization of these technologies. In an uncertain economic environment, companies normally take a conservative approach to investment. Prudent government policies and standards are required to change this mindset. Efficient government programs supporting the renewable-chemicals industry would accelerate the transformation of ideas into increased employment and decreased reliance on foreign oil.

Mr. Chairman, Ranking Member Hall, Members of the Committee, thank you for this opportunity to share our views today. I look forward to your questions.

[The prepared statement of Mr. Chakrabarti follows:]

PREPARED STATEMENT OF DEBTOSH CHAKRABARTI

I.	**U.S. Manufacturing and Chemical Manufacturing must revive its growth trajectory.**	
II.	**Renewable Chemicals, defined as chemicals that are derived from renewable sources, should be an area of focus,** to:	
	(i)	Increase manufacturing activity and promote growth of high-paying chemical jobs.
	(ii)	Reduce our dependence on imported petroleum based feedstocks, i.e. foreign oil.
	(iii)	Establish the United States as a leader in "petroleum-to-renewable feedstock" transition technologies.
	(iv)	Promote the United States as a leader in a viable and sustainable manufacturing sector.
III.	**The Federal Government should focus its efforts in supporting small and medium-sized enterprises as well as large enterprises in their efforts to develop and commercialize viable technologies to manufacture renewable chemicals through:**	
	(i)	Funding programs for the development of chemicals from renewable sources.
	(ii)	Funding the development of pragmatic standards for the renewable chemicals industry.
	(iii)	Coordinating the efforts of the various government entities to provide financial support to small and medium enterprises in their research and commercialization efforts.
	(iv)	Providing financial support and incentives for investment in the production of renewable chemicals.

Mr. Chairman and Members of the Committee, on behalf of myself and PMC Group, I thank you for the opportunity to testify today on the important subject of the Federal Government's role in supporting innovation by U.S. manufacturers. My name is Debtosh Chakrabarti and I am President of PMC Group.

PMC Group ("PMC") is a growth oriented, diversified, global chemicals and plastics company dedicated to innovative solutions to everyday needs in a broad range of end markets including plastics, consumer products, electronics, paints, packaging, personal care, food, automotive and pharmaceuticals. Our company was built on a sustainable model of growth through innovation while promoting social good. We are dedicated to sustainability; over half of our raw materials are derived from renewable sources.

In our nation's history, Federal Government programs for scientific research and development have yielded the seeds of tremendous advances in the private sector. We must now refocus our efforts in our federally funded research to the most important and promising areas of growth, align them through central focal points that coordinate these programs and invest in the transitioning of these technologies to the private sector, especially to small and medium-sized enterprises.

PMC is a rapidly growing manufacturing enterprise. From our genesis in 1994 to today, we have experienced the challenges that come with growth and implemented workable solutions. This journey of ours gives us a fresh and real perspective on the issues facing U.S. manufacturers, especially in the chemical industry.

We are a U.S. based multinational innovator, developer and manufacturer of chemicals and have a significant interest in the growth and sustainability of the manufacturing industry in the United States. Accordingly, we appreciate the opportunity to share our views on the future of U.S. manufacturing and the role that the Federal Government can play in supporting the cornerstone of our sustainability—the continuation of our country's leadership in innovation and manufacturing.

The chemical manufacturing industry is one of the most important sectors of the U.S. economy. The chemical industry employs in excess of 840,000 employees with average hourly earnings 22% greater than the private sector average. Considering the indirect employment associated with supplier jobs and expenditure-induced jobs, the chemical industry is responsible for greater than 5.4 million jobs [1]. The products of chemical manufacturing are an integral part of our everyday lives and the industry provides high-paying jobs that utilize our country's skilled and productive workforce.

Despite its importance to the economy, the U.S. chemical industry has faced and continues to face challenges. The global spread of existing efficient manufacturing technologies, lower costs of operations and compliance elsewhere in the world, combined with freer global flow of investment capital has intensified the competitive landscape. Efficiency-improving manufacturing technologies are spreading faster than ever across the globe, rapidly reducing the productivity advantage that once compensated for higher costs of operations in the U.S. Lower barriers to the flow of investment capital has led to newer more efficient manufacturing plant investments to be installed elsewhere in the world. These challenges apply to the entire manufacturing industry. The gaps to our leadership are shrinking. Innovation must lead the pathway to the future if we are to maintain our leadership position.

The U.S. chemical industry is in need of growth revival. We believe that two of the most important challenges facing our nation today are (i) how to increase the number of good, high paying jobs and (ii) how to reduce the dependence of our nation on foreign oil. We believe that increased development and production of chemicals based on renewable sources is a viable, sustainable pathway to further both of these objectives, while at the same time reducing our nation's carbon footprint.

Replacement of crude oil by renewable feedstocks through the chemical supply chain is a "real and now" possibility. By the virtue of their higher value based on more diverse applications, downstream chemicals from renewable sources can rapidly lead to reduction of imported crude oil and increased job creation. Those of us that are involved in renewable chemicals manufacture know that this is a near-term and realistic opportunity. Government programs to support small and medium-sized enterprises as well as larger enterprises in this effort have the ability to have a sustainable and catalytic impact. The foundation of this strategy should be our strengths, namely our large, existing chemical manufacturing and related infrastructure, and our deep base of skilled workers. However, the renewable chemicals industry faces challenges to get off the ground, these challenges lie primarily in the development and commercialization phase.

We believe that there should be three critical pillars to the successful development of a sustainable renewable chemicals industry:

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[1] Source: Bureau of Labor Statistics, Bureau of the Census, PMC Analysis

1. **The development of new chemical products based upon renewable resources** to (i) reduce our dependence on petroleum, (ii) promote America as a leader in a growing manufacturing sector; and (iii) support the creation of high paying chemical manufacturing jobs. The petroleum based chemical industry has attracted decades of investment to adapt chemical technologies to produce products that touch almost every minute of our daily lives. Research and innovation in renewable chemicals should, in the near term, be focused on the adaptation and application of existing chemical processes on renewable feedstocks and, in the mid-term, be focused on the creation of new techniques to convert renewable feedstocks into valuable products. Sustainable efforts by private industry in this type of research should be supported by the Government through:
    a. Funding programs to support private and public research activities in the application of existing chemical know-how to produce chemicals from renewable feedstocks.
    b. Funding programs to support private and public research activities for developing new and novel chemical processes for converting renewable feedstocks.
    c. Creating a stable policy environment and incentives for manufacture of renewable chemicals.
    d. Introducing "jump-starting" legislature that calls for replacing petroleum-based chemicals in certain end-uses.
    e. Funding the development of pragmatic standard methodologies for identifying renewable chemical content, carbon footprint, and petroleum replacement content.
2. **Invest in retooling existing facilities to commercialize renewable chemicals**. Reconfiguring existing facilities to support the manufacture of new chemical products will require investment. Our infrastructure, skill base and manufacturing knowledge are our strengths. The access to commercialization phase investment capital, especially for small and medium sized enterprises, is a significant challenge to the early stages of transformation. The transformation of existing manufacturing infrastructure to support the growth of the renewable chemicals industry should be supported by our Government through:
    a. Funding programs to leverage private capital in the commercialization phases of transformed facilities.
    b. Implementing incentives for private investment in the production of renewable chemicals.
    c. Supporting small and medium-sized enterprises through capital access programs and through the development of a one-stop shopping approach to Government support programs.
    d. Elevating renewable chemicals to an important position in the nation's agenda, similar to biofuels.
3. **Maintain and extend our productivity leadership** through (i) retrofitting existing facilities with world-class measurement systems and process control to support productivity improvement to compete with newer facilities in other countries; and (ii) improving the access to best practices in manufacturing for small and medium enterprises. The use of existing manufacturing infrastructure must be accompanied by investment in process control and measurement systems for productivity improvement. New manufacturing facilities in other countries are being built with state-of-the-art process control and productivity improvement systems. (*Recall what happened to our steel industry.*) The competitiveness of American manufacturing must be supported by retrofitting our facilities with state-of-the-art technology for manufacturing productivity. The development of these systems will benefit the entire manufacturing sector. The government can support these efforts through the National Institute of Standards and Technology by way of:
    a. Funding programs for renewable chemicals manufacturers to upgrade the competitiveness of their measurement systems and process control technologies.
    b. Funding public and private research in new productivity improvement and process measurement systems.

c. Leveraging the existing efforts of the Manufacturing Extension Partnership to assist small and medium-sized manufacturers in implementing best practices focused on cost efficiency and productivity.

Finally, we appreciate the opportunity to share our views. Our Government should continue and expand its roundtable programs to create a dynamic process for feedback from small and medium-sized enterprises to ensure that the most effective programs and policies are advanced.

At PMC, renewable chemicals are a substantial part of our growth strategy. We have committed to this strategy because we believe that it is a sustainable pathway for manufacturing growth. The challenge that we face along with other U.S. manufacturers is in accelerating the commercialization of these technologies. In an uncertain economic environment, companies normally take a conservative approach to investment. Prudent Government policies and standards are required to change this mindset. Efficient and pragmatic government programs supporting the renewable chemicals industry would accelerate the transformation of ideas into increased employment and decreased reliance on foreign oil.

PMC Group Vision and Commitment

Vision

The vision of PMC Group is to create a new kind of global corporation – a corporation with a soul and one that acts as an engine for regional economic growth and exists primarily to promote common good by creating social values. This engine is fueled by its profit but it derives its power from its ability to innovate and from the quality of service it provides to its customers.

Commitment

PMC Group is committed to providing the very best of products and services to its customers. In doing business with PMC Group you will be helping to build a new model for a global corporation that can grow rapidly, create jobs, promote social responsibilities, and generate the profits necessary to do these functions well. We appreciate your patronage in this journey of ours.

PMC Group Key Values

Commitments: Innovation, Quality and Service

Focus of Commitments: Customer

Citizenship: Global

Loyalty: To Society, Employees and Shareholders

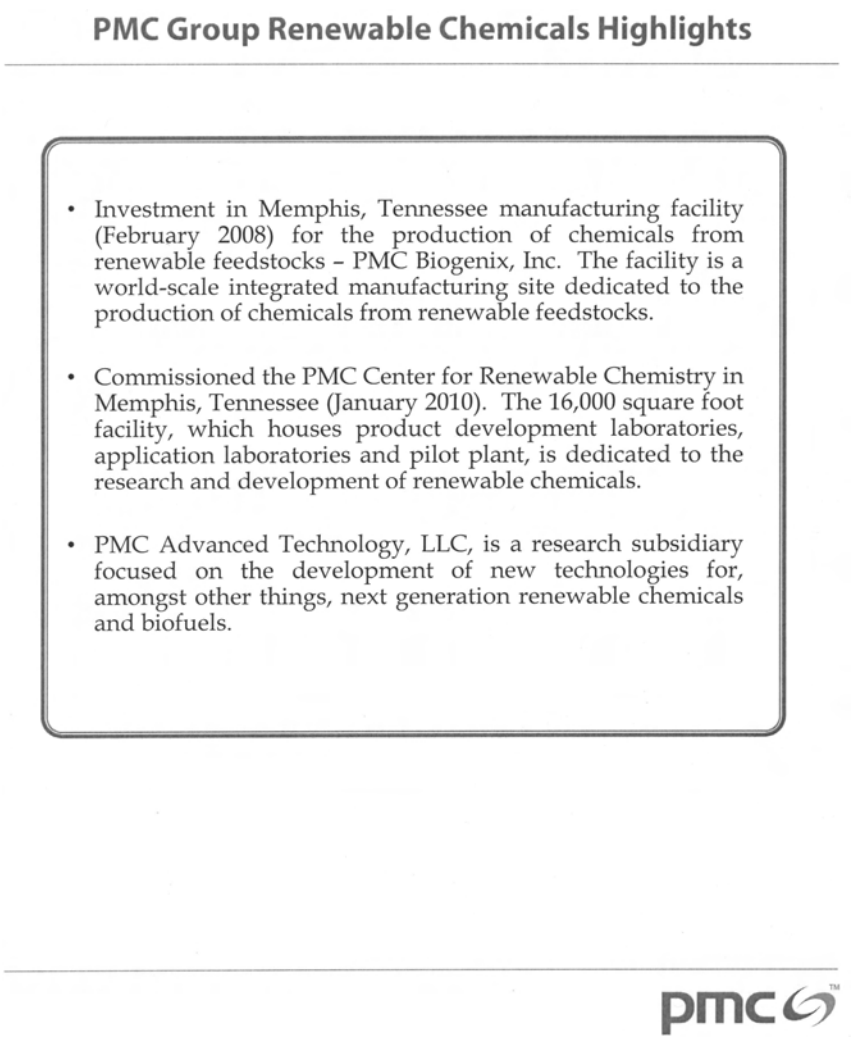
Unassailable Factors: Health and Safety of our People

Prized Assets: Integrity and People Working as Teams

Style: Swift and Prudently Aggressive

Profile: Lean and Agile

Treasured Philanthropy: In Promotion of Education



BIOGRAPHY FOR DEBTOSH CHAKRABARTI

Debtosh Chakrabarti is the President of PMC Group. In this capacity, he is responsible for the North American based operations and businesses of PMC Group. In addition, he serves on PMC's corporate committee responsible for overall corporate management of the global group. PMC Group is a growth oriented, diversified, global chemicals and plastics company dedicated to innovative solutions to everyday needs in a broad range of end markets including plastics, consumer products, electronics, paints, packaging, personal care, food, automotive and pharmaceuticals. The Company was built on a sustainable model of growth through innovation while promoting social good. Dedicated to sustainability, PMC derives over half of its raw materials from renewable sources and operates from a global manufacturing, innovation and marketing platform with facilities in the Americas, Europe and Asia. Mr. Chakrabarti has been instrumental in the growth of PMC from a single site manufacturing operation to a global chemical company. Born on June 11, 1973 in Wayne, New Jersey, he attended primary and secondary schools in New Jersey and Pennsylvania. He received his Bachelor of Science in Chemical Engineering from Massachu-

setts Institute of Technology and is a graduate of the Advanced Management Program at Harvard Business School. He currently resides in Moorestown, New Jersey with his wife, Juliana, son, Deven and daughter, Asha.

Chairman GORDON. And now we will hear from Dr. Mark Tuominen.

STATEMENT OF MARK TUOMINEN, DIRECTOR, NATIONAL NANOMANUFACTURING NETWORK

Dr. TUOMINEN. Good morning. First I want to thank the Committee for the opportunity to discuss this critically important subject on behalf of the National Nanomanufacturing Network. I am going to get directly to the heart of the matter.

Innovation is the raw fuel of the American economy. Manufacturing is the engine. Now, although the discussion today is on manufacturing innovation broadly, I am going to use the key example of nanomanufacturing to emphasize my points.

Research and development in nanomanufacturing exemplifies what we must pursue in 21st century manufacturing innovation. It is the highest of high tech. Our Nation needs to embrace a long-term strategy of manufacturing innovation and excellence. Nanomanufacturing is the use of new techniques and tools that generate and manipulate nanomaterials for reproducible commercial-scale manufacturing. Nanomanufacturing is emerging today because of the investment the Federal Government made in the National Nanotechnology Initiative [NNI]. We must be strategic now to reap the return on this investment.

The NNI, with its focus on fundamental research and research infrastructure, has been a huge success with many exciting nanotechnology demonstrations. Some are already in products. However, making the transition from proof-of-concept demonstration to full-scale manufacturing is not trivial. Manufacturing brings up issues such as process development and modeling, scale-up, metrology, process control, tooling, workforce, safety and supply chain.

There have been huge strides in nanomanufacturing research and development over the last few years, including a few examples I will name now: processes to make transparent conducting electrodes using carbon nanotubes: this replaces indium tin oxide for displays and solar cells during a time when the world supply of indium is becoming dramatically scarce; the use of diblock copolymers for nanoscale patterning: utilization of molecular self-assembly for magnetic data storage, electronics, energy conversion and energy storage applications; synthetic processes for making monodisperse nanoparticles with designer surfaces, impacting many applications from efficient lighting to solar cells to disease diagnostics and therapy, and there are many others.

The companies and nations that figure out how to manufacture products from these recent nanomanufacturing innovations will reap the greatest benefits: jobs, economic security, intellectual progress and sustainability.

I would like to address the specific questions posed by the Committee. The first is on the NSF [National Science Foundation] support of nanomanufacturing. The following NSF activities are relevant. There are four complementary nanomanufacturing research and development centers. There is a National Nanomanufacturing

Network, which is represented here today, which networks these centers together and supports the broader nanomanufacturing community through collaborative activities and information sharing and through its Web resource, InterNano. And there is also at the NSF a nanomanufacturing program, which administers mainly individual-investigator and small-team grants. There are other programs at the NSF, including SBIR/STTR [Small Business Innovation Research/Small Business Technology Transfer] and the Nanoelectronics Research Initiative, that also support nanomanufacturing research, but as a subcomponent only. The NSF nanomanufacturing programs are currently funded at a level of $22 million from the NNI. This low level severely limits the impact and the speed that such activities could have on the Nation's competitiveness and economy.

What else should be done? Strengthening the activities to build a robust manufacturing workforce. This is at all levels, but especially at the technical community college level. Another is to strengthen nanomanufacturing research development and education by adding the support for university-industry manufacturing test beds and pilot projects. The close involvement of industry in identifying fundamental research targets is critical. We also need more activities based on 21st century manufacturing research in general, and we also need to strengthen the activities of the National Nanomanufacturing Network through facilities, staff and scope.

In terms of the Federal Government, there is not currently enough U.S. activity in process development combined with tool and instrumentation development. Designing and building future generations of scalable manufacturing tools enable us to get our return on investment. Roll-to-roll manufacturing, TIP-based [Technology Innovation Program, NIST] nanomanufacturing and others are low-hanging fruit. There is not enough support for nanoinformatics. There should be a stronger emphasis on standards development. And in terms of the industry's role, I would have to say that in the NNI, the industry has played an important role. The semiconductor industry, the chemical industry, the forest and paper industry have all provided valuable input. Now the Industrial Research Institute and its member companies are working to try to develop a program with the NSF for industry-inspired fundamental research.

In terms of the nanotechnology's transition effectively to manufacturers, this has occurred in some but not in all cases. One barrier to successful technology transition is the cultural mismatch between the priorities between fundamental researchers and manufacturing experts.

Lastly, in terms of coordination and prioritization, supporting manufacturing innovation overall should be a priority for the Federal Government.

In conclusion, to leverage resources effectively, the Federal Government should consider the creation of a serious interagency initiative focused on manufacturing innovation. As I have already emphasized several times, a vibrant national manufacturing enterprise system rich in innovation requires a culture in which industry, academia and government work closely together. Thank you.

[The prepared statement of Dr. Tuominen follows:]

PREPARED STATEMENT OF MARK TUOMINEN

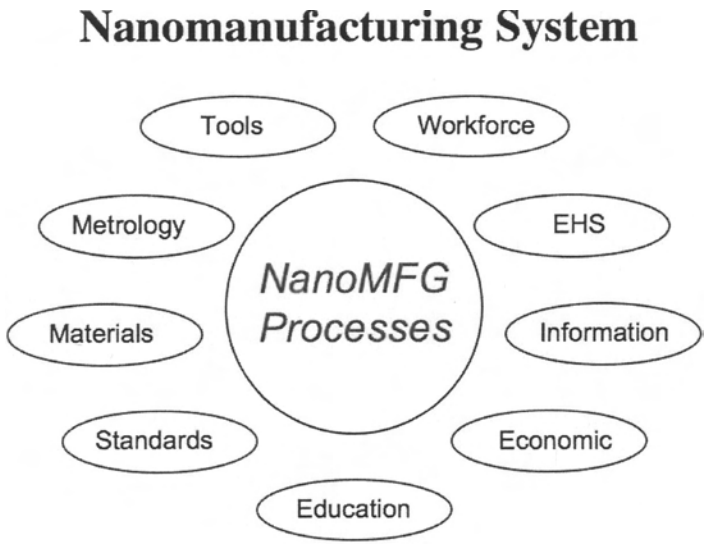
I thank the committee for the opportunity to discuss innovation and manufacturing. It is an honor to be here and speak directly and plainly about this vitally important topic.

Innovation is the raw fuel of the American economy. Manufacturing is the engine.

I speak to you today on behalf of the National Nanomanufacturing Network. Nanomanufacturing is the use of new techniques and tools that generate and manipulate nanomaterials for reproducible commercial-scale manufacturing. As I will discuss today, research and development (R&D) in nanomanufacturing exemplifies what we must pursue in 21st century manufacturing innovation. The National Nanomanufacturing Network (NNN), funded by the National Science Foundation (NSF), operates as an open-access network of centers, leaders, experts, and stakeholders from the nanomanufacturing research, development and education community. The network's mission is to serve as a catalyst to advance nanomanufacturing in the U.S. by facilitating collaboration, roadmapping, and prioritization activities on critical enabling areas of nanomanufacturing, and by information sharing through its nanomanufacturing database and information resource, InterNano. The NNN includes a core of four contributing NSF Nanoscale Science and Engineering Centers focused specifically on nanomanufacturing, as well as nanomanufacturing centers from the Department of Energy (DOE) and the National Institute for Standards and Technology (NIST), and many other contributors from academia, industry and government. More details about the ongoing activities of the NNN are described below. My comments today are the distillation of ideas from many experts who contribute to NNN activities.

Nanotechnology Research and Nanomanufacturing

The U.S. investment in nanotechnology through the National Nanotechnology Initiative has resulted in enormous advancements in our ability to make, control and utilize nanomaterials whose characteristic features are 1–100 nanometers. The last ten years in nanotechnology has been a period of dramatic discovery and exploration. Brilliant scientists and engineers from interdisciplinary teams have created proof-of-concept demonstrations with high performance nanoscale materials and devices. These results are now beginning to impact just about every commercial product sector, including, at the very least, electronics, materials, health, transportation, consumer care products and, especially, energy. However, making transition from proof-of-concept demonstration, to prototype, to manufacturing pilot, to full-scale manufacturing is not trivial. This is especially true in the case of an emergent field like nanotechnology, where, in most cases, we cannot simply adapt old designs of production tools for these new methods. Manufacturing brings to bear a new range of issues: process development and modeling, scale-up, metrology, process control, tooling, workforce, safety, and supply chain. Ultimately, these issues have to be addressed because, without manufacturing, there are no products. Perhaps more than any other previous activity, *nanomanufacturing* requires close cooperative efforts between industry, academia and government. Since a considerable amount of the Federal funding in nanotechnology has supported research at universities and government labs, many of the new fundamental discoveries have occurred at those places. Yet product development and manufacturing traditionally occur in industry. For the U.S. to take full economic and societal advantage of the many nanotechnology breakthoughs it has fostered, the Federal Government needs to help build and support a culture that strives to develop leading-edge manufacturing capabilities through *close collaboration* of industry, academia and government. Creating a culture that thrives on manufacturing excellence is a challenge, but at the same time, an enormous opportunity.



Strides in Nanomanufacturing R&D

Nanomanufacturing R&D is focused on the creation of new processes and tools to produce and utilize nanomaterials at a commercially-relevant scale. Nanoscience research has resulted in the discovery and development of new techniques to make and manipulate nanomaterials that are so out-of-the box and revolutionary that it is difficult for the manufacturing community to quickly reposition and take advantage. A few recent examples include:

- The production of carbon-nanotube-based transparent conducting electrodes—replaces indium tin oxide for displays and solar cells, during a time when the worldwide indium resources are becoming increasingly scarce.
- The use of diblock copolymers for nanoscale patterning—utilization of molecular self-assembly for magnetic data storage, electronics, energy conversion and energy storage applications.
- Self-alignment processes—utilizing natural molecular interactions for device integration at the nanoscale and enabling low cost roll-to-roll manufacturing processes.
- Plasmonic lithography—producing nanostructures with smaller critical dimensions by using surface plasmons to circumvent the diffraction effects that limit conventional optical lithography.
- Scalable processes for the production of carbon nanotubes and graphene—impacting many applications from electronics to structural materials to thermal management materials.
- Synthetic processes producing monodisperse nanoparticles with designer surface ligands—impacting many applications from efficient lighting to solar cells to disease diagnosis and therapy.

More examples are discussed at the end of this written testimony. The key point here is that nanomanufacturing introduces many new disruptive, rather than evolutionary, process technologies. In most cases, these innovations were not on any industrial roadmap. As a consequence, there are gaps in the value chain—such as the lack of availability of suitable production scale tools, feedstock suppliers and trained workforce—that hinder commercial implementation. The companies, and nations, that figure out how to manufacture products from these recent innovations will reap the greatest benefits. It is both a challenge and an opportunity.

A Strategic Long View of Nanomanufacturing

The Nation needs to embrace a strategic long view to advance manufacturing science and engineering. The fast progress we observe in nanomanufacturing R&D serves as an important reminder. It is a reminder that we must continue to inno-

vate in manufacturing, that manufacturing holds many yet unsolved challenges, that manufacturing is an area that needs continual research, and that we must train and sustain a workforce driven to continue advancing our national capabilities in manufacturing. This can only be accomplished effectively with strong public-private partnerships with equally vested industry, academic and government stakeholders. To complement the recent strides in fundamental research, pre-competitive joint-development projects are needed to take promising nanomanufacturing processes to scalable manufacturing. If well managed and adequately supported, manufacturing prototype and pilot projects will create critical knowledge to help enable the considerably expensive jump to full-scale manufacturing. This includes process development and modeling, application prototyping, tool design and development, manufacturing informatics, sustainable manufacturing design and manufacturing-by-design method development. Doing so will translate into numerous societal benefits including jobs, economic security, intellectual progress and sustainability.

Nanomanufacturing Support by the National Nanotechnology Initiative

The Federal Government has steadily ramped up its support in nanomanufacturing R&D in the National Nanotechnology Initiative (NNI) funding[01]. In total, the NNI's actual nanomanufacturing funding level was $75.6M (4.4% of NNI total) in 2009, with an added $28.5M (5.5%) of 2009 ARRA funding. The estimated funding is $96.7M (5.4%) in 2010 and proposed funding is $101.4M (5.7%) in the 2011 budget request. Historically, the NSF, NIST and DOD were the early leaders in creating funding programs to address the distinct issues associated with nanomanufacturing. Now DOE, NIH and other agencies have joined suit, recognizing the essential role that nanomanufacturing plays in progress. Advancing manufacturing in the U.S. is a *mission* and should be increasingly supported, with long-term strategic management, by the mission-based agencies. NIOSH has made substantial efforts to provide guidance on controls for nanomanufacturing worker safety, and the EPA has a growing base of activities in nanoparticle environmental, health and safety. The topic of *Sustainable Nanomanufacturing* is one of three NNI Nanotechnology Signature Initiatives planned for the 2011 budget. This initiative, which involves contributing efforts by NIST, NSF, DOE, EPA and NIH, at a level of $23M, will focus on the long-term development of flexible "bottom up" nanomanufacturing methods that can be applied broadly to applications including, solar energy harvesting, communications and computation, waste heat management and recovery, and energy storage.

Now, after this rather long introduction, I will address the specific questions posed by the committee.

What is the National Science Foundation (NSF) doing to foster innovation in manufacturing through research and development in nanomanufacturing? In your opinion, are NSF's current research programs sufficient? If not, why not?

Ultimately, it is my opinion that the NSF has some well-designed programs supporting nanomanufacturing, it is primarily the low overall level of support which limits the impact and speed that such activities could have on the Nation's competitiveness and economy.

The NSF is placing a growing emphasis on nanomanufacturing R&D, with $22.4M (5.4% of NSF NNI share) estimated in 2010 from the National Nanotechnology Initiative budget and proposing $32.2 (8.0%) in 2011. Currently NSF supports nanomanufacturing R&D within the following listed programs or activities. The first three are specifically focused on nanomanufacturing, whereas the others contain only a subcomponent of activity on nanomanufacturing.

- Four Nanoscale Science and Engineering Centers (NSECs) specifically dedicated to nanomanufacturing:
  - Center for Hierarchical Manufacturing (CHM)—University of Massachusetts at Amherst and partner institutions; CHM is also the administrative hub of the National Nanomanufacturing Network
  - Center for High-Rate Nanomanufacturing (CHN)—Northeastern University and partner institutions

[1] "The National Nanotechnology Initiative: Research and Development Leading to a Revolution in Technology and Industry: Supplement to the President's FY 2011 Budget," Subcommittee of Nanoscale Science, Engineering, and Technology (NSET), Committee on Technology, National Science and Technology Council. Available from the National Nanotechnology Coordination Office (NNCO), *www.nano.gov*

- Center for Scalable and Integrated NanoManufacturing (SINAM)—University of California Berkeley and partner institutions
- Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS)—University of Illinois Urbana Champaign and partner institutions

- The National Nanomanufacturing Network—collaborative activities and information sharing among a network of U.S. centers, experts and stakeholders, including the four NSECs listed above;
- The Nanomanufacturing program within the NSF Engineering Directorate;
- SBIR/STTR program, for small companies, frequently working in collaboration with universities;
- The Nanoelectronics Research Initiative (NRI)—a program cooperatively funded with the Semiconductor Research Corporation, research based on fundamental research needs of the semiconductor device manufacturers, all large companies;
- The GOALI program for joint university-industry projects;
- NSF manufacturing research programs, generically, within the Engineering Directorate, some of which have nanomanufacturing relevance;

The proposed 2011 NSF investment plans to emphasize several program topics that will have substantial nanomanufacturing impact:

1) New tools for measuring and restructuring matter for production purposes;
2) Hierarchical manufacturing of nanosystems by assembling nanoscale components into new architectures and fundamentally new products;
3) Manufacturing by design by using new computer principles, computer simulations, and nanoinformatics;
4) Hybrid nanomanufacturing, including nanobiotechnology and nanostructured catalysts.

One overall goal for 2011 is to strengthen support across the National Nanomanufacturing Network in order to advance innovation and to implement research results through partnerships with industry, medical institutions and other government agencies. In my opinion, the NNN effort should be strengthened and expanded *significantly* to provide the physical and intellectual infrastructure needed to spur industrial nanomanufacturing. This includes new centers on complementary nanomanufacturing themes and stepping up the support to existing nanomanufacturing centers to provide shared-use facilities and professional staff specifically dedicated to nanomanufacturing development with industry partners. As identified in NNN roadmapping workshops, rapid progress could be made by strengthening R&D activity, in a set of well-chosen, well-focused manufacturing test bed development projects involving close university-industry collaborations.

Overall, more co-funded projects are needed to enable universities and industry to work collaboratively on advanced nanomanufacturing issues. The NRI program, listed above, accomplishes this to a limited degree, but only in the nanoelectronics area. More analogous efforts are needed for other industry areas, including materials, energy, health, communications, and others. One new program currently under development to take steps in this direction is the "*Industry Inspired Fundamental Research*" (IFR) program. This is a joint effort between the NSF and 28 member companies of the Industrial Research Institute (IRI). These are mainly large companies. The emphasis here is to develop co-funded fundamental research projects at universities on focused scientific topics that will have a direct impact on the success of American industry. This partnership model should serve to simultaneously train the future workforce and advance knowledge that can be directly implemented in industry. If well managed and amply funded, it should prove to be successful. In such case, its funding should be augmented.

It is often stated that the most effective way to transfer new technology from universities to industry is by way of people. Graduating students who carry with them the ideas developed in an environment rich with research activities, innovation culture, and a genuine understanding of industry needs are ideally suited to quickly transform ideas into products in industry. Student involvement in university-industry projects will have a significant impact on the speed by which new innovations can be implemented in industry.

I would like to emphasize an important and relevant observation: From their inception in the late 1990s, NSF nanotech funding program solicitations for group and center research projects required that research be performed by *interdisciplinary teams*. Looking back, this was a visionary strategy. It is my opinion that, over time,

this emphasis on interdisciplinary research *transformed* U.S. science and research in a substantially beneficial way, since almost all the great advancements in nanotechnology have occurred due to the synergy between distinct, but complementary, disciplines. One may argue that without such a required push, there would have been far less progress in nanotechnology overall. The notion of interdisciplinary "boundary spanners" as catalyst for innovation is well known, and in the recent nanotechnology progress we have observed this in action. We see from this recent experiment that suitable incentives can transform research effectiveness.

Are there areas of nanomanufacturing research and development that are not currently being addressed by the Federal Government that should be addressed?

Currently, there is not enough support for tool and instrumentation development, in the form of longer-term continuing projects. Without the development of manufacturing tools that enable the utilization of new nanomanufacturing processes, we cannot benefit from the huge research investment already made in nanotechnology research. This type of research is best done through jointly-funded industry-university projects, so that the manufacturing science learned can be directly implemented in a new wave of process tools. For example, there are several nanomanufacturing processes that could be implemented in a roll-to-roll platform to substantially lower the production cost. The knowledge gained and the tools developed here could be leveraged into several distinct product areas including batteries, solar cells, water filtration membranes and many other technologies. The same is true for a variety of other emergent processing methods.

There is currently not enough support for nanoinformatics, where cyberinfrastructure, data mining tools, modeling tools, and automated data gathering are utilized to accelerate progress in discovery, development, design and manufacturing. Nanoinformatics will be a critical factor in cost- and time-efficient design of nanomanufacturing processes and products. Associated with this is the collection and curation of data that manufacturers can use for evaluation and design. There should be more support for pilot projects that advance nanoinformatics.

There should be a stronger emphasis and support for the development of international documentary standards and standard reference materials for metrology and tool calibration. Nanomaterials certification standards, nanomanufacturing process specification language (PSL) standards, and reference standards for nanomanufacturing process control are vital. Standards will impact nanomanufacturing capabilities in environments ranging from the single production facility to the global supply chain network.

In general, there are not enough funding opportunities for industry and academia to work together collaboratively to pilot new manufacturing methods based on promising laboratory discoveries. By getting valuable test data, the industrial engineers can make go/no-go decisions and design for scale up, and university scientists and engineers can gain new knowledge regarding the underlying fundamentals. To be effective and serious, it is important that for such projects to be successful, all the stakeholders must have "skin in the game" and co-invest in the project. I am shocked by the stark comparison I see when observing the close industry-university ties in countries like Ireland, Japan and China. In other countries such as these, I have seen the equivalent of technical community college students, Ph.D. students and industry scientists all working together under the same roof. We have very few examples like this in the U.S., but that can change if we create a favorable environment. Proximity and shared mindsets matter significantly, especially with regards to closing the cultural gaps that currently exist between community colleges, universities, and industry in the U.S.

The development of new manufacturing education curricula should be an integral part of such activities, with the natural involvement of industrial engineering programs. There should be a strong emphasis on innovation education and manufacturing engineering principles. The principles underlying both continue to evolve, especially considering the complexities of a new field such as nanomanufacturing. We need the education and research in science-based manufacturing process-property models, scale-up principles, design-of-experiment methods, data-rich statistical techniques and design-for-manufacturing methods. These all contribute to manufacturing excellence as measured by quality, cost, process reproducibility, property optimization, process flexibility and extensibility.

What role does the manufacturing industry play in shaping the Federal Government's nanomanufacturing research and development agenda? In your opinion, are Federal Government programs focused on nanomanufacturing responsive to the needs of the manufacturing industry and other stakeholders? If not, why not?

I will mostly defer to my industrial colleagues on this issue, but from my nanotechnology perspective, there have been several valuable industry inputs toward the development of the National Nanotechnology Initiative priorities. The semiconductor industry (through the SIA and the SRC) helped to identify areas of priority for integrated circuit chip manufacturers. Similarly the Council for Chemical Research and the American Forest & Paper Association provided input for nanotechnology priorities through the development of their respective 2020 roadmaps.

As discussed above, the companies of the Industrial Research Institute (IRI) are working with the NSF to create an Industry-inspired Fundamental Research program to jointly fund research driven by industry needs. This program could fund "collaboratory" style university research projects focused on tackling scientific problems that would advance future generations of manufacturing capabilities. More joint interactions of this type would be desirable. Fast "skunkworks"-style projects and facilities, co-funded by the Federal Government and industry, would result in test data that would advance the development of new manufacturing capabilities. In the case of nanomanufacturing, the centers already established by research agencies could be leveraged for this purpose.

The NIST Technology Innovation Program (TIP) is one good example in which industry and universities can work together towards the development of nanomanufacturing processes and techniques. The Department of Energy's Energy Efficiency and Renewable Energy (EERE) nanotechnology program, similarly has projects based on an industry need: the creation of better materials for energy efficiency and more energy efficient nanomanufacturing processes for sustainable manufacturing. Augmenting both TIP and EERE would be beneficial.

Lastly one should not neglect the support and involvement of the small and medium sized companies. The SBIR/STTR programs are one mechanism, but it is important that these companies also have the opportunity to benefit from all of the programs discussed above. Small companies are rich with innovative ideas, but they often lack the manufacturing experience and resources possessed by large companies. Small-company/large-company partnerships can be very beneficial to success.

Are nanotechnologies developed through federally-funded research and development being transitioned effectively to use by manufacturers? If not, why not?

In some, but not all, cases. One barrier to successful technology transition is the huge "impedance mismatch" in priorities between fundamental researchers and manufacturing experts. The best ways to improve this is to incentivize a change in the culture and support innovation education. As observed in the impact of the NSF requirement for interdisciplinary team research in nanotechnology over the last decade, we see that that mindsets can be changed, and rather quickly, over a period of only a few years. To do so requires the right incentives. Funding of projects with requirements for university-industry partnership, innovation education, or small-company/large-company partnerships, are all activities that over time, emphasize new priorities that change mindsets in beneficial ways.

Another barrier to success is the lack of sufficient data to make informed go/no-go decisions for the implementation of new technologies. Too many of the breakthroughs are only at the proof-of-concept level. When there is far too much uncertainty in the properties, performance and reproducibility of a new nanomaterial or property, it is an enormous economic risk to jump in with both feet. Supporting the development of the most promising nanotechnologies, in the form of pilot projects or manufacturing test beds, can produce reliable test data and build confidence for further investment and development.

In your opinion, is there a need for better coordination and prioritization of federally-funded manufacturing research and development?

Supporting manufacturing innovation overall should be a priority for the Federal Government. Why? Countries that do not manufacture products are poor, typically. We do not want to head in that direction. With home-grown U.S. research breakthroughs, such as those in nanotechnology, we have a rich foundation of innovations from which we can build manufacturing excellence. Better coordination for manufacturing R&D is needed, indeed, but it can be built upon existing or emerging programs that are already successful, but underfunded. In the case of nanomanufacturing, the National Nanomanufacturing Network and industrial organizations that the NNN works with (eg. IRI, SRC, AF&PA) can assist the process substantially, since these organizations have already started roadmapping activities with key stakeholders and have identified priority activities that represent the "low hanging fruit" as well as long view strategic action that can advance U.S. manufacturing. In the case of nanomanufacturing, each research agency already has engaged in manufacturing R&D prioritization at some level, as discussed in a few ex-

amples mentioned above. For manufacturing in general, it is important to have a complementary set of roadmapping exercises, some tightly focused on specific themes and some broad, so as to identify the needs, challenges, opportunities and desired outcomes. As is currently the case in nanomanufacturing, through such roadmapping efforts the key priorities will emerge. To leverage resources efficiently, the Federal Government should consider the creation of an interagency initiative focused on manufacturing innovation. As I have already emphasized several times, a vibrant national manufacturing enterprise system, rich in innovation, requires synergistic participation of industry, academia and government.

More Information on the National Nanomanufacturing Network

The mission of the National Nanomanufacturing Network (NNN) is to serve as a catalyst for progress in nanomanufacturing in the U.S., through the facilitation and promotion of nanomanufacturing workshops, roadmapping, inter-institutional collaborations, technology transition, test beds, and information exchange services. The NNN operates as an open-access network of centers, leaders, experts, and stakeholders from the nanomanufacturing research, development and education community. It is a partnership among academia, industry and government that is built to foster and serve nanomanufacturing communities of practice. The core foundation of the NNN consists of the four NSF nanomanufacturing NSECs—the Center for Hierarchical Manufacturing (CHM), the Center for High-Rate Nanomanufacturing (CHN), the Center for Scalable and Integrated NanoManufacturing (SINAM), and the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS)—as well as the DOE Center for Integrated Nanotechnologies (CINT) at Sandia National Laboratories and the NIST Center for Nanoscale Science and Technology (CNST) and other affiliations. InterNano is the information arm of the NNN—a digital library clearinghouse of timely information on nanomanufacturing and a web platform for collaboration. It should be noted that each center described above is funded independently. The NSF funding for the NNN's cooperation and information sharing activities is provided as a portion of the grant for the Center for Hierarchical Manufacturing.

The NNN functions as part electronic resource, part community of practice, and part network of experts working on the development of nanomanufacturing. The NNN has made key progress in launching and establishing an effective mechanism for information sharing (InterNano), facilitating and organizing workshops and events with topical focus on critical and emerging nanomanufacturing issues, facilitating and contributing to critical areas of informatics, standards, education and workforce training, and further providing an open platform for archiving information where stakeholders can contribute or access relevant information specific to their needs in the area of nanomanufacturing. Subject to available funding resources, the NNN has a vision of providing the following activities to support nanomanufacturing R&D:

- Facilitate collaborative R&D activities that support the development of nanomanufacturing systems through pilot projects and test beds with industry partnership
- A complementary portfolio of nanomanufacturing education and training activities.
- Share and disseminate best practices (process implementation, tech transfer, EHS, supply chain)
- Leading or assisting technology visioning and roadmapping activities via workshops and working groups, symposia, and summits on nanomanufacturing themes.
- Guide the development, implementation and growth of the InterNano nanomanufacturing information clearinghouse via broad-based informatics.
- Economic analysis of emerging nanomanufacturing activities.
- Federated nanoinformatics efforts linking materials, process, and application databases.

More Information on the Centers Affiliated with the NNN

The collection of centers represented by the NNN provides a complementary portfolio of nanomanufacturing process technologies. Detailed information can be found at *www.internano.org* and at each center's website.

The **Center for Hierarchical Manufacturing** (CHM) led by the University of Massachusetts Amherst provides methods that use self-assembling diblock copolymers and complementary nanomanufacturing process to control structure from the nanoscale to the macroscale. The center develops processing techniques and modeling methods for nanomanufacturing both in batch and roll-to-roll production formats. These processes have significant impact for the low-cost production of data storage media, nanoelectronics, batteries, solar cells, water filters and communications. The CHM is also the administrative hub of the National Nanomanufacturing Network.

The **NSF Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing** (Nano-CEMMS) headquartered at the University of Illinois concentrates on developing innovative processes that function in ambient (as opposed to high vacuum processes) conditions, are well suited to large-area formats, and with material sets not usually associated with microelectronics. Nano-CEMMS has developed a manufacturing platform that exploits efficient nano-fluidic and ionic transport phenomena to realize a whole new class of products such as semi-transparent flexible solar collectors, flexible-stretchable solid-state lighting and bio-compatible electronics.

The **NSF Center for High-Rate Nanomanufacturing** (CHN) headquartered at Northeastern University provides methods for fast large scale directed assembly and transfer of nanostructures, including carbon nanotubes as on chip wiring interconnects, transparent flexible electronics using carbon nanotubes, wafer-level template-free assembly, and custom made nanostructured carbons of various forms. The CHM also works on the development of best practice guidelines to limit exposures to nanomaterials and fast toxicity screening methods.

The **NSF Center for Scalable and Integrated Nanomanufacturing** (SINAM) led by the University of California Berkeley has developed tools and techniques for plasmonic nanolithography, which provides a high throughput route to pattern nanostuctures having feature sizes below 22 nm. This technology is relevant to semiconductor device manufacturing and other application areas.

The **DOE Center for Integrated Nanotechnologies** (CINT) at Sandia National Laboratory has developed and deployed the Discovery Platform™. These platforms are modular micro-laboratories designed and batch fabricated by CINT to allow easy integration of nanomaterials into microscale structures. They allow easy connections, a range of diagnostic and experimental measurement conditions, and a degree of standardization and reproducibility in nanoscale measurements. Sandia also is home to the National Institute for Nano-Engineering (NINE)—a Public-Private Partnership formed to develop the next generation of technical innovation leaders for the U.S., employing the national strategy of the *America COMPETES Act*.

The **NIST Center for Nanoscale Science and Technology** (CNST) supports the development of nanotechnology from discovery to production. The Center provides this support through a research program that develops innovative nanoscale measurement and fabrication capabilities, and is accessible via collaboration with CNST scientists and a national nanofabrication facility, the NanoFab, which is a shared-use R&D facility with a suite of tools and processes for nanomanufacturing research.

BIOGRAPHY FOR MARK TUOMINEN

Professor **Mark Tuominen** is the Director of the National Nanomanufacturing Network, Co-Director of the NSF Center for Hierarchical Manufacturing and a Professor in Physics at the University of Massachusetts Amherst. He was raised on a dairy farm in northern Minnesota, worked as logger, in sheet metal manufacturing in a small company, in manufacturing scale-up for a large multinational company, and ultimately, in academia as a scientist and educator. Mark has a bachelor's degree in Chemical Engineering (1986) and a Ph.D. in Condensed Matter Physics (1990), both from the University of Minnesota. His current research includes nanomanufacturing R&D, magnetism, nanoscale charge transport, and energy devices. He currently serves as a U.S. delegate to the ISO TC–229 Committee on Nanotechnologies and as leader of the ISO nanomanufacturing terminology project.

Chairman GORDON. Thank you. And Mr. Crews is recognized.

STATEMENT OF WAYNE CREWS, VICE PRESIDENT FOR POLICY AND DIRECTOR OF TECHNOLOGY STUDIES, COMPETITIVE ENTERPRISE INSTITUTE

Mr. CREWS. Good morning, Mr. Chairman. I appreciate the opportunity to appear.

I am a strong advocate of these new technologies but I do want to sound a few warnings today. When it comes to our economy, where are we going and why are we in this hand basket? We want to make things in the United States, and create jobs, but mired in recession, what is the national government's role in manufacturing a more robust manufacturing economy?

First, we must avoid fostering a declaration of dependence on the part of America's most crucial frontier industries. Second, we must avoid having the government steer while the market rows. Worthy knowledge and ideas are too widely dispersed for that.

The need to deregulate this economy shouts at us, and I will say a little bit about that in a few moments. Basically you don't need to tell the grass to grow, you just need to take the rock off it. America's real wealth is yet to be created, but to fulfill that optimism requires recognizing the limitations of politically driven R&D. Overly aggressive taxpayer funding of science and manufacturing research can be incompatible with a lightly regulated future. For one, Federal science fosters conflicts over public access to data, the merits of basic versus applied research, government versus industry science, and intellectual-property disputes. For another, politics has trouble with tradeoffs. When will it be nanotech, or biotech, or fuel cells in the hydrogen economy, or robotics, or bioengineered gills so we can live in the ocean. Meanwhile, the science not created by the political redirection of resources remains unseen. It wasn't the power to tax and dispense that made the United States leapfrog the world's economies in only 100 years.

So simply a warning: subsidies can mean subprime technology policy for many reasons. Number one, government steering can create artificial booms. Number two, government funding comes with strings attached. Number three, political failure can overwhelm market failure and basic research. Number four, politicians can't choose rationally, present company excepted, of course. The latest conceit is yesterday's FCC [Federal Communications Commission] national broadband plan, which in a way is 'cap and trade' for telecom. Number five, taxpayer funding sometimes wrongly fosters a view of technology as a zero-sum global race, but commerce and trade are not like war. Moreover, subsidies don't alter the ratio of GDP spent on research and development. Number six, taxpayer funding can create a glut of the wrong kinds of technology graduates. Number seven, taxpayer funding creates pressures for poor intellectual-property outcomes, like too much compulsory licensing. Number eight, taxpayer funding can undermine safety, because "undiscovery" of even the riskiest science is unlikely, but market disciplines like liability and insurance need to evolve alongside.

So what do we do? Well, doing something is more than just spending money. The COMPETES Act may pull together a few billion dollars for a lot of very worthy projects, but the real gains come if we liberate to stimulate, if we work on separating state and economics.

First, avoid picking technological favorites. Rather than trying to improve speeds by picking the particular R&D horses to run around the racetrack, improve the business and regulatory environment so all can go faster, and let jockeys keep more of their earnings.

Second, allow freer trade in skilled labor. Bright foreign workers want to stay in the United States and create jobs after graduating here. That is a better way to address the global competitiveness issue.

Third, avoid safety regulation that makes us less safe. Many frontier technologies like nanotech make our environment far cleaner. Emphasizing the hazards of these new technologies overlooks the hazards of stagnation.

Fourth, liberalize capital markets. Post-Enron, Sarbanes-Oxley regulation has distressed smaller companies severely. Exempt firms with smaller market capitalizations.

Fifth, privatize. During the 1990s it was proposed that commercial aspects of Federal labs be offered to the industries they benefit or by allowing employees, research employees, to buy them out.

Sixth, award prizes rather than grants, which is something that is in the COMPETES Act that should be explored more.

Seventh, liberalize the infrastructure supporting American commerce and manufacturing. Tearing down the regulatory silos that artificially separate our great network industries, like electricity and telecom and transportation, has enormous potential for creating wealth in the United States.

Eighth, relax predatory and anti-consumer antitrust. Markets require competition, but sometimes collusion is merely a partial merger instead of a full one. In other words, constraining productive firms in ways the market never intended hobbles entire industry sectors and undermines the wealth creation itself at times.

Finally, deal with regulation generally. Sixty agencies issue 4,000 regulations a year, costing over $1 trillion and some 70,000 Federal Register pages. So implement a bipartisan regulatory reduction commission, sunset regulations, have Congressional approval for controversial rules, more flexibility for smaller businesses, points of order for unfunded mandates, and a basic regulatory report card on the state of regulation that accompanies the Federal budget.

I will close there, and I thank the Chair for your attention.

[The prepared statement of Mr. Crews follows:]

PREPARED STATEMENT OF WAYNE CREWS

Separation of State and Economics: A 21st Century American Manufacturing Stimulus Package

Everyone agrees we still want to make a lot of stuff in the United States of America and create jobs. So what are the prerequisites for prosperity? Mired in recession now, how do we "manufacture' a robust American manufacturing economy?

For starters, we avoid fostering a "Declaration of *De*pendence" on the part of America's most crucial frontier industries.

The purpose of this hearing ("The Future of Manufacturing: What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?") is to examine "the need to adopt innovative technologies and processes" and assess the National Government's role.

The positive message is that most of America's wealth has not been created yet. But to fulfill that optimism, recognizing limitations of politically driven research and development compared to what capital markets and economic liberalization can

achieve is vital. Most politicians defend a significant, even pivotal, governmental role. I say instead that when it comes to the creation of knowledge wealth itself, that's a worrisome stance and better alternatives exist.

To go overboard in enshrining Washington predominance in terms of "*America COMPETES Act*" and "Recovery and Reinvestment Act"-style spending in a sense is taking the easy way out. The latter in particular shirked genuine duties as the Nation endured economic upheaval. Instead, there's difficult, important *actual* work for Washington to do. At this vulnerable stage of business, economic, and American history, Washington can't spend money on technology education, science and manufacturing and think it's done any of the work required to reinvigorate manufacturing.

The *America COMPETES Act* you might reauthorize should be different in kind, not degree. It is now a vehicle for subsidizing various popular education and technology ventures; it instead should removing accumulated impediments to innovation: it should "liberate to stimulate."

"COMPETE"ing Visions:

Let's Avoid Having Government Steer While the Market Rows

The *America COMPETES Act* is bipartisan, but fifteen years ago the tone was different; Congress sought to reduce government with sweeping proposals like privatizing national labs and curbing business and corporate welfare. Ironically, The National Nanotechnology Initiative signed by President Bush directed about a third of funding to the very Energy Department slated for abolition in 1995.

Aggressive taxpayer funding of scientific and manufacturing research is not compatible with a future of optimally and lightly regulated science and manufacturing specifically, or with limited government generally.

Moreover there are opportunity costs—tradeoffs. Politics cannot determine optimal research portfolios: Why nanotech instead of biotech, or space travel, or bioengineering gills so we can live in the oceans? Or fuel cells and the hydrogen economy? All such rifts are impervious to political resolution. And that's good.

No political party is immune from exacerbating distortions created by politicized science, as politicians channel Federal dollars back home regardless of scientific merit. In a sense, the debate over science policy and where to allocate taxpayer resources isn't one over science policy as such; rather, it's over problems of allocating the spoils artificially created when government (an institution with the power to tax) gets involved in the very production of knowledge itself (and seducing industry), rather than in merely protecting rights in the property that knowledge makes possible. Further, we want to avoid politicized situations like "junk science," "climategate," bubbles created by governmental investment, the undermining of freedom of "research speech" (or of its corollary, withholding one's speech/research).

Today, we see examples of artificially created conflicts rooted in governmental science policy. These disputes include disagreements over:

- The fundamental merit of basic vs. applied research
- The impact of private vs. public funding on discovery and well-being
- The alleged objectivity of government vs. "industry" science and the chastisement of industry science in the marketplace of ideas
- Potential confusions over the ownership or intellectual property status of federally funded discoveries (for example does the Genome belong in the public domain, or are components patentable?)
- Related information commons vs. proprietary views of information; that is, the "information wants to be free" ethic that permeates Internet policy but can threaten scientific endeavors
- Public access to scientific data upon which regulations are based
- The right to not fund science with which one disagrees
- Purported (but often exaggerated) conflicts of interest among federally funded scientists [1]

We need at least some consideration of rising above or stepping outside such seemingly irresolvable policy conflicts. Indeed, there are lessons from other non-scientific areas—such as entertainment intellectual property, financial and privacy de-

[1] Iain Murray, "The Nationalization of Basic Science: Overzealous Attempts to "Protect" Scientific Integrity will Damage American Science as a Whole," *CEI OnPoint No. 100*, July 21, 2005. *http://cei.org/pdf/4696.pdf*.

bates, and the media ownership debate (where many presume that information can be "monopolized")—that have implications for the science policy debate.

Disconnecting science from the technological gains to mankind in the name of "basic" research can become a misguided passion. Science is likely to advance human welfare and remain most relevant to mankind if it is pulled into being by the actual needs of humanity, including practical ones. There are also stories to tell about how practical R&D led to general "truths" with wider application. Many are aware how the attempt to solve problems in microwave transmission led to discovery of the cosmic f background radiation, helping validate the big bang.

To advance science and manufacturing, it's right for the committee to ask what the Federal Government should be doing; but rather than run with the implied invitation to propose spending on scientific endeavors (obviously Washington can't fund them all), Congress should "liberate to stimulate" rather than try to steer research and investment in particular directions. The national government's role in actually fostering "knowledge wealth" is properly limited, but it's role in liberalizing the American economy so that *others* can foster that wealth is of the utmost importance.

I'll probably stand alone in suggesting to you that for the most part, in civil society, "science" is not properly a public policy issue. What fosters fundamental scientific and in turn manufacturing wealth? What made the newborn United States lurch ahead of all the world's economies in only 100 years, including Great Britain? Not the power of taxation and dispensation. The nature of the relationship of the state to free enterprise hasn't changed because our economy has become high-tech. And getting policy right now is arguably more important now than at America's founding; free enterprise is even more crucial to tomorrow's scientific and information wealth than to the paper clips and widgets of yesteryear.

Markets maximize output in tangible products and intangible services. But what we forget is that markets maximize the production of useful information economywide—*including scientific information*. It's important for Washington to recognize free markets in knowledge-creation as the source of true and more objective "information wealth" and the resulting advances in manufacturing.

In asking about fostering innovation, we're really talking about what conditions create a better business environment whether we're talking about tangible manufacturing on the other hand the creation of knowledge underlying it.

Anyone can propose a smorgasbord of subsidies to add to the ones already contained in the COMPETE Act; but that shouldn't necessarily be regarded as promotion of science and technology. There's also a bit of the broken window fallacy here: not seen is the science not created by the redirection of resources to this or that temporarily favored project or field. Bolstering manufacturing and science requires vigorous competition among ideas for funding, not a Scientific New Deal. Nor is it optimal for sciences and applications to proceed walled off apart from one another in an appropriations environment; that undermines the swirling competition, cooperation, and "co-opetition" needed for the U.S. economy to surge and to stand up against overseas competition.

So what is the national government's proper role in manufacturing? Promote it? Constrain it? Or leave it alone?

The national government can't be the supercompliant superprovider in an increasingly complex society with tacit knowledge dispersed in countless ways; your outcome-oriented interventions, as opposed to liberalizations that leave outcomes up to the free choices of others, will produce prominent successes, but fail taken as a whole. Interventions, subsidies and regulations create an economy made up of suboptimal commercial entities that don't resemble what they would under free enterprise, and that cannot function as the job engines needed now.

Basically, you don't need to tell the grass to grow, just take the rock off of it. Following the next section on some specific hazards of government steering the market, I'll point to some of the rocks to move; that is, alternative approaches to advancing science and manufacturing that you should implement.

Why Subsidies and Steering Can Mean "Sub-Prime" Technology Policy

Government Steering can create artificial booms

Vigorous calls for government research seem in part a reaction to the tech market downturn and the harshness of America's recession. But one lesson of the telecom meltdown is that government can contribute to the inflation of artificial technology bubbles; we are at risk of a similar "green technology" bubble or conversely inefficiencies right now. For example, Spain's King Juan Carlos University released find-

ings that each "green job" created by the Spanish wind industry cost 4 other jobs elsewhere. [2]

In another sector, policies may be teeing up another real estate bubble as well. A brand new National Broadband Plan will distort evolution in the crucial field of communications. Forthcoming technologies should be products of capitalism, not central planning, government-favored R&D, and pork barrel. That helps discipline excess.

We don't want a scientific world of researchers chasing politically favored fads and steering their grant requests according to politics, whether biofuels, alleged energy conservation, materials conservation, smart grids, politically favored medical research, or whatever. Eisenhower warned in his 1961 Farewell Address of the risks of researchers designing proposals to link politically fashionable themes. It should worry us that:

> public policy could itself become the captive of a scientific-technological elite . . . Partly because of the huge costs involved, a government contract becomes virtually a substitute for intellectual curiosity . . . The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present—and is gravely to be regarded.[3]

Government funding comes with strings attached

Washington passed the bipartisan *21st Century Nanotech Research and Development Act* in 2003 to provide nearly $4 billion to establish numerous research grants for nanotechnology initiatives, set up nanotechnology agencies, programs, subsidies, and steer students toward nanotechnology research. Anti-nanotech groups were already lined up in opposition, but Federal agencies are positioning themselves to regulate risks of nanotech, not necessarily to the good.

Still another government/business funded report, called "Nanotechnology: a UK industry View" reaches yet again the same conclusions about nanotechnology as the ones that appear occasionally like the U.S. Environmental Protection Agency's "Nanotechnology White Paper" or the Food and Drug Administration's "Nanotechnology". Such reports uniformly call for open-ended role for political bodies to govern otherwise private endeavors in frontier sciences like nanotechnology.

The reports say—brace for it—that governments should fund nanotechnology and study (endlessly) nanotechnology's risks; and that they should then regulate the technology's undefined and unknown risks besides. Since the business parties can become so dependent on political funding, they go along, cut off from envisioning an alternative approaches either to funding or managing hazards.

Fundamentally, we face the choice of treating frontier manufacturing research, development and production like software and essentially leaving them alone, or of treating them like medical research such that they are regulated at every stage by an entity like the Food and Drug Administration (which may not necessarily foster safety).

Unfortunately, the approach of government steering while the market rows is opposite from the way software is produced and marketed, and assures that there will never be a "Bill Gates of nanotechnology" as CEI's Fred Smith often puts it. That is, if every new nanotechnology advance faces FDA medical-device-style hurdles, this is an industry that cannot begin to reach its potential. Naturally we must defend against risks (and this report will cover approaches shortly), but the strings attached to American frontier sciences' practical applications may move our entrepreneurs overseas, assuming overseas markets don't overtake ours first.

Political failure overwhelms "market failure" in basic research investment

The intellectual case for taxpayer funding of science and favored manufacturing is based on the market failure argument. Supposedly research creates value not easily captured, and rivals can free ride. Some also suggest an investment payback period intolerably distant for market entrepreneurs. The market, it is argued, will under-invest. Of course, everything about competitive rivalry is geared toward compressing that discovery-to-deployment phase.

Part of the problem here is a false dichotomy between basic and applied research. Regardless, price signals are needed to allocate scarce R&D resources to challenges that, if overcome, would most reward innovators, advance human needs, and maximize the rate of technological progress and job creation. The absence of a residual claimant who can garner windfall returns undermines the political appropriations

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[2] "The Big Wind Power Cover-Up," *Investor's Business Daily*, March 12, 2010. *http://www.investors.com/NewsAndAnalysis/Article.aspx?id=527214*

[3] Eisenhower's Farewell Address to the Nation. *http://mcadams.posc.mu.edu/ike.htm*.

environment, but private investors can rationally invest in a range of low probability projects, counting on the profits from the rare success to offset the many failures (somewhat like the music business).

Besides, Teflon, Tang and Velcro did not spin off from NASA. Memory foam did though.

Politicians can't choose rationally (no offense)

Except when a local earmark or pork-barrel project is at stake, almost any politician will admit that government has no innate ability to pick among competing technologies, particularly using taxpayer money. And government plans operate on an election timeline that doesn't conform to market needs; A current example, the Federal Communications Commission's "National Broadband Plan" was presented to Congress March 16, 2010, but it has little chance of going anywhere this year,[4] yet creates damaging uncertainty in the industry about what will or won't happen. Making America's precious scientific and manufacturing resources subordinate to such a process is sub-prime public policy to say the least.

Politicians cannot assign rational priorities to the endless parade of "significant" projects, thus will select popular ones benefiting local constituencies; just note the continuing funding of new libraries in the digital age (as opposed to just handing out wireless-enabled laptops), new Post Offices, elements of the just-noted National Broadband Plan, the Nanotech Initiative, recent jockeying over tech programs for rural small businesses, and so on and on. Scientific merit may be underwhelming, but the rhetoric of science and technology are assured.

The hazards of a government appropriations process and the accompanying beehive of lobbying for sub-optimal projects are numerous. And expensive. Consider the Superconducting Supercollider. Or the Space Station (recently called "scientifically worthless"). In the space program, entrenched contractors and legislators from flight-center districts enjoy cost overruns, and lobby against cheaper unmanned flights. An ethic of revolutionizing space flight becomes unthinkable, and is a lesson for future technology implementation.

International competition is not zero sum

Sometimes politicians will bolster the market failure argument and urge national government investment by characterizing technology as a race against other nations that we stand to lose.

Experience suggests foreign investments like supersonic airliners and before-its-time high definition TV can be turkeys as easily as some U.S. domestic boondoggles.

But more importantly, we all benefit globally when countries find more efficient ways of producing some good or service. Viewing such gains as losses is to revert to the old mercantilist idea that international trade and commerce are like war.

Besides, a better way to deal with this particular concern of overseas competitors is for our policy to allow more of the world's best and brightest to become American citizens and entrepreneurs. As CEI analyst Alex Nowrasteh put it in a recent *Detroit News* column, "Either businesses will move to the talent or the talent will move to where the opportunities are. What movement occurs depends on immigration, trade, and other regulatory regimes. Generally, all else remaining equal, it is far cheaper and more beneficial to all concerned when talent moves toward opportunities."[5]

Taxpayer Funding Misdirects Resources

Markets have to be good at killing bad projects as well as creating new ones to prosper,[6] but appropriations processes are less capable of systematic pruning. The problem with government science is that virtually all interested parties seek to grow government rather than pull the plug on exhausted ill-considered projects, from tiny ones to the gargantuan like the space station, shuttle or the supercollider. The result is higher taxation and dollars directed to multiplying unchosen ends. Science resembles any other rent-seeking interest in this respect. In an examination of testimony before congressional panels, nearly all ask for more money, not less, and the ratio was hundreds seeking growth to one asking for less government.

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[4] *http://www.pcworld.com/businesscenter/article/191438/fccs_national_broadband_plan_whats_in_it.html*

[5] Alex Nowrasteh, "Let Immigrants Power America's Scientific Progress," *Detroit News*, December 2, 2009.

[6] Auren Hoffman, "To Grow a Company, You Need to Be Good at Killing Things," *Summation*, February 21, 2010. *http://blog.summation.net/2010/02/to-grow-a-company-you-need-to-be-good-at-killing-things.html*.

Expansion of government-funded science doesn't help anyway if the metric is the proportion of a nation's GDP devoted to R&D. Research by scientist Terence Kealey suggests both that the private sector funds basic research out of competitive necessity in a global economy, and that total R&D expenditures tend to correlate to GDP rather than to particular national policies.[7] That is, where government R&D is low, the private sector simply invests more. Higher GDP begets higher R&D, in other words. Substitution and tradeoffs mean taxpayers gain little from increased political R&D, and may lose a lot because of the inefficiencies, sub-par policy and anti-competitive political choices. (See **Appendix I** for a summary of some of Kealey's findings and other bullets about government science funding.)

Taxpayer funding can create a glut of or the wrong kind of graduates

The COMPETE legislation is not alone in proposing higher numbers of technology graduates; another is the recent cybersecurity legislation. But if the market needs them, higher salaries will draw people to the application-specific training actually required. Creating a premature government-sponsored glut of Ph.D.s in this or that technological field is not the same as actually advancing useful knowledge sought in the marketplace. America's companies don't need Ph.D.s as such, they need knowledge, which in the Internet age materializes in ways unrelated to brick and mortar universities' offerings or to subsidies. It also appears that government funding may have potentially detrimental impacts on scientists' salaries (Appendix I).

Taxpayer funding artificially complicates intellectual property disputes

Other complications involve patent ownership disputes between university and corporate collaborators over who controls future profits, the rights of taxpayers to the spoils, and access to research results or data for competitors or the public. Examples are disputes over the ownership status of genetic discoveries or basic molecular information, the current controversy over access to source data underlying predictions of global warming models (so-called "climate-gate"). Pharmaceuticals routinely face compulsory licensing threats globally. Taxpayer funding as such assures similar vulnerability for other frontier sciences.

Nanotechnology, biotechnology and other "information wealth" fields arise against a backdrop of disputes in seemingly unrelated fields that nonetheless should set off alarms, such as the open source vs. proprietary debate surrounding software. Even entertainment—online music—faces calls for compulsory licensing, when digitization itself has undermined the very "market failures" that led to compulsory licenses in the first place. Property rights are also vulnerable in the so called "net neutrality" debate, by which some hope to outlaw proprietary business models altogether in favor of compulsory "openness" on communications networks. Taxpayer funded science and manufacturing are inescapably vulnerable in this environment. Congress must recognize that while we had a John Locke for the tangible property, industrial age, we regrettably lack one for today's information and knowledge-economy age.

One answer to the question raised in this hearing, "What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?" is that we urgently must legitimize the private-property status of new forms of wealth, and not pursue policies that delay these underlying institutional innovations.

Taxpayer funding may confront a "Regulatory Bias Problem"

The Regulatory Bias Problem occurs when agencies' charters encourage them to consider only certain risks or certain benefits. As CEI president Fred L. Smith Jr. has pointed out in past testimony, DOE and EPA both view energy efficiency as a "good thing" rather than one of multiple product features. But a less safe energy efficient car may be a "bad thing." Inadequate attention to research on the unintended consequences of funding and overregulation impacts technological evolution.

Substituting Government Funding For Competitive Discipline Can Undermine Safety

Policymakers rarely can admit it, but their "safety" regulation can undermine safety.

That's a problem, because "undiscovery," or abandoning even the riskiest scientific research is likely out of the question. Bans will be ignored in a global environment, as failed cryptography bans and spam laws and overseas (and likely domestic) efforts to clone demonstrate.

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[7] See, for example, Terence Kealey, "End Government Science Funding," Cato Institute, April 11, 1997. *http://www.cato.org/pub_display.php?pub_id=6168.*

Government can exacerbate risks of new technologies. An appropriations environment can send technology lurching in non-market directions (again like the broadband plan), all subject to future political rug-pulls. Meanwhile while political funding comes with strings attached on the one hand, it can indemnify companies for the hazards they create on the other. Homeland security technologies like gas masks for example, can be indemnified in the event they fail.

Free enterprise actually can do a better job regulating risk. In normal markets, before your nanotech company (for one example) can attract investors and get off the ground, disciplinary institutions like liability and insurance have to accompany you; One must satisfy capital markets, insurers, upstream business suppliers, horizontal business partners and institutional buyers, downstream business customers, investors, consumers, public and global markets. Markets and capitalism should, and do, bring highly risky products forth (financial instruments, electricity, new forms of energy, behavioral advertising, cybersecurity for sensitive-information networking, emergent low-earth-orbit space touring); but government promotion, subsidies and indemnification can short circuit the risk-mitigating disciplines that must emerge alongside.

Dangerous, uninsurable ventures rightly scare off investors. But government domination of risky, but promising frontier research can take it out of the realm of insurability and an otherwise impossible appearance in the marketplace, and even provide immunity. The Price Andersen Act artificially limited the liability of nuclear power plants but meant total regulation. Would a more market-oriented development path have made nuclear power more viable over the past decades? We may never know.

Today's military and homeland security emphasis for technologies has significant implications for the evolution of and for the public policy stances taken new technologies. Homeland security legislation indemnifies companies from liability when their "security technologies" fail. Taken too far, liability markets in crucial areas may never emerge. But in a healthy marketplace, liability coverage and product certification will likely flourish contingent upon adhering to guidelines demanded by many stakeholders.

We want the defensive mechanisms to emerge, as well as appropriate professional ethics regimes, but the way we choose to fund frontier scientific fields will impact safety and the prospects for competitive discipline as well as the horizon available to engineer counterbalancing technologies to offset any risks that emerge. Market "regulation" or competitive discipline is quite demanding. If nanotechnology (for example) introduces a risk of "gray goo,"[8] the competitive disciplines arrayed against it can constitute "blue goo," or a policing mechanism. Government dominance can give our most promising new industries an undeserved black eye, and guarantee counterproductive regulation and less innovation.

Moving the Rocks So the Grass Can Grow

"COMPETE" by Separating State and Economics

We need an agenda for strengthening private manufacturing that offers specifics on separating state and economics. This includes the obvious, like systematically evaluating and reducing tax and regulatory burdens. It also means thinking about how it was that the U.S.—only 235 years old—became richer than the rest of the world in a historical eye-blink; and how that remarkable achievement can be sustained as other nations embrace institutions of liberty and create ever-competitive markets.

"Doing something" is not the same as just spending money. When linking research to human needs and promoting manufacturing wealth, capital markets trump the appropriations process. Interestingly, adding up the dollars in the COMPETE Act, seems to total perhaps a few billion. But the gains from removing barriers to private research could yield far greater benefits. Emphasizing spending stimulus for science and manufacturing has strings attached, invites rent-seeking and can have a detrimental impact on safety. Government's proper stance is one of indifference or neutrality, since many technologies, some not in existence yet, will always compete for scarce investment dollars. A better approach now is to "*liberate to stimulate*."

It was noted earlier that that Congress has a far more important job to do that it can't escape by sprinkling cash on the technology sector. As discussed in *Still*

[8] As for the "gray goo" catastrophe scenario of runaway "nanobots," it's not compelling since in every other instance environmentalists say an organism needs an eco-system to survive. The scenarios are silly, and moreover there's no shortage of proposed solutions to the problem were it genuine.

Stimulating Like It's 1999,[9] there exists a natural tendency toward recession when government fails to perform its "classical" function of ensuring that prices of materials, labor and other inputs aren't hoisted above market clearing levels by rent-seeking behavior in the economy.

The job now is to liberalize, to perform the actual job of removing impediments that hobble wealth creation, in particular in science and technology. Borrowing from Friedrich Hayek in "The New Confusion About Planning," the issue is not whether industry has to be regulated, or "planned." Rather, the question is who will do that planning; the right approach is to unleash competitive discipline. Suggestions follow.

First, Avoid Picking Favorites Among Technologies

As CEI's Fred Smith points out, in the Federal R&D sweepstakes, bolstering promising technologies has been compared to efforts to improve the speed records at a racetrack by picking the R&D horses to run. However the condition of the track and the rewards available also matter. Faster speeds might also be had by improving the track, the business and regulatory environment, and by letting jockeys keep more of their earnings.

The government-picking-technologies model undermines economic liberty, innovation, wealth creation, "national competitiveness" (the ever-present rationale for government R&D) and consumer benefits, and is itself a source of risk. Many have argued that viable technology doesn't need a subsidy, and non-viable technologies probably can't be helped by one. Otherwise, we are distorting markets, creating bubbles, and teeing up future rippling recessions. Rather than picking the winning horses (or worse, actually *being one* of the horses), government's legitimate role is to improve the track on which all the horses run; that means liberalizing the tax and regulatory environment within which entrepreneurs operate, for starters.

Interestingly, when the Wright Brothers made their historic flight, their rival was Samuel Langley's War Department-funded, "Aerodrome." He was catapulting the thing out over the Potomac river. The Wrights ran a *bike shop*, but it became a state of the art aeronautics lab.

Frontier scientific manufacturing fields are plainly viable on their own, moving forward on fronts too numerous to catalog. To approach the matter otherwise is an impediment.

Minimize Tax Burdens and Implement Rational Tax Policy

Other commentators routinely address tax burdens. This report focuses instead on the regulatory environment, which policy more often tends to ignore. Nonetheless, accounting standards that treat R&D as an investment to amortize, rather than an immediate expense, can be a deterrent to non-governmental basic research that Congress should evaluate. (Tax credits would be a poor substitute because they amount to picking among technologies.)

Allow freer "trade" in skilled labor in the US

As noted briefly before, many knowledge workers want to move to the United States and create companies and jobs, or want to stay after being educated here.

Avoid Safety Regulation that Makes Us Less Safe

As Henry Miller of the Hoover Institution explained, "A regulator can approve a harmful product, or delay a beneficial product. Both outcomes are bad, but regulators are attacked by the media and politicians only approving a harmful product. Delaying beneficial ones is a non-event."

Biotech, nanotechnology and other frontier sciences introduce risks but can also mitigate them. We should care about this not merely because of the fact that wealth is enhanced by keeping precaution in perspective, but because the precautionary principle is itself a hazard; moving forward has risks, but so does stagnation. For example, rather than being the asbestos or "gray goo" of tomorrow, nanotechnology could be an input to make our environment cleaner. Most agency studies emphasize the hazards of nanotechnology; they should study the hazards of *regulation* and the hazards of government funding hobbling the industry as well.

As described before, the drive to regulate safety isn't only undermining wealth creation in frontier science and manufacturing, but also threatening the emergence of needed safety and disciplinary practices. It's important to avoid safety regulation that either inadvertently or deliberately preempts superior competitive discipline.

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[9] *http://cei.org/cei_files/fm/active/0/6425.pdf*

Liberalize Capital Markets

While it doesn't enjoy the reputation for it, capitalism is among the greatest democratizing forces in the world. The corporate structure that emerged to spread risk in the days of sailing ships is now a system of spreading of ownership of companies to millions of citizens; the miracle of the fact that people unknown to one another can work together to create unprecedented wealth is one of the great advances of the millennium.

Recent regulation in the wake of the Enron and WorldCom scandals has impacted smaller entities in unfavorable ways. While it did not pass late last year, the "Wall Street Reform and Consumer Protection Act of 2009," would have rolled back at least one of the excesses of Sarbanes-Oxley financial regulation impacting small public companies.

In a media advisory, the Biotechnology Industry Association praised two provisions: one would have permanently exempted companies with market capitalizations below $75 million from the SarbOx Act's Section 404(b) internal control requirements (which the Obama administration supported along with most Republicans and 101 House Democrats. The other provision would require an SEC study examining SarbOx compliance costs (and benefits) for companies with floats below $700 million and revenues under $250 million. Despite the bipartisan criticism of that legislation, no reforms for small business relief have yet passed.

Nor were the relaxation provisions a part of the Chris Dodd financial reform bill under consideration this March, but it could be offered as an amendment.

Privatize: (Remember That?)

One aspect of liberalization is privatization of Federal research facilities, which itself would remove constituencies for government funding. Of course the America COMPETES emphasis is on government spending rather than privatization. During the 1990s, it was proposed that essential military aspects of Federal labs be transferred to the Department of Defense, while commercial aspects should be privatized by offering them to the industries they supposedly benefit or by allowing research staffs to take them over via an employee buyout approach. Such options should be discussed more than they are.

Award "Prizes" for the time being

Privatization of Federal research is a hard sell when the topic at hand is public funding expansion. Perhaps one approach is to forbid Federal funding for technologies that do not yet exist, and grow out of the problem. In any event, a worthy idea noted in the discussions surrounding the *America COMPETES Act* is that of awarding prizes, the idea being that "Payment to researchers would reward accomplishments rather than promises."[10]

The idea is an appropriate one to consider in transitioning to a more privately funded regime and will be (and is) attractive to foundations. But why did grants take over prizes—which used to be prevalent—in the past?

> The answer appears to be the power of patronage. Research by Robin Hanson when he was at UC Berkeley suggests that during the 19th century, scientific societies that had collected money from bequests to distribute as prizes realized that they had much more power over the direction of scientific research if they distributed the money as grants instead. So they could finance favored scientists and preferred research directions, something that genuine prizes would not allow . . . . All of which suggests that scientific bureaucrats knew exactly what they were doing when they moved from prizes to grants.[11]

Enlarge regulatory flexibility to bolster small business

Congress can't manage and deal with the regulatory burden that undermines innovation if it doesn't measure it, so should regularly consider how regulations mount as a small firm grows. Especially in today's economic recession, it's important to inventory all the regulations that impact a small business as it grows, and look hard at rollbacks (See **Appendix II** for a draft chart of how regulations mount as a firm grows.)

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[10] See Iain Murray, "A Wall of Separation Between Science and State," *Competitive Enterprise Institute*, October 19, 2006.

[11] From Iain Murray, "Patronizing Science," National Review Online's Corner, September 24, 2007. *http://corner.nationalreview.com/post/?q=Yzg0MThlYzFlMDAlMjY0NGM2NjlhOGM2ODQ0YzhiNjk=*

Relatedly, Congress could boost a more ambitious "R3" program (Regulatory Review and Reform) at the Small Business Administration's Office of Advocacy[12] to give entrepreneurs an avenue to protest onerous rules pouring out of more than 60 agencies.

Avoid New Regulatory Mandates in Service and Manufacturing Sectors

The challenge is to foster the creation of scientific and manufacturing wealth. Research and manufacturing do not happen in a vacuum, and all our communications and critical infrastructure impact the educational, scientific and manufacturing concerns at issue in the *America COMPETES Act*. To that end, Congress should avoid such sweeping policies as cybersecurity mandates that threaten infrastructure investment, avoid the likes of the new "National Broadband Plan," and avoid "net neutrality" mandates that either inappropriately influence funding decisions or dictate business models. New health care legislation likewise will inevitably affect the ability of firms to invest in research.

Liberalize the Nation's Communications Networks and Infrastructure

Innovation like basic research itself doesn't proceed in a vacuum; sectors inform and enrich one another, making it advisable to tear down regulatory silos artificially separating our great infrastructure industries wherever possible so that knowledge, ideas, products and collaboration flow more freely.

Maximizing infrastructure wealth creation—communications, transportation, energy, electricity, water and so on—bolsters the manufacturing sector that depends upon it all (as well as consumer well being). Here are a few steps Washington could implement:

- With respect to broadband deployment, declare "net neutrality" permanently off the table; announce that proprietary networks and investments will not be subjected to forced sharing and price controls, only voluntary agreements and alliances.
- Remove exclusive franchises that make it illegal, not difficult, for firms to compete with incumbent electric companies. Right now, it's illegal to run an extension cord across the street.[13]
- Establish an aggressive campaign to liberalize network and infrastructure industries, which are now artificially segregated into regulatory silos (telephone, electricity, water, sewer, cable, railroad, airline, air traffic control). This would create opportunities for them to work together and *jointly* invest in new power lines, fiber to the home, roads, bridges, airports, toll roads and more, and boost industries that depend upon them.
- Relax antitrust so that firms within and across industry sectors can combine and create business plans to bring capitalism and infrastructure wealth creation to the next level (described further in the following section).
- Liberalize spectrum and secondary markets in it such that wireless wealth is freely created apart from regulators.

Relax Counter-Productive Antitrust Laws

President Obama has suggested a desire to boost antitrust enforcement.[14] That's unfortunate. Antitrust can be a highly predatory anti-business and anti-consumer phenomenon.

Today, many universities and scientific centers pursue parallel research. In an alternative setup, innovators might pool efforts, and in so doing be a better target for VC investment with sophisticated profit sharing agreements. Such approaches may be hampered by government domination.

A recent *Financial Times* article noted over 800 research institutes involved in nanotechnology in the UK alone. What this reveals is an industry crying out for consolidation into perhaps a few large-scale research enterprises. Thus, antitrust liberalization obviously might occur to observant political authorities, for example, but you may rest assured that it likely has not. The same government-steers-while-the-market-rows approach dominates in the U.S.; nanotech funding is spread out not always according to market pressures, but across dozens of congressional districts.

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[12] *http://www.sba.gov/advo/r3*.

[13] See Wayne Crews, "The Free Market Alternative to Mandatory Open Access," *Electricity Journal*.

[14] *http://www.nytimes.com/2009/05/12/business/economy/l2antitrust.html?_r=1&adxnnl=l&adxnnlx=1268514088-MohE/8/mpcqIAEXJNqJ1JQ*.

The antitrust laws remain a significant barrier to a flowering of cooperative business efforts and private R&D. It is precisely in tech industries that private standard setting, joint research and risk sharing arrangements are most likely to overcome alleged market failures in basic research output. Yet some would block such arrangements, as well as mergers among firms engaged in like research. While vertical mergers are accepted, this sentiment should be extended to horizontal mergers or "collusion" that could bolster frontier research. Markets require competition, sometimes merger, and sometimes merely the kind of cooperation or "partial merger" often miscast as damaging collusion.

Through artificial constraints and interference, antitrust sends our great, productive firms into directions the market never intended, hobbling entire industry sectors. Antitrust vetoes market decisions and subdues enterprise by keeping it fearful. That destroys the very process of wealth creation itself. The misallocation of time, talent and resources, and wealth destroyed over the years by antitrust, is difficult to envision.

No firm is "larger" than the rivals, upstream suppliers, downstream business customers downstream purchasers, partners, consumers, Wall Street, advertisers, future competitors, global competitors media watchdogs, trade press, local-national-and-global capital markets. All of these discipline behavior, arrayed against the firm if it misbehaves.

Antitrust deprives the marketplace and consumers of the otherwise necessary competitive responses to the presumed monopolist's actions by these entities. Such short-circuiting of the frenzy of large-scale free enterprise causes economic disruption on a level a single firm could never do. Other ways to discipline errant market behavior include reinvigorating the market's own forces like hostile takeovers, the private "market for corporate control,"[15] that government itself in some instances has neutralized.

No "monopoly" is as large as the government. At a time when the economy needs stimulus we should not distract the wealth-creating sector's attention with artificial hindrances to growth rooted in smokestack era law.

Emphasize Rational Intellectual Property Policy

Give thought to the property rights regimes best suited to sustain wealth creation.

Government funding of research will increasingly present intellectual property dilemmas, such as calls for "open access" to either the data used in the conduct of research, or to the rights to the intellectual property underlying the fruits of the research, or use of the product itself.

Industries and companies seeking government funding of their pet projects would best reconsider. In an era in which so much new research in frontier scientific fields is government funded they should pause to consider that they are undermining their own chances at self-protecting their intellectual property, and are creating an environment for global "compulsory licenses" of sorts. Future hearings should address alternatives to compulsory licensing, and address the hazards to monitor regarding ownership status of government funded research. Ray Kurzweil testified that "The golden age of nanotechnology . . . will bring us the ability to essentially convert software, i.e., information, directly into physical products." If the product is the Ferrari he mentioned, we definitely want to get this policy right.

Public funding also creates often-needless conflict of interest disputes when government scientists interact with private ones. See "NIH Bans Collaboration With Outside Companies"[16] for example.

Public funding reintroduces the conflict between those who favor an "information commons," and those who feel information might best remain proprietary. The "information commons" approach is already leading to compulsory licensing calls in entertainment—movies and music—so it's a guarantee that open access will be demanded with respect to the genome, biotech, nanotech, pharmaceuticals, space science. If that occurs, even those who shun government money will not be immune to threats to their intellectual property. In our mixed, highly taxed and regulated economy, it's easy for anyone to claim that all research is subsidized in some way, leading to ever more public access, and a decrease in willingness to undertake research.

In certain respects public access to government data is appropriate (when that information is used to regulate, for example) but as a rule, that inclination is too sweeping, and we need to consider the broader implications; we need a different,

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[15] *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=244158.*

[16] Rick Weiss, "NIH Bans Collaboration With Outside Companies: Policy Comes After Conflict-of-Interest Inquiry," Washington Post, September 24, 2004; Page A23.

more complete vision that cuts across issues, that warns of the downside of any expectation of automatic public access to research data.[17]

The ethic of public access sounds appealing and it is, but there can be downsides. Properly construed, in the productive economy, proprietary models can serve to increase the amount of information created more than open, non-proprietary ones do. In the productive sphere, all government needs to do is permit open access to information for those who prefer to operate that way (consider the case of open source software), but leave room for other business models too. Sometimes people and companies keep "secrets," and there's nothing sinister about their doing so, and it's ultimately good for basic research and for mankind, and others can reject their results.

It's one thing for policymakers to be reluctant to extend legal intellectual property protections; but for data and results to *automatically* belong in the public domain, to even forbid private intellectual property protection, seems to be the ultimate end of some points of view. (In entertainment, for example, full-blown opposition to copy protection technology is seen as a normal viewpoint.)

Open access policies are, of course, almost impossible to avoid when government is funding the science. Transparency is critical when government is involved since government does not rely on voluntary arrangements. Thus, the analytic basis for, say, air pollution regulations should be available. In contrast, no one should be able to demand that a scientist disclose the recipe for Red Bull.

Sunset Regulations and Implement a Regulatory Reduction Commission

More than 60 departments, agencies and commissions issue some 4,000 regulations a year in thousands of *Federal Register* pages, all of which are documented in *Ten Thousand Commandments: An Annual Snapshot of the Federal Regulatory State*.

Costs of regulations run at an estimated $1.2 trillion annually. Congress should implement a bipartisan "Regulatory Reduction Commission" to survey existing rules and assemble a package to eliminate with a straight up-or-down vote, no amendments allowed.

Halt "Regulation Without Representation" by Requiring Congressional Approval for Major Business Regulations

Of the 4,000 annual regulations, 100 plus are "economically significant." Rather than the current "resolution of disapproval" process, these rules should require an expedited congressional approval before they are effective. Apart from the competitiveness and innovation issues that concern the COMPETE Act, the delegation of legislative power to unelected agencies has long been something needing attention. We should continue to challenge delegation of legislative authority from Congress to agencies, and at least require congressional fast-track approval before major or significant non-quantifiable agency-promulgated regulations take effect.

Perform Basic Deregulatory Housekeeping

A difficulty is that the specific regulatory programs under each agency also have cheerleaders that make it difficult to reform. So in the meantime, freezes, purges and the like should be actively pursued; those can be based on gleaning better information about just what it is that the dozens of agencies are up to.

Performing government's proper task of liberating economic enterprise instead of spending stimulus requires tasks like the "move the rock" policies noted above; but also basic annual procedures, monitoring and housekeeping like the below are part of maintaining rational policy:

- Re-discover federalism, that is, circumscribe the Federal role regarding investment and regulatory matters best left to states and private enterprise. Congress should look at what Federal Government does that it could eliminate, or that states could do instead to provide a manufacturing boost.
- Improve the ethic of quantifying regulatory costs, and selecting the least-cost compliance method.
- Codify President Clinton's executive order on "Regulatory Planning and Review" (E.O. 12866), or, Reagan's E.O. 12291 which provided for more external review.
- Require OMB's Regulatory Information Service Center to publish number of major and minor rules produced by each agency, and strengthen its oversight.

[17] For a related debate see James Robinson, "MPs to call for free online access to science journals," July 11, 2004. *http://politics.guardian.co.uk/news/story/0,9174,1258849,00.html*.

- Reinstate the Regulatory Program of the U.S. Government, which formerly appeared routinely as a companion document to the Budget.
- Declare *Federal Register* notices as insufficient notice to small business
- Hold hearings to boost the scope of the Small Business Administrations' "r3" regulatory review program.
- Lower the threshold at which a point-of-order against unfunded mandates applies.
- Implement a supermajority requirement for extraordinarily costly mandates.
- Lower the threshold for what counts as an "economically significant" rule, and improve explicit cost analysis.
- Explore, hold hearings on, and devise a limited "regulatory budget."
- Establish an annual Presidential address or statement on the state of regulation and its impact on productivity and GDP.
- Sunset regulations after fixed period unless explicit reauthorization is made.
- Require that agencies calculate Costs, but not benefits, which Congress should have considered already
- Create new categories of major rules to improve analysis
- Publish data on economic and health/safety regulations separately
- Disclose transfer, administrative and procedural regulatory costs
- Explicitly note indirect regulatory costs
- Require agencies and the OMB to: (1) Recommend rules to eliminate and (2) Rank rules' effectiveness
- Create benefit yardsticks to compare agency effectiveness

Issue and Act Upon a Annual Regulatory Report Card to Accompany the Federal Budget

In attempting to implement economic liberalization for the wealth creating sector, a "Regulatory Report Card" should be part of the basic housekeeping just noted.

Regulatory Report Card . . . with five-year historical tables . . .

- Total major ($100 million-plus) rules and minor rules by regulatory agency
- Numbers/percentages of rules impacting small business
- Numbers/percentages featuring numerical cost estimates
- Tallies of cost estimates, with subtotals by agencies and grand total
- Numbers and percentages failing to provide cost estimates
- Federal Register analysis: Pages, proposed and final rules by agency
- Most active rule-making agencies
- Rules that are deregulatory rather than regulatory
- Rules that affect internal agency procedures alone
- Numbers/percentages required by statute vs. rules agency discretionary rules
- Rules for which weighing costs and benefits is statutorily prohibited
- Detail on rules reviewed by the OMB, and action taken

If Taxpayers Do the Funding, Let Taxpayers Call the Shots

Other people have goals that are just as legitimate as those with the wherewithal to get representation by lobbyists in Washington or to appear at a hearing. We don't always hear their voices. My Cato Institute colleague Tom Miller put it best when asked by tech reporter about Federal nanotech funding: he said, "I suggest giving them nanodollars."

In proposing an end to the Advanced Technology Program years ago, Michael Gough offered a real test of taxpayer support: "Let the government give taxpayers who want to invest . . . a deduction from their income . . . [and] share in any profits that flow from it. That's what taxpayers get from private investments. It's not what they get [when government] takes tax money . . . and invests it in private enterprise."

In Conclusion, Compete for Real

As sometimes noted, occasionally the problem with research isn't market failure but the failure to have markets.

This call for reassessment coincides with many months of recession. The bold political action and genuine leadership needed in a crisis today is different from what's going on. Indeed, the political price can be too high for election-bound lawmakers or career politicians to entertain non-governmental recession recovery.

As Friedrich Hayek pointed out, the politicians blamed during a bumpy transition to something closer to laissez-faire will be the ones who stop interest-group benefits, stop labor union benefits, or stop the inflation, stop the mal-investment created by earlier government interventions and favoritism, and so on—not the ones who started those costly processes decades ago. Instead, government proposes to spend a great deal of money, but leave all these interventions in place and add more besides, cementing a national government "role" in science and manufacturing.

Real stimulus, that of comprehensive liberalization of a fettered economy, requires perhaps unpalatable changes in what people expect from government now that they've come to depend on what it redistributes. That's a seemingly intractable problem, and I'm not sure the country can recover from it—but leadership would require making the attempt. So, again, political reality prevents halting the compounded economic damage that artificial stimulation and financial "bailouts to nowhere" promise to deliver. Political reality tends to prevent the separation of state and economics.

Markets and capitalism manage risk and generate wealth; our shortfall is often to have too little capitalism and free enterprise, properly understood, not too much. Unfortunately that lesson isn't being learned, and the ability to reinvigorate the disciplinary institutions of capitalism diminish by the day as governments assume greater control and powers over important economic sectors like science and technology that will be difficult, if not impossible, to wrest from them. Another Contract with America may or may not be welcome, but a handshake in deference to free enterprise would go a long way today.

APPENDIX I

Terrence Kealey* and others on Government R&D

Prepared by Roger Abbott, research assistant, CEI

Government funding is UNNECESSARY:
Industry has an incentive to fund pure & applied research: Nelson / Arrow argue that industry will not fund basic science, because it cannot capture all of the benefits accruing from their investment. Kealey refutes this by arguing that aside from the protections offered by IP law, efforts to assimilate new technological development are expensive and require industries to fund pure research. "It takes years of training before a scientist can read research papers properly and understand their implication for the future. It takes hours, every week, to read all the new research papers, to assimilate them and to integrate them into a future research strategy… To retain good scientists, therefore, companies – essentially – bribe them with laboratories, money and the freedom to publish, much as a company pays lawyers' fees."

Government funding is HARMFUL:
"Politicians are poor judges of commercial opportunity, generally lack the necessary expertise, and are unduly influenced by short-term political considerations."

- Wrong Incentives result in waste. Large projects, therefore, are frequently awarded as pork barrel grants (regardless of actual need), or out of a nationalistic fear of "falling behind" other governments in funding science.
- Politicians have historically been inept at judging commercial opportunity, as the heady pace of technological development frequently renders grandiose projects redundant before they are even completed. As Kealey points out, European governments wasted huge sums of money in the early 1990s to improve domestic electronic manufacturing: e.g. Alvey and ESPRIT, include BRITE/EURAM, COMETT, COST, EUREKA, MONITOR, RACE, SPRINT, Telematics and VALVE.
- Government funding unreliable: Finally, it is risky for scientists to stake their careers on government projects that could easily be killed by politicians, either due to low revenues or to some other political whim. For instance, in 1993, Congress suddenly cut the Superconducting Super Collider (SSC) project. "This project, which had already consumed $2B of its $11B budget, employed 2000 scientists and engineers who, on 21 Oct 1993, were given just 90 days' severance pay – insulting treatment." [Kealey]
- Scientists waste thousands of hours filling out grant applications: e.g. within two months of the passage of the stimulus bill, 21,000 applications had been made for stimulus funds. Due to the complexity of the process (each lengthy application is judged on a 41-point scale), an average application takes three reviewers twelve hours to consider.
  http://blogs.sciencemag.org/scienceinsider/2009/06/nih-feeling-ove.html
- Grant process awards networking skills / encourages patronage, rather than rewarding results. This argument is convincingly made by Robin Hanson, who highlights the nexus between government centralization, the use of grants rather than prizes, and the rising importance of patronage ties.
- Taxpayer funding crowds out private funding by reducing the availability of capital / increasing the tax burden on companies, and creating an incentive for companies to "fish" for cheap research by building ties with universities (e.g. relying on cheap post-docs) rather than funding their own. Kealey points out that this trend results in much lower wages for scientists.

* Terence Kealey is professor of clinical biochemistry at the University of Cambridge, England, and author of The Economic Laws of Scientific Research.

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APPENDIX II

FEDERAL WORKPLACE REGULATION IMPOSED ON GROWING BUSINESSES
(Draft—Wayne Crews/CEI)

**Assumes non-union, non-government contractor, with interstate operations and a basic employee benefits package. Includes general workforce-related regulation only. Omitted are important categories such as environmental and consumer product safety regulations, and regulations applying to specific types of businesses such as mining, farming, trucking or financial firms.*

ONE EMPLOYEE
-Fair Labor Standards Act (overtime and minimum wage [27% min. wage increase since 1990])
-Social Security matching and deposits
-Medicare, FICA
-Military Selective Service Act (90 days leave for reservists; rehire discharged veterans)
-Equal Pay Act (no sex discrimination in wages)
-Immigration Reform Act (eligibility must be documented)
-Federal Unemployment Tax Act (unemployment compensation)
-Employee Retirement Income Security Act (standards for pension and benefit plans)
-Occupational Safety and Health Act
-Polygraph Protection Act

4 EMPLOYEES: ALL THE ABOVE, PLUS
-Immigration Reform Act (no discrimination with regard to national origin, citizenship, or intention to obtain citizenship)

15 EMPLOYEES: ALL THE ABOVE, PLUS
-Civil Rights Act Title VII (no discrimination with regard to race, color, origin, religion, or sex; pregnancy-related protections; recordkeeping)
-Americans with Disabilities Act (no discrimination, "reasonable accommodations")

20 EMPLOYEES: ALL THE ABOVE, PLUS
-Age Discrimination Act (no discrimination on the basis of age against those 40 and older)
-Older Worker Benefit Protection Act (benefits for older workers must be commensurate with younger workers)
-COBRA (continuation of medical benefits for up to 18 months upon termination)

25 EMPLOYEES: ALL THE ABOVE, PLUS
-Health Maintenance Organization Act (HMO Option required)
-Veterans' Reemployment Act (reemployment for persons returning from active duty, reserve, or Nat'l Guard)

50 EMPLOYEES: ALL THE ABOVE, PLUS
-Family and Medical Leave Act (12 weeks unpaid leave or care for newborn or ill family member)

100 EMPLOYEES: ALL THE ABOVE, PLUS
WARN Act (60-days written plant closing notice)
Civil Rights Act (annual EEO-1 form)

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APPENDIX III

BIO and Selected Writings

Clyde Wayne Crews Jr. is vice president for policy and director of technology studies at the Competitive Enterprise Institute and a former Cato Institute scholar. He is widely published and a frequent speaker at venues ranging from the DVD Awards in Hollywood, to the European Commission, to the National Academy of Sciences, and has testified before congressional committees on various policy issues. Wayne is a dad of four, can do a handstand on a skateboard, and loves his custom motorcycle.

Wayne's work explores the impact of government regulation of free enterprise on individual liberty, rights and innovation: Areas of interest include antitrust and competition policy, safety and environmental issues, and information age concerns like privacy, online security, broadband policy, intellectual property and frontier sciences.

Wayne is the author of the popular *Ten Thousand Commandments: An Annual Snapshot of the Federal Regulatory State*, and he co-authored the recent reports This Liberal Congress Went to Market? a Bipartisan Policy Agenda for the 110th Congress and Communications without Commissions: A National Plan for Reforming Telecom Regulation. Prior to the assorted government bailouts, he wrote the report Still Stimulating Like It's 1999: Time to Rethink Bipartisan Collusion on Economic Stimulus Packages.

Wayne is co-editor of the books *Who Rules the Net?: Internet Governance and Jurisdiction*, and Copy Fights: The Future of Intellectual Property In the Information Age. He is co-author of *What's Yours Is Mine: Open Access and the Rise of Infrastructure Socialism*, and a contributing author to other books. He has published in the *Wall Street Journal*, *Chicago Tribune*, *Forbes*, *Communications Lawyer*, the *International Herald Tribune* and others. He has made various TV appearances on Fox, CNN, ABC, CNBC and the Lehrer NewsHour, and his reform ideas have been featured prominently in such publications as the *Washington Post*, *Forbes* and *Investor's Business Daily*. He contributes to blogs such as OpenMarket, Tech Liberation Front and the Daily Caller.

Earlier Wayne was a legislative aide in the United States Senate to Sen. Phil Gramm, covering regulatory and welfare reform issues. He was an Economist and Policy Analyst at Citizens for a Sound Economy Foundation, and has worked as an economist at the U.S. Food and Drug Administration and as a Research Assistant at the Center for the Study of Public Choice at George Mason University. He holds an M.B.A. from William and Mary and a B.S. from Lander College in Greenwood, South Carolina. He was a candidate for state senate as a libertarian while at Lander. He started the Dysfunction Network as a side project.

Selected Writings

Here are links to some of Wayne's CEI articles, studies and media citations. Below appear some selected writings, congressional testimony and other official filings, as well as articles from the Cato Institute.

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BIOGRAPHY FOR WAYNE CREWS

Clyde Wayne Crews Jr. is vice president for policy and director of technology studies at the Competitive Enterprise Institute and a former Cato Institute scholar. He is widely published and a frequent speaker at venues ranging from the DVD Awards in Hollywood, to the European Commission, to the National Academy of Sciences, and has testified before congressional committees on various policy issues. Wayne is a dad of four, can do a handstand on a skateboard, and loves his custom motorcycle.

Wayne's work explores the impact of government regulation of free enterprise on individual liberty, rights and innovation: Areas of interest include antitrust and competition policy, safety and environmental issues, and information age concerns like privacy, online security, broadband policy, intellectual property and frontier sciences.

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Earlier Wayne was a legislative aide in the United States Senate to Sen. Phil Gramm, covering regulatory and welfare reform issues. He was an Economist and Policy Analyst at Citizens for a Sound Economy Foundation, and has worked as an economist at the U.S. Food and Drug Administration and as a Research Assistant at the Center for the Study of Public Choice at George Mason University. He holds an M.B.A. from William and Mary and a B.S. from Lander College in Greenwood, South Carolina. He was a candidate for state senate as a libertarian while at Lander. He started the Dysfunction Network as a side project.

Visit http://hyperfamily.blogspot.com/2004/12/about-wayne-crews.html for more information about Mr. Crews.

Chairman GORDON. Thank you, Mr. Crews.

As I had mentioned earlier, but for the Members that have just come in, we are expecting to have votes at 11:00, which means that we will probably need to be leaving at 11:10 or so. For that reason, I am going to be stricter on the five-minute rule so that we can try to get through, and not impose on our witnesses to have to stay, and also since I made an earlier statement, I am going to waive my right for questions. I will wait until later and call on Dr. Baird.

Mr. BAIRD. I thank the Chairman. I thank our distinguished panel. Mr. Chairman, I think this is a critical issue and I commend you.

One of the things I am most impressed with is the initiative of your various organizations, you know, especially the chemical industry, particularly the consumer products, the work you are doing

in creating jobs, creating new products, GM as well, and in nanotech that are environmentally friendly. I think you deserve a tremendous amount of credit.

I am very intrigued by this issue, Dr. Tuominen, of an interagency approach. You know, we tend to silo a little bit and we hear a lot about this on this Committee. We have got NSF and NIH [National Institutes of Health], sort of the basic research, and then how do we scale that up? Dr. Smyth talked about MEL as a vehicle, but it tended to seem to me that, if I may paraphrase, we are strong on the innovation side but we are not as strong on linking that innovation to the actual manufacturing that is going to create the long-term jobs. Expand on that theme, if you would. What else do we need to do to make this more efficient? Dr. Tuominen and then any others.

Dr. TUOMINEN. I first will mention that I am answering from the nanomanufacturing hat, and nanomanufacturing being a new field, and that the agencies are already working together in the National Nanotechnology Initiative, it makes it much easier. But I can say from where I sit, that has been a great benefit to the field, because we are aware of what is going on in NIST, DOE, DOD [Department of Defense], NSF and other agencies with regards to nanomanufacturing, and we see the benefits of having this global vision in terms of avoiding duplication, of taking advantage of synergies between the agencies. It is proving to be very productive.

Mr. BAIRD. So you feel we have got some of that happening already in the interagency work on the nanotech initiative. Dr. Smyth or Sauers or Chakrabarti?

Dr. SMYTH. I think I mentioned there are a number of successful collaborations but they are kind of like islands of excellence, such as the NASA robot initiative, such as some of the work that we have done at MEL. I think if you had a cross-agency forum, and not just one that created papers but one that created a strategy and had people who were engaged from both academia, the government and the systems perspective, both from small and large business—get a strategy, get a roadmap and start plugging in the technologies to that, because I am going to quote the wall: "Where there is no vision, the people perish."

Dr. SAUERS. And I think I will just continue the thought. P&G has benefited greatly from the relationships we have had with some of the national labs and the relationship we have with the Department of Energy, but we stumble upon these opportunities. There really isn't a transparency of what is available and who is willing to work with industry, et cetera. You know, I could see some sort of interagency approach like that, helpful in providing that transparency.

Mr. BAIRD. Mr. Chakrabarti?

Mr. CHAKRABARTI. I am going to concur with Dr. Smyth. The ability to create a cross-agency approach that also takes feedback from both small and medium enterprise and large enterprise is very critical. We have excellent technological programs that are federally funded. We have large enterprises that have both the financial ability as well as the expertise to commercialize, and you have small and medium enterprises that have the willingness and the entrepreneurialism to take risk. Being able to bring all three

of them together is a very critical challenge, but a very critical opportunity for our country.

Mr. BAIRD. I should say, Mr. Chakrabarti, you have got two delightful children in the back there.

There was an article in *Harvard Business Review* that I bring up a lot in this Committee, and it was about maybe five months ago now, about how we tend to do the innovation here and then offshore the manufacturing and then ultimately the manufacturing drives the innovation elsewhere and we lose our lead. What can we do to reduce that?

Mr. CHAKRABARTI. I think a first step is involving the entire manufacturing economy in feedback when it comes to Federal research. You touch upon a very sensitive point. If you remember our steel industry, it is exactly what happened. We were conquered with our own technology built on our own soil. We don't want to see that happen again. The ability to create the feedback and the input, it needs to be a dynamic process between industry and federally funded research. The world is changing. Our response must be dynamic. If we can have an agency, a cross-agency approach that we just talked about, along with an industry forum committee roundtable that provides continuous feedback on its approach and its programs, I think we would be much better off.

Chairman GORDON. Thank you, Dr. Baird.

Mrs. Biggert is recognized. Oh, I am sorry. Mr. Hall is recognized. Excuse me, Mr. Hall.

Mr. HALL. I yield to Mrs. Biggert.

Mrs. BIGGERT. Oh, Mr. Hall, you are so kind. I appreciate it. I will take advantage of it.

Dr. Smyth and Dr. Sauers and Mr. Chakrabarti, Dr. Holdren testified before this committee a few weeks ago about how this Administration's R&D investments will keep America competitive. However, there are many factors other than that that play into our competitiveness in the world, and what particular laws or regulations are increasing your company's costs, and how is this affecting your ability to manufacture in the United States and invest in R&D? I will start with Dr. Smyth.

Dr. SMYTH. That is basically outside my span of the ability to comment. I would say in terms of laws, maybe if we go to charters rather than laws, and talk about NIST or some of the national labs, what you have is a charter that focuses on technology readiness. If you had a scale from one to ten that focuses one to three. What we really need to do is expand that charter from three to six and do, for example, what Germany does with the Fraunhofer Institutes and take technology from where the concept of the product is ready to where you are addressing manufacturing issues, so you can deploy stuff at volume and at rate, because that is when you are going to make the economic and you are also going to make the environmental impacts. So it is about stretching maybe a charter rather than a law in the context of manufacturing technology.

Mrs. BIGGERT. Dr. Sauers?

Dr. SAUERS. And again, the specifics are outside my specific area of knowledge but just in generality again, I think we find ourselves more in so much uncertainty, and it is really the uncertainty that causes problems, the lack of predictability. And you can just see a

whole host of regulations today where we live in uncertainty: R&D tax credit, health care, those kinds of things. And I think for us to be most competitive, a sound, predictable, certain regulatory structure is helpful.

Mrs. BIGGERT. Thank you.

Mr. Chakrabarti.

Mr. CHAKRABARTI. I am going to echo what Dr. Sauers said, but coming from the chemical industry, I will make two points. Regulatory compliance in the United States, the costs associated with it, as Mr. Chairman brought up in his opening statement, is a significant cost to chemical industry. And by its very virtue, it pulls capital dollars from other areas of investment, especially innovation. Secondly, the cap and trade has us very concerned. As we enter into a new era in environmental responsibilities, we have to be very careful not to increase the transaction costs associated with doing so.

Mrs. BIGGERT. Thank you.

Then Dr. Smyth, in your testimony you talk about vehicle electrification and the domestic manufacturing needs to support deployment. Do you see a need for more infrastructure capacity to support electric vehicles?

Dr. SMYTH. Absolutely. I think one of my esteemed colleagues here talked about the infrastructure and the grid, and that is essential if we are going to develop a reasonable percentage of electric and extended-range electric vehicles. You have to have an infrastructure to plug them into, so that is very, very important.

Mrs. BIGGERT. Then Dr. Sauers, I think you answered part of this, but in your testimony you mentioned that your company sets a goal for innovation to have at least 50 percent of all initiatives with at least one significant external partner. So what type of entities do you typically seek partnership with? You did mention the labs, but are there others that you deal with?

Dr. SAUERS. Well, our process is to go through a consumer understanding, understanding the needs of the consumer relative to consumer products, then go through the innovation process to develop those products that meet those needs. We are open to partner with anybody that is able to bring forward to us ideas that help us accomplish that goal. So we work with small and medium enterprises, we will work with governments, national labs, anyone that is able to come forward. We have a website, our Connect + Develop website, where we put out what our needs are relative to innovation, and then we ask people to respond back to us through that website with their ideas.

Mrs. BIGGERT. Thank you. I yield back.

Chairman GORDON. Thank you, and Mr. Miller is recognized.

Mr. MILLER. Thank you, Mr. Chairman. I am unconvinced by any argument that government simply needs to get out of the way and that innovation will come entirely from the private sector. Far too many of the most important innovations, including transformational technologies like DARPANET [Defense Advanced Research Projects Agency Network], have come originally from government research, and there obviously is too much at risk in some basic research to think that it can all be privately funded. But I am intrigued by the idea of prizes as encouragement to the private

sector. The Malcolm Baldrige awards have been remarkably effective in encouraging not just those who win the awards, but in kind of getting their minds around what constitutes excellence. They have had remarkably useful results for those companies that have competed for Malcolm Baldrige awards. I think Mr. Crews mentioned the idea of prizes as encouraging an entrepreneurial type of effort to—we aren't going to dictate the technology, we are not going to pick who does it, but if you can go do this, we will give you a prize, and the prize can be big. And from what I have heard from high-tech companies in my area at the Research Triangle, SBIR and STTR is about as important for the imprimatur that you get from having those awards as it is for the money itself.

What do each of you think about prizes? What are the limits? What are the values? How can they fit into the overall government effort, the role of government in encouraging innovation in manufacturing?

Dr. SMYTH. I think prizes are a really interesting mechanism, and I think it depends very much on the type of technology you are trying to drive. If you look at advanced manufacturing, and you can go from anything from virtual down to real, where you are working on sensors or you are working on production lines, if you are focused on something that is more capital-intensive, I would say prizes would be least effective. If you are focused on something that is perhaps virtual, that could open up maybe basically a person with a laptop trying to figure out a solution, then I think it is a fantastic approach.

One thing I will say is, there was a DARPA Grand Challenge and that was a prize that General Motors, in collaboration with Carnegie Mellon, won a couple years ago. It was the autonomous vehicle. And without going into detail, suffice to say the investment in producing the autonomous vehicle outweighed by orders of magnitude the individual prize, but the point that I am making was that prize was about developing a system. It was about developing a technical solution to a system on autonomous driving. There were maybe 100 different sensors and detectors that had to be integrated so we could understand how the vehicle could move on its own. Only a company, or a partnership as it was in this case of companies and universities, with a systems-level approach could achieve the end goal.

Dr. SAUERS. First to your initial comment, I personally see great value in the government being involved in the R&D investment. I think the government is necessary, through their funding, to develop the disruptive technologies, and also plays a great role in education, especially the STEM program as we're seeing today. I think the R&D investment by our government is really what sets us apart from others.

If I think about P&G and their R&D activity, you know, we are driven by meeting consumer needs and will partner with those that help us develop the innovations that meet those needs. It is hard for me to necessarily see a primary role for prizes to motivate something like that. It is really the business application that does it.

Mr. CHAKRABARTI. First of all, I agree that the government's role is very important in research. I can't talk specifically on prizes, but

the concept of a competition—I will talk a little bit about the SBIR. I think it is a truly valuable program. It targets high-risk innovators and provides both the capital and, very importantly, the credibility they desperately need for private funding. In addition, the competitive nature not only helps pick the best prospects but readies the recipients by requiring them to think through their projects in a comprehensive manner, creating better quality projects for research. The government's role in funding research, both federally funded and through the private industry, is very critical for the risk sharing that is necessary for transformational technologies for the government to assist private industry in taking those high-end risks for technological innovation.

Chairman GORDON. Mr. Miller, if it is okay, before we run out of time, why don't we skip over to Mr. Crews, who really raised this issue in the first place?

Mr. CREWS. Okay, just quickly, I think prizes do have some merit. The only point I would make about it is, you do have to be careful about whether the end you are trying to achieve is something that ought to be a governmental role or private-sector role. If you need to come up with a new homeland security technology, a much better—you know, any kind of major technology like that that involves America's ends, political ends and security ends, prizes make a lot of sense. They also make a lot of sense in transitional ways, of finding new ways of dealing with government investment in high-tech areas like nanotech and other areas. The spaceship one was a prize phenomenon, or parts of it were, same with the way Netflix always tries to upgrade its search system and things like that. There are numerous ways that they can be used as an alternative. You just have to be careful and make sure that the end is the right one, that it is something that——

Chairman GORDON. Thank you, Mr. Crews, and Dr. Ehlers is recognized.

Mr. EHLERS. Thank you, Mr. Chairman, and I thank the panel.

When I was elected to Congress some years ago, I never expected how much time I would have to be spending on manufacturing issues, largely because I come from a manufacturing state first of all, but secondly, there was little interest in the Congress in manufacturing and innovation. There was sort of this laissez-faire attitude—well, they are a business, they have got money, they can do the research, they will develop the products, et cetera—neglecting a very important role, and I have often compared the issue in manufacturing with farming and agriculture and the role that the government played in that starting with the land-grant universities and going forward. And most people don't realize the money that we spend still today on helping farming, and I find it ironic that in agriculture, because of the change in mechanization and so forth, back in the 1880s something like 80 percent of our economy was in farming and employees were in farming. Today it is closer to two percent of the employees are employed in farming. And yet we continue to spend about $400 million a year as a Federal Government on the Cooperative Extension Service. Now, I am certainly not opposed to that. It is very useful. That is a way for the government to get its research results out quickly to the farming community, and I was amazed that Michigan State University developed

something new in the labs one year and the next year the farmers are using it in the fields. We don't have anything like that in manufacturing. I have spent far more time than should have been necessary on the Manufacturing Extension Partnership. It has been like pulling teeth every year to try to get $100 million out of the Congress and the President for the Manufacturing Extension Partnership, which combined with SBIR, all of those things working together really are very effective. This year we are spending $400 million on a part of the economy that has two percent of the employees, and I have to struggle to get $100 million to go towards a part of the economy that has 15 percent of the workforce, namely manufacturing. We just don't have our heads screwed on right here in the Congress, and I think in the Nation, as to the importance of manufacturing and the importance of the government role in innovation. I agree with Mr. Miller and his comments, this idea that somehow if we interfere with manufacturing we are interfering with the private sector, but we interfere with agriculture and we are not. It doesn't make sense. So I apologize for giving a sermon but this is—now that I am retiring, I can act like an angry old man and say why didn't you listen to me all these years. But that is one of our big problems.

I do have a question that is related to this. How can we more effectively compete as a Nation, and what is the government's role in this competing against low-wage nations? That is a major problem we face today. And I don't see a clear path there, and I am wondering if any of you have any really good wisdom on how we can best proceed there.

Dr. TUOMINEN. I will just make a short comment. In the new technologies that are promising, we have to keep them here. We have to set up the manufacturing base for those here and we have to do it posthaste, and how do we do it? We need to educate the workforce quickly so that there becomes a manufacturing base, so, for example, in nanotechnology where this is this demand for all these workers and they don't exist in the United States, well, where do the ideas go? They go overseas. The other thing we have to do is create an environment for shared risk and loosen the capital markets by any mechanism possible so that all factors can help those companies grow here.

Mr. EHLERS. Yes, the capital market problem I hope is a transitional problem we are having right now, but you are absolutely right. I have a lot of manufacturers in my district. They have firm orders: they cannot borrow the money to build the product. But I appreciate the comment you made vis-à-vis other countries but we really have to concentrate on that, and the government's role is to the high-risk, high-reward research but also to aid. It drives me out of my mind. Every year I have fought to make the R&D tax credit permanent because the bean counters in your companies don't want to take a chance that it won't be renewed, and so it is not really a factor in their thinking. If we make it permanent, it is there for you and I think it should be increased.

Chairman GORDON. Thank you, Dr. Ehlers, and we are going to let Mr. Smith have rebuttal in just a moment, but right now we will go to Mr. Peters.

Mr. PETERS. Thank you, Mr. Chairman.

Dr. Smyth, a question for you. You talk in your testimony about the importance, certainly in the auto industry, of the auto supplier network, where a great deal of innovation occurs and certainly in the manufacturing process critical for General Motors and all of the Big Three. If you could maybe flesh out a little bit as to what we should be thinking about at the Federal level to be helping those auto suppliers who right now are, as you know, hanging on by their fingernails given where the economic situation is right now, and their budgets are strained for their ability to do the kind of research and development necessary for them to continue to be competitive, particularly with foreign suppliers that may be looking to supply to our domestic automakers. What should we be doing?

Dr. SMYTH. Well, I think two things. The suppliers being a part obviously, a huge part of the relationship with USCAR, which is the United States Council for Automotive Research and that has been a big factor of it, and developing technologies—I think a lot of times when people talk about developing technologies in the automotive sector, I really think you are developing it for the OEMs. We talked about some of the work that we did at NIST to develop standards that generate into smaller companies. There is a lot of technology that we can develop that we will never be using as our core technology. I think it is about providing forums for the big companies to work with the small companies, but again, those forums, they have to be resourced. They can't just be paper-generating, strategy-writing forums, and I think that is really essential. But I do think we should build on the success of consortia like USCAR and introduce other Federal agencies—maybe it is DOD or maybe it is the EPA [Environmental Protection Agency] or whatever, introduce a wider spread of government agencies, get that cross-agency forum and plug in supplier bodies.

Mr. PETERS. Now, many of you have mentioned public-private partnerships as the model for this kind of funding, so perhaps there are some brief comments as to what is an ideal structure for that public-private partnership. Mr. Crews, you may not believe that there are any, and if there are, is there a model? Maybe I will start with you. Is there a model that we could use?

Mr. CREWS. Well, basically we talk a lot about cross-agency consortia. I am just reminding you that whatever you do with COMPETES Act and the investment, it is still a small fraction of the resources that need to be freed up to get the economy going. That is what I think is important to point out. You have got to deregulate, you have to make it so that the foreign workers who come here and get educated can stay. There are a number of things like that, liberalizing infrastructure so tech and telecom and those kinds of things can move along. But in addition to considering cross-agency partnerships, also think about what institutions it is in society that are the source of wealth creation, and we know that is markets and the ability of capitalism to bring together people who don't know one another to put resources together to create great wealth. So look at cross-industry consortia too. Look at what impact the antitrust laws might have on preventing American companies from taking free enterprise to the next level, so to speak, to compete on a global level.

Chairman GORDON. Mr. Peters, would it okay if I went on to Mr. Smith now?

Mr. PETERS. Absolutely.

Chairman GORDON. Thank you. Mr. Smith, representing the rural part of our country.

Mr. SMITH. Thank you, Mr. Chairman. I will try to be brief. A couple things.

One is my concern that the inputs to manufacturing are not always subject to the marketplace and yet the output, although some public policy folks would like to dictate what those products are, ultimately it is still up to the consumer whether or not—and the marketplace whether or not to purchase vehicle A, B, C or D. And so I see that as unsustainable. If you might wish to comment about that, but perhaps even more specifically, Dr. Tuominen—with a last name like Smith, I am a big challenge except by those with a Y instead of an I.

Dr. SMYTH. Nice catch.

Mr. SMITH. I do—I want to talk a little bit about the Environmental, Health, and Safety program component area of the National Nanotechnology Initiative. I know it is getting a 20 percent increase in fiscal year 2011 after receiving a substantial increase in fiscal year 2010 as well. How do these increases impact funding for the other, and I would say equally important, six program component areas, one of which is nanomanufacturing?

Dr. TUOMINEN. Well, with regards to nanomanufacturing, it hasn't affected it at all, and in fact, I think they are complementary, that worker safety, consumer safety, environmental safety is a natural twin to nanomanufacturing development, and here is a case where in terms of the funding levels, if you look at 2009 through the proposed 2011, both of these have grown commensurately, and that is how it should be. So I think there is good progress in both areas.

Mr. SMITH. Mr. Crews, would you wish to comment?

Mr. CREWS. So what were you implying about the input to manufacturing compared to output?

Mr. SMITH. If you want to comment. I mean, the inputs into manufacturing are not always based by the marketplace or based on the marketplace and yet the output is. I mean, that seems to be not sustainable, not necessarily environmentally but economically sustainable, and how do we get around that perhaps, and then also how do we counter that?

Mr. CREWS. Well, I guess there a lot of ways. In the testimony, I outline a lot of ways of looking at liberalizing the economy and looking at different particular sectors and removing regulation and looking at tax burdens and things of that sort, but—well, I don't know. In terms of—I think it is important to restructure, you know, look at this in terms of, if you are going to invest federally, are there different ways of doing it? Maybe taxpayers could have some selection, some choice in what technologies they want to foster. It is just that you run into a real problem when trying to select technologies to invest in and what that will do in terms of how that steers the market and where that is going to take things. That is what you have to be really careful about, so while you look at general research, also look at other ways that also foster general re-

search that the private sector can do too. I know that the Federal Government has that role to play. I see it specifically in defense areas and things of that sort.

But, please, I urge you to look at ways that you can deal with antitrust law, liberalizing infrastructure, looking at what it is that motivates scientists to do basic research in the first place. It is true that basic research can get captured, and there is always that market failure argument that the private sector doesn't do enough, but it turns out that when you have unfettered global markets, companies don't always capture their own intellectual property, their own resources, but they capture it from other firms who are doing it too. To retain scientists, you have to pay them more and you can create problems and disruptions in that by trying to direct things—I am just saying you have to be very, very, very careful about the Federal, I called it, you know, the Federal Government steering while the market rows. You have to be very careful about where you do that but at the same time that you do it, make sure that you are liberalizing in other areas so that if there is a way the private sector can take on that role, you let that happen because that——

Chairman GORDON. Mr. Smith, is it all right if we go to Mrs. Dahlkemper?

Mr. SMITH. Thank you.

Chairman GORDON. Mrs. Dahlkemper, sorry, but could you maybe have one real good question?

Mrs. DAHLKEMPER. I will be very brief.

I just want to reiterate what Dr. Ehlers said in terms of the MEPs, and I sit on the Ag Committee too so I see that from both sides, but I agree that the MEPs are doing a great job but the small manufacturers sometimes struggle with the government support programs. And Mr. Chakrabarti, could you talk a little bit about—you talked about a one-stop-shop approach to government support programs, and really how you would see that, where it might be housed, how you could see the Federal Government's role in terms of helping our small manufacturers, small to medium?

Mr. CHAKRABARTI. Absolutely. Small and medium enterprises lack the resources to evaluate the programs that can help them innovate. These business leaders and owners are wearing many hats every day. I speak from experience when I say the task of identifying these programs from the government is very daunting. I believe that a one-stop-shopping approach could be developed using the input of agencies that are responsible for the programs as well as a council of small and medium business leaders. The inputs of the various constituencies will help sharpen the efficacy of such a program. The cross-experience team would need to evaluate which agencies have the best access to the small and medium enterprises and specific industries in order to find the best home for the one-stop shop. In other words, the ability of the chemical industry to access government programs may be housed in a different function than the ability of a nanotechnology industry company or an automotive industry company. The key is, how can we provide single points of contact as low in the chain as possible that have the access to the small and enterprise.

Mrs. DAHLKEMPER. So basically you see this as depending on the industry there would a one-stop shop for that industry, not one stop for all manufacturing going forward?

Mr. CHAKRABARTI. Correct.

Dr. SMYTH. Can I make a comment?

Mrs. DAHLKEMPER. Yes.

Dr. SMYTH. On the one-stop shopping, I think it is a great idea but I think it should be expanded to big plus small. I will just give an example. If you are looking at electrification of the vehicle and you are working on technologies to support that, if you are a small organization and if the one-stop shopping—if I am a national lab and my charter is, for example, a small business, then I will look and say, okay, there is a lot of welding involved so I may go and look at ultrasonic welding, and those people will work, small companies, to optimize that process. If you include large business, they look at a systems-level approach and they will say yes, welding is a great idea but you also have to invest in quality systems, you also have to invest in something like reversible bonding that is going to put welding out of business and allow us to make reconfigurable batteries that will be—it will be able to recycle and re-manufacture. So you do get a different perspective. I think the one-stop shopping is a fabulous idea but I don't think it should be constrained to small business.

Chairman GORDON. Thank you. If we could——

Mrs. DAHLKEMPER. Thank you. I yield back.

Chairman GORDON. I suspect that Mr. Rohrabacher has an answer rather than a question and so do you want to give your answer quickly?

Mr. ROHRABACHER. Thank you very much, Mr. Chairman. I would just like to go on the record. I am sorry, I had to rush back to another hearing that happened at the same time. But if we are going to have U.S. manufacturing be competitive, the Federal Government does have a role and the most important role is protecting the intellectual-property rights of those American businesses that will utilize technology to outcompete the foreign competition. Unfortunately, Mr. Chairman, the patent reform legislation that has been going through here for the last few years would have the opposite impact and make the theft of intellectual property more likely, and let me note that we also need to make sure that the limited research and development dollars that we are able to spend are not then in some way used to set up manufacturing overseas, and I don't think we have taken care in that job.

Chairman GORDON. Thank you, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you.

Chairman GORDON. In the future you can just say "number one" and we will put that into the record.

Mr. Hall is recognized.

Mr. HALL. I will probably answer mine too as I ask it. Mr. Chakrabarti, I noticed PMC Group has manufacturing facilities in France and India, and I guess my question is, what is it about these countries or what business climate have they created that make them more attractive to PMC than the United States? Now, let me see if I can't answer it. Other than their low cost of labor and Dr. Sauers said that we regulate over here but we overregu-

late, which is probably true, and my suggestion there is to do away with the EPA or have a three-year moratorium on EPA and lawsuits. Now, if that doesn't answer your question, we will write it to you again and let you give it to us in writing.

Mr. CHAKRABARTI. I appreciate that.

Mr. HALL. Thank you.

Chairman GORDON. It is really unfortunate we had to hurry today, and I don't mean any disrespect. We have had more what you might call "high-profile witnesses" but we haven't had a panel that has addressed an issue that has been more important to us, I think, in trying to really save our manufacturing base here in this country. We are at a tipping point. I think the *America COMPETES Act* can help us greatly, and your input will help us do a better bill. So I thank you for being here.

The record will remain open for two weeks for additional statements from Members and for answers to any follow-up questions the Committee may ask the witnesses. The witnesses are excused and the hearing is adjourned.

[Whereupon, at 11:14 a.m., the Committee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Len Sauers, Vice President of Global Sustainability, Procter and Gamble

Questions submitted by Representative Daniel Lipinski

Q1. I know that Proctor and Gamble has used high-performance computing in novel ways to help implement parts of its sustainability program. For instance, you use numerical simulation of foams, detergents, and packaging to develop products that save energy and materials and give you a competitive advantage. In your written testimony, you recommend increased collaboration between government and industry through the National Labs.

Q1a. Would you say that high performance computing is an area ripe for collaboration?

A1a. Yes, without question. A key focus area should be developing the Software that takes full advantage of the latest hardware in solving problems of interest to manufacturers. The commercial codes that are being used today have their origins in National Lab codes from 20 to 30 years ago, but these have not been updated to utilize efficiently the large multi-processor computer architectures that are part of the complex today.

Q1b. What other roles do you think the National Labs can play in helping U.S. manufacturers innovate?

A1b. At SNL, LANL, ORNL and ANL we have collaborated and worked with codes to better understand the physics of interest to us (as you talked about earlier in the question). However, these codes are academic, some would even say 'user hostile', and their use by non-expert, non-Ph.D.'s, that are more typical of our supply-chain is not reasonable. We could see the National labs playing a role in progressing these codes toward a commercial offering if there were fewer barriers in the IP, some 'larger scale' ways to pay for the conversion, and a higher degree of collaboration between the Labs and the ISV's (independent software vendors).

Q1c. Are there things we should be doing at our National Labs to take this collaboration beyond large manufacturers, to help reach smaller supply-chain manufacturers?

A1c. Why is an everyday use goods maker better connected with the Labs on sophisticated software and high performance computing then a U.S. company that makes its living selling high-end software that runs on high performance computing? The answer normally offered to use is that they do not perceive the market demand beyond the fortune 30 and do not have the scale or the risk appetite to lean forward to make the connection.

P&G is part of a 'working group' of manufacturers (Boeing, GE, Caterpillar) partnering with the Council on Competitiveness to promote the idea that Modeling and Simulation and High Performance Computing are not just for us . . . but for the entire supply chains that also provide us goods and services. From the smaller regional Engineering Service Providers, Packaging suppliers, Parts suppliers, Tool providers, these enterprises are currently not able to 'afford' using high performance computing. Therefore, they use it ONLY for very rough and coarse guidance . . . never to replace the slow and expensive learning that is the hallmark of the larger higher tech entities.

What role is the Council on Competitiveness playing and what role would be helpful for Congress?

The Council, coupled with the 'working group' as described above, has been communicating very broadly to increase awareness on the role of HPC on national manufacturing competiveness and its influence on jobs and the economy.

It has been very important to the working group, which does not contain any ISV's or Computing Hardware manufacturers, that it is understood that our advocacy here is not for the Government to buy more. The working group has evolved out of a call to service for use to mentor and support U.S. industry to remain strong and competitive.

As large multi-national companies, we for the most part have the computing hardware and software we need to innovate. However, for small to mid-sized enterprises and especially those in our supply chains, they appear to be stuck in a PC world that is not able to solve the larger, more realistic problems that replace the slow

and expensive learning cycles of today. In fact, the manufactures of the working group do the analysis for the products or services that our suppliers provide— most of the time.

Our group sees HPC like the enabling 'roads and bridges' of our digital age. For some of us, we are able to build our own roads to get around our own 'place'—so to speak. The Internet has also been part of it . . . it allows data to move around, but move around to what—is the question we are addressing. We seem far from having a commercially viable infrastructure that small and mid-sized enterprises can utilize when they support us or their other customers.

So, how can the congress help? Work with Industry, National Labs, Academia to help create the support, partnership, and creative alliances that can allow for the 'trans-continental railroad' of our modern era? When built, industries will pay for their time and usage of the system, through usage fees, but it is something that they can have access to when they need it.

Background

It is correct that Modeling & Simulation, using High Performance Computing, plays an important and increasingly critical role in our innovation. It is replacing the slow and expensive learning cycles typical of using only large scale, high speed, or very numerous prototypes and samples to learn. Since we are in the business of making and selling billions of products to billions of people every year, we must learn how to design and manufacture these products to meet a wide range of consumer needs from the store shelf to the landfill. Doing this with 'physical-only' prototypes is expensive, time consuming and ultimately limits innovation.

One of the most important enabling capabilities changing the 'physical only' learning is the emergence of computers. It has changed science and engineering at least as much as aviation has changed travel. And it is not just the personal computer that everyone sees everyday . . . it is also the large computer with hundreds and thousands of processors that enables calculations that were not dreamed possible a decade ago. This has enable us to learn about a chemical reaction with a billion atoms, a bottle or mix tank expressed with millions of equations, or an optimization that finds the best formulation from thousands of choices.

As a large multi-national company dedicated to innovation, we have invested in our own capability to use modeling & simulation, enabled by high-performance computing, to innovate HOW we innovate. Our relationships with Los Alamos, Sandia, Argonne & Oak Ridge National labs are a matter of record in the attached document. Through CRADA's, WFO agreements, and an INCITE award, we have focused on software and the physics that has progressed both our interests.

Appendix 2:

Additional Material for the Record

WRITTEN STATEMENT FROM NATIONAL PETROCHEMICAL AND REFINERS ASSOCIATION (NPRA)

NPRA, the National Petrochemical and Refiners Association, appreciates the opportunity to submit testimony on "The Future of Manufacturing: What is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers." Our association represents more than 450 businesses, including virtually all U.S. refiners and petrochemical manufacturers, their suppliers, and vendors. NPRA members supply consumers with a wide variety of products used daily in their homes and businesses, including fuels, lubricants, and chemicals that serve as building blocks for everything from plastics to clothing, medicine, and computers. NPRA's members have a keen interest in the future of research and development (R&D) and manufacturing in this country, and we appreciate the opportunity to share our views on this topic.

I. Petrochemical Products Are Vital to Our Economy and Way of Life

Petrochemicals, or chemicals derived from petroleum (crude oil) and natural gas, are the foundation for many of the products used by millions of Americans every day. Without petrochemicals, the standard of living we have come to know and enjoy would simply not exist, nor would thousands of petrochemical-based products ranging in applications from healthcare to military supplies, safety and child care products, food packaging, and even clothing.

One of the most prominent uses of petrochemical products is in protecting the food we eat. Much of the food enjoyed by millions of Americans every day is made possible because of the advances in food packaging that have been made possible due to our products. Over 40 percent of the beverage packaging materials used in the U.S. are derived from petrochemicals.[1] Plastic packaging makes food transportation much more energy efficient, since the lighter packaging allows more food to be transported at lower costs. Plastic jars are approximately 90 percent lighter than their glass counterparts and weigh 38 percent less than steel cans.[2] Lighter packaging also allows for lighter loads, which decreases emissions, lowers shipping costs, and reduces fuel consumption.

An often overlooked use of petrochemicals is the prominent role these products play in our nation's armed forces. The United States military depends on petrochemical products to outfit American troops with top-of-the-line combat gear essential for the protection of our armed forces serving both domestically and in dangerous regions around the world. The Army Combat Uniform (ACU) worn by every soldier in the United States Army is made of approximately 50 percent nylon.[3]

Innovations in manufacturing have allowed our industry to develop advanced helmets made of petrochemical materials capable of stopping a 9-millimeter round. The boots used by soldiers that allow them to move easily over both desert and rocky terrain are composed of over 50 percent petrochemical products. Furthermore, Kevlar fiber, which is a flame-resistant carbon-based aromatic polyamide five times stronger than steel, is the main component of bullet-proof material, and has allowed for the development of the bullet-proof vest, which protects the wearer not only from ballistic threats, but from blasts and fire as well. These vests provide crucial protection not just for our military personnel, but also for police officers and other public servants serving in dangerous professions.

Perhaps most significant to average Americans is the role petrochemical products play in the health and safety of our society. Protective clothing used by those working in hazardous or even deadly environments is almost entirely made up of petrochemical products. This includes bio-hazard suits, safety goggles, protective helmets, and respiratory equipment. The seat belts in every passenger motor vehicle sold in the United States are made pound for pound from the petrochemical precursors paraxylene (aromatic) and ethylene.[4] Nearly a billion pounds of petrochemicals are used to make the approximately 22 billion diapers used annually in the United States.[5] Surgical gowns for hospitals, many bandages for wounds, sutures, blood bags, sanitizing liquid, soaps, detergents, and aspirin are all mainly comprised of petrochemicals. Furthermore, the 35 million Americans who use dentures and the

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[1] "Petrochemicals in Consumer Products Critical to the United States Economy." CMAI: January 2010.

[2] Ibid.

[3] *http://www.armystudyguide.com/content/bm–doc/acu-presentation.ppt*

[4] *http://www.epa.gov/ttn/chief/ap42/ch06/final/c06s06-2.pdf*

[5] Joyce A. Smith and Norma Pitts. "The Diaper Decision, Not a Clear Issue." Ohio State University.

24 million Americans who rely on contact lenses are also reliant on the petrochemicals used to make these indispensable products.[6]

Petrochemicals also play a critical role in transportation and alternative energy innovation. Polypropylene is often used in the interior and exterior panels and bumpers of light vehicles, and polycarbonate is used instead of glass in relevant applications. Also, polyurethanes are used in seating cushions and ethyl vinyl acetate is used in wiring and cables. All of these lightweight materials are essential for helping vehicles to meet Corporate Average Fuel Economy (CAFE) standards without compromising vehicle safety. Every passenger motor vehicle in the United States uses over $1,300 in chemical products.[7] Additionally, major aircraft manufacturers Airbus and Boeing both use carbon fiber-reinforced plastic wings in their aircraft. Half of the airframe of one of the most popular new domestically produced aircraft, the Boeing 787, is composed of carbon fiber reinforced plastic. In the development of renewable energy sources, 15 percent of wind turbine blades are derived from petrochemical products, as are all solar panels.

II. Current Business Environment

The American petrochemical industry is an essential part of this country's economic independence and stability in the global market. Not only does our industry produce materials that are used in thousands of products Americans rely on in their daily lives, but it is also a key component of our international trading market. Our industry employs nearly 195,000 Americans directly with an annual average salary of $100,945. This industry employment number increases to more than one million individuals when indirect employment is considered. These are high-quality American jobs and our employees enjoy higher than average wages, good benefits, and a safe working environment. Furthermore, the American petrochemical industry is the global leader in providing the raw materials for the development of new chemicals for the international market that advance safer and more efficient manufacturing techniques.

However, our country is at risk of losing its status as the international leader in this industry due to international competition and an increasingly hostile domestic business environment. Taxes, an increasing number of overly burdensome regulations, and a flawed domestic energy policy are adversely impacting our industry and allowing other countries to forge ahead of us in research and development, production, and international trade.

In the 1990s, the North American petrochemical industry enjoyed strong demand growth, adding almost 50 million tons of new supply in the basic chemicals and plastics market. However, 2000–01 saw a steep rise in raw material prices, which abruptly muted this growth, and North America has lost 10 million metric tons of chemical production capacity over the past decade. This represents the equivalent of approximately fifty facilities closing[8]. Furthermore, during the current economic recession, demand for these products in North America fell an alarming 16.2% over a two-year time span.[9]

While the capacity to produce major petrochemical products in the United States has stagnated since 2000 and continues to decline, new capacity is rapidly being added in other parts of the world.[10] In recent years, China has begun to decrease its petrochemical imports from the United States and has expanded its own domestic production of petrochemicals to provide materials for the many consumer goods the country produces. Concurrently, countries in the Middle East, such as Saudi Arabia, Qatar, and the UAE, have begun to build their own petrochemical plants and have become very competitive in the international market. As a result, countries such as China that used to import many petrochemical products from the United States have now turned to these geographically closer, lower-cost Middle Eastern markets to supplement their own domestic supply.

Due to the abrupt pace of economic advancement in developing countries, global demand for petrochemical products is booming and some estimates show demand increasing seven percent a year. However, the petrochemical industry in the United States is unable to benefit from this international increase in demand due to the stagnant state of our domestic industry, which allows countries like China and those in the Middle East to fill the increasing global demand for petrochemical products.

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[6] "Petrochemicals in Consumer Products Critical to the United States Economy." CMAI: January 2010.

[7] Ibid.

[8] "State of the Industry: Exploring Tomorrow's "Whys."" CMAI: March 2010.

[9] Ibid.

[10] "Petrochemicals in Consumer Products Critical to the United States Economy." CMAI: January 2010.

In 2010, Chemical Market Associates, Inc. (CMAI) analyzed the production capacity for 21 of the most commonly produced chemical products (Attachment A). From 1999 to 2009, the United States' production capacity for nearly every chemical has either decreased or remained virtually stagnant, while overall global production capacity has drastically increased.[11] Unfortunately, as we are well aware, decreasing or stagnant product growth is not conducive to job growth in this country, but rather leads to jobs loss. Instead of focusing on expansion and research and development, the domestic petrochemical industry is simply trying to maintain its global competitiveness.

III. The Future of the Domestic Petrochemical Industry

The lack of support for research and development (R&D) is one factor hindering the development of the manufacturing sector in the United States. In fact, it can be readily observed that historically, research and development, innovation and higher education tend to follow the manufacturing base. Scientists from overseas who receive their education in the U.S. are now leaving this country in ever greater numbers. They are getting chemistry and engineering degrees in American schools and returning to countries such as China and India to work in the manufacturing sector. While R&D is beneficial for start-up industries or in situations where risks may be too high for private business ventures, a hostile business environment prevents the private-sector R&D funding necessary for long-term development of new technologies.

Simply increasing R&D budgets and fostering innovation in the United States does not ensure that the manufacturing and production that comes about as a result of the R&D will occur here. Overall U.S. manufacturing, no matter what the industry, will continue to move overseas and lag behind international manufacturing until Congress addresses four critical issues relating to the U.S. business environment: education, taxes, over-regulation and energy costs.

It is common knowledge that the United States' primary and secondary education systems suffer from a serious science and math education deficiency. Since the United States has continually cut budgets for these programs, many of our brightest young minds find themselves considering going overseas to countries that advance policies to expand the manufacturing base of their economies while simultaneously increasing R&D budgets. Federal R&D grants that companies can apply for in the U.S. often come with preconditions on accepting government money, which stifles innovation even further.

Another issue that plays a significant role in hindering the expansion of manufacturing in the U.S. is resource availability and volatility. The petrochemical industry is very energy-intensive, and relies on massive quantities of energy for production. U.S. manufacturers account for nearly one-third of total U.S. energy consumption. It is important to note that a decade ago, American manufacturers benefited from energy prices 30 percent lower on average than those of the United States' major trading partners. Today, energy costs for U.S. manufacturers are nearly on par with those of their global counterparts.[12] In order to manufacture petrochemical products, large quantities of feedstocks, such as oil and natural gas, also are needed. According to the Energy Information Administration, in 2006 about 331 million barrels of liquefied petroleum gases (LPG) and natural gas liquids (NGL) were used to make plastic products in the plastic materials and resins industry of the United States.[13] Natural gas prices have been very volatile in the last decade, leading to great energy cost uncertainty for domestic manufacturers. While recent prospects of potential new shale gas resources provide hope for more reliable and hopefully more stable supplies of natural gas, domestic policy still limits development of natural gas resources. Congress is also looking at policies that could lead to significant fuel switching from coal to natural gas, contributing to uncertainty about future costs at a time when total costs already put domestic manufacturing at a disadvantage. Overall, in 2008, structural costs (costs of taxes, labor, energy, and raw materials) for U.S. manufacturers were 17.6 percent higher than major international competitors on a trade-weighted basis.[14] In addition, the cost of energy and raw materials fluctuates significantly on a daily basis, making it very difficult for companies to financially plan for the cost of the materials that go into making their products.

One of the largest threats to the survival of the domestic manufacturing industry is the regulatory uncertainty that is more prevalent in the United States than in

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[11] Ibid.
[12] Ibid.
[13] *http://tonto.eia.doe.gov/ask/crudeoil_faqs.asp*
[14] "The Tide is Turning: An Update on Structural Cost Pressures Facing U.S. Manufacturers." National Association of Manufacturers. November 2008. p 14.

any other country in the world. In previous decades, the decision for a company to expand was much easier than in today's marketplace, where companies must now look at not only their financial situation, but also regulatory issues and challenges that could arise in commissioning new projects and capital investments. Furthermore, with increasing regulations, many companies have been forced to decrease their R&D budgets and shift their resources to regulatory compliance.

The recent regulatory environment limits what businesses can do and how they can expand in the United States as well as overseas. In 2009–10 alone, American businesses have faced the conceivable reality that they could be forced to comply with several new, burdensome, and costly governmental regulations. The past 15 months have witnessed serious debates in Congress relating to cap-and-trade legislation, inherently safer technology mandates, regulation of greenhouse gases (GHGs) under the Clean Air Act and reform of the Toxic Substances Control Act, just to name a few. Each of these proposals could result in costly programs businesses would have to comply with or change their processes for, leaving American industry in limbo, unable to expand or invest in new projects because of the financial and regulatory uncertainty companies will face in the upcoming years.

Businesses in the United States are faced with some of the most extensive government regulations in the world. Several studies have indicated that by 2004, regulatory compliance costs exceeded $160 billion annually for U.S. manufacturers—equivalent to a 12 percent value-added tax.[15] United States manufacturers pay some of the highest regulatory compliance costs in the world. Furthermore, individual states often enact their own regulations, creating a regulatory patchwork of different standards with which businesses that operate in multiple states have to comply. For example, one state may regulate a product as a consumer product, while another may regulate the same product for solely industrial use, leading to two entirely different standards.

The current regulatory environment forces companies to devote significant financial resources that could otherwise be used in R&D or capital investments to compliance with regulations promulgated by the Environmental Protection Agency (EPA) and other government agencies. For example, polyvinyl chloride is derived from petrochemicals and is the third most widely produced plastic. It is an essential component of hoses, flooring, and roofing, and is used commonly in clothing and upholstery. In August 2009, EPA sent polyvinyl chloride manufacturers an Information Collection Request (ICR) to provide data so that EPA could establish emission limitations in accordance with the 40 CFR Part 63 PVC MACT rule. The cost of this information collection effort was initially estimated to be $32 million, entirely paid for by the manufacturers, simply to provide the EPA with testing information to assist in their rulemaking process. These are financial resources that otherwise could have gone to R&D.

To be clear, the petrochemical industry is not advocating weakening existing environmental or safety regulations. On the contrary, our members hold public and environmental safety in the highest regard. However, the complexities, breadth and uncertainty of the current domestic regulatory environment place American manufacturers at a significant competitive disadvantage in the international marketplace. Congress and the Federal Government should examine the current regulatory climate and develop a framework for providing industry with more regulatory certainty to create a predictable and favorable financial environment. Such an initiative is critical to maintaining the industry that exists in this country and expanding our domestic manufacturing in the future.

In addition to regulatory uncertainty, one of the most significant reasons for the decline of the American manufacturing industry is the burdensome tax environment businesses face in the United States. Tax policies make it increasingly difficult to compete with businesses in more favorable tax environments overseas. While the United States has been losing jobs, other countries such as China and those in the Middle East and Southeast Asia have succeeded in attracting new business development which has flourished under a more favorable tax environment.

A PricewaterhouseCoopers survey released in 2009 showed the total tax rate of U.S. businesses to be 36.4 percent, the second highest corporate tax rate among the 30 countries in the Organization for Economic Cooperation and Development (OECD). Furthermore, in addition to income taxes, corporations bear a wide variety of non-income taxes, adding $62 of tax liability for every $100 of corporate income taxes. These non-income taxes do not include the additional $169 of sales, excise,

[15] "The Tide is Turning: An Update on Structural Cost Pressures Facing U.S. Manufacturers." National Association of Manufacturers. November 2008. p 11.

withholding, and other taxes imposed on customers and employees for every $100 of corporate income taxes paid by survey participants.[16]

United States businesses are more highly taxed than those of any other country in the world. While other countries have been lowering their corporate tax rates in an attempt to grow their manufacturing industries, the United States has continued to increase business taxes. This has led to a tax rate discrepancy between the United States and other countries that increases every year. On a trade-weighted basis, the United States tax rate is 7.8 percent higher than its nine largest trading partners.[17] Only Japan has imposed a higher business tax rate than the United States.

Taxes are not the only fees that businesses are expected to pay to the Federal Government. Over the past 30 years there has been a move by the government to "recover" costs it incurs to regulate business. In addition to industry's enormous corporate taxes, companies are also expected to fund the regulatory operations through ever-increasing fees for everything from permitting to applications for introducing new chemicals into commerce. For example, the current debates over TSCA reform include a fee-based system similar to the one used to regulate pesticides. Advocates of a fee-based system tend to dismiss the argument that corporate taxes should be used to pay for the regulation of those entities already paying taxes.

The United States also has one of the highest rates of labor costs in the world. The largest share of taxes remitted, 43.5 percent, go to employment-related taxes such as Social Security, pensions, and Medicare. This amounts to an average of $25,889 in employment-related taxes per U.S. employee, which is more than one-third of average domestic employee compensation.[18]

With these extraordinarily high tax rates, rather than expansion in the United States and investment in more research and development, domestic innovation and capital is forced to relocate to other countries with lower tax rates and a more favorable business environment. This allows manufacturing and the jobs that come with it to flourish in other countries, while manufacturing in the United States declines, American jobs go overseas, and our country becomes more dependent on products imported from abroad.

IV. Conclusion

The American petrochemical industry is a vital source of American jobs and products that allow us to maintain and advance our way of life. The United States is a world leader in innovation and manufacturing technology, and there is no reason why our country should not remain superior in this field. The United States government must set policies that not only foster R&D, but also encourage researchers to remain in this country rather than go overseas. Many petrochemical production companies were founded in the United States and would rather operate here than in any other region around the world. However, in order for our industry to not only maintain what we have already created but to grow and capitalize on future demand increases and global economic development, the Federal Government must create an environment that attracts American businesses to expand their operations in this country and fosters innovation rather than encouraging jobs to be shipped overseas.

NPRA urges Congress to consider policies to bolster the overall business environment in the United States as it examines initiatives to advance R&D. We appreciate having the opportunity to submit comments on this extraordinarily important topic.

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[16] *http://www.pwc.com/en_US/us/national-economic-statistics/assets/total_tax_contribution.pdf*

[17] "The Tide is Turning: An Update on Structural Cost Pressures Facing U.S. Manufacturers." National Association of Manufacturers. November 2008. p 13.

[18] *http://www.pwc.com/en_US/us/national-economic-statistics/assets/total_tax_contribution.pdf*

PREPARED STATEMENT FROM REPRESENTATIVE JOHN D. DINGELL

Thank you, Mr. Chairman, for your kind invitation to submit testimony concerning the role of the Federal Government in supporting innovation by U.S. manufacturers. As the representative of Michigan's 15th Congressional District, which has suffered more than most as a result of the downturn in U.S. manufacturing over the past decade, I believe fundamental changes in Federal policy are necessary for the preservation and growth of this country's industrial base. These changes include not only enforcement of existing law, but also the drafting and implementation of new Federal initiatives, ranging from loan and tax credit programs to improvements in the Nation's education system. The comprehensive nature of this approach will by necessity involve the participation of multiple committees of jurisdiction in the Congress, and I commend the Committee on Science and Technology for its continued desire to be at the forefront of this effort, as particularly evidenced by today's hearing.

Prior to any discussion of supporting innovation by U.S. manufacturers, we would do well to consider their current state. In years gone by, the United States was the world's leading exporter of high-quality manufactured goods. According to the World Bank, the United States now ranks 15th in the world for the proportion of manufacturing production its companies export. For years, the manufacturing sector fostered the growth of the middle class in the United States. Thanks, among other things, to this country's lack of a pro-manufacturing agenda, its own short-sighted trade agreements, and unfair practices by our trading partners, we have seen the U.S. trade deficit balloon at an obscene rate and domestic industrial production sink to dismal levels. As a result, millions of Americans, many of whom live in my District, no longer have the option taking a manufacturing job, something which allowed their parents and grandparents to make better lives for themselves and their families.

With this in mind, I suggest the Federal Government take immediate action with respect to our trading partners to shore up what remains of this country's industrial base. For too long, the U.S. Department of the Treasury has been reticent to cite countries such as Japan and China for currency manipulation in spite of evidence that they have used such policies to gain an unfair trade advantage vis-à-vis the United States. These countries and others must not be allowed to continue this illegal and trade-distorting practice, particularly given the President's express desire to double U.S. exports in five years' time. Similarly, the Administration must do all within its power to open foreign markets to U.S. goods, while at the same time rigorously enforcing domestic trade laws. Failure to do so will encourage our trading partners to perpetuate unfair trade policies like Japan's, which have been of particular detriment to U.S. automakers. While foreign automakers collectively account for less than four percent of vehicle sales in Japan thanks that country's restrictive trade policies, Japanese automobile manufacturers enjoy considerable market share in regions around the world, most significantly in the United States, and benefit handsomely from the export subsidies their home country's currency policy creates.

While ensuring our manufacturers can compete globally, we must also make it easier for them to compete right here in the United States. As I have argued for years, healthcare reform is necessary not only because it is a fundamental right of all people, but also because it makes good economic sense. In the automotive industry, healthcare benefits account for a significant proportion of production costs. This industry traditionally has had very slim profit margins, and by enacting a national healthcare policy, we would improve the ability of our domestic automakers to compete on a global level. The money they would save as result of such reform could be re-invested in research and development to produce advanced technologies for more environmentally friendly vehicles, something which will be in high demand in the future. Moreover, to those who would oppose national healthcare on economic grounds, I offer the examples of Germany and Japan, both of which have had national healthcare for some years now, while at the same time maintained robust export economies.

At the same time as leveling the playing field for U.S. manufacturers with adjustments to trade and health policy, the Federal Government must ensure the existence of a well-trained domestic workforce. In particular, I agree with President Obama's call that community colleges must receive more funding. These institutions have traditionally led the way in the technical and vocational training essential for a worker's success in the manufacturing sector, let alone the benefits a manufacturing company accrues from a well-educated labor force capable of creative and independent thinking. Secondary and primary schools in the United States must also renew emphasis on mathematics and science, much as they did in the 1950s at the onset of the space race.

On a related note, the Federal Government can prompt innovation in the manufacturing sector by supporting public-private partnerships like those fostered under the Manufacturing Extension Partnership (MEP). Through a nationwide network of centers and specialists, MEP helps small and medium-sized manufacturers improve their productivity, increase their economic competitiveness, and enhance their technological capabilities. Lamentably, MEP has suffered for want of Federal funding over the past decade, and the amount of funds individual states have been able to provide MEP centers has dwindled due to budget shortfalls. Increased Federal appropriations to MEP would be an easy and straightforward way to augment this program's ability to spur manufacturing innovation.

Beyond workforce development, the Federal Government can incentivize manufacturing research and development via tax credits, grants, and loans. The Federal research and development tax credit has long provided great encouragement to manufacturers to invest in innovative new technologies and improve existing facilities. Sadly, this credit expired for the 14th time at the end of 2009. I believe Congress should act to make this tax credit permanent in order to provide a long-term incentive to manufacturers to invest in research and development. Similarly, Congress should enact legislation to allow companies to use their existing alternative minimum tax (AMT) credits to hire new workers and finance investments in manufacturing facilities and new equipment. Also, tax credit programs like section 48C of the Internal Revenue Code, which provides a 30 percent credit for investments in new, expanded, or re-equipped advanced energy manufacturing projects, should be funded for the long-term.

As I have noted, long-term incentives are necessary to ensure U.S. manufacturers continue to devote substantial portions of their resources to innovation. In this time of recession, however, manufacturers require immediate short-term assistance in order to continue operations and invest in the future. Section 136 of the Energy Independence and Security Act of 2007, or the Advanced Technology Vehicles Manufacturing Incentive Program, is one such source of assistance. Demand for funding under the program is nearly double the available funds, indicating the industrial sector's clear potential for innovative growth. Congress should act to double funding for section 136, and the House of Representatives made wonderful strides in this effort by passing the *American Clean Energy and Security Act of 2009*, which contained such a provision.

Beyond direct loans to manufacturers from the Federal Government, I remain convinced more must be done to increase private lending, particularly to small and medium-sized manufacturers. Many manufacturers, both in my district and around the country, find themselves with diminished cash flow and depleted collateral. As a result, even where private banks have the capital to lend, many viable manufacturers are unable to qualify for the loan they need to diversify their operations into so-called "new economy" products, such as clean energy. My colleagues, Representatives Levin and Peters, and I have introduced legislation to address small and medium-manufacturers' pressing need for private sources of capital. H.R. 4629, the *Manufacturing Modernization and Diversification Act*, provides Federal funding for state-run collateral support and capital access programs, building on a successful Michigan model that has yet to encounter a loan default. I urge that this legislation be included in any small business lending package the House and Senate send to the President for signature.

Promoting innovation in domestic manufacturers makes economic sense for United States. In addition to serving as an important component of our effort to climb out of the current recession, Federal support for manufacturing in the long-run will ensure our economy's foundation is built on useful goods of tangible value. Just as manufacturers helped Americans create better lives for themselves and propelled the United States to historically unseen levels of economic prosperity, so too will they again, but only if given proper, adequate, and enduring support.