Technology Leadership and Strategy Initiative

2009

Change & Explore

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Council on Competitiveness

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TLSI Dialogue Series 2009: Change & Explore
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Change.

Dialogue 1:
The Changing Global Landscape for Technology Leadership

June 22, 2009
Washington, D.C.

Letter from the President

On behalf of the Council on Competitiveness, I am please to release *Change*—the first report from our newly launched **Technology Leadership and Strategy Initiative (TLSI)**.

Led by Ray Johnson, senior vice president and chief technology officer (CTO) of the Lockheed Martin Corporation, and Mark Little, senior vice president and director of GE Global Research for the General Electric Company, the TLSI is a multi-year engagement of technology leaders from America's premier companies, universities and laboratories aimed at establishing a new paradigm for collaboration between the public and private sectors to optimize America's investments in research, talent and technology.

We believe the efforts of these experts are essential to address the critical challenges currently facing the United States. While technology remains essential to economic competitiveness and national prosperity, the United States is increasingly being challenged by a world that has fully embraced globalization and the benefits that come from technological sophistication and innovation capacity—coupled with the ability to deploy rapidly and successfully in the global marketplace.

The genesis of the TLSI stems from the Council's longstanding work in understanding the role of technology in driving innovation, productivity growth and living standards; from our seminal work in the 1980s and 1990s (most notably, *Going Global: The New Shape of American Innovation*); and culminating in our 2004 National Innovation Initiative's *Innovate America* that focused in part on the criticality of frontier research and deployment of knowledge to create value (new jobs, new companies, new industries). In this spirit of understanding how the nation—the public and private sectors together—prioritizes for competitiveness and value creation in the 21st century, the Council created the TLSI.

This report, *Change*, does two things. First, it lays the groundwork for the inaugural TLSI Dialogue, held in Washington on June 22, 2009. Second, *Change* highlights the key findings and observations from TLSI Dialogue 1, which focused on the changing global landscape for technology leadership, and the challenges to and opportunities for a new "21st century collaboratory"—a new way for the public and private sectors to cooperate. *Change* also sheds light on the initial findings of a new CTO survey from Council and Seed Media Group.

In addition, *Change* captures the perspective of President Barack Obama's new CTO of the United States, Aneesh Chopra. The Council was honored to host Chopra during TLSI Dialogue 1 and looks forward to engaging him and the administration in a continuing conversation on a wide range of issues that cut across the missions of government, business and academia affecting a nation's ability to innovate.

The Council would also like to recognize and thank the U.S. Department of Defense for its partnership and generous support of the TLSI. The commitment and leadership of the Department to create a robust, public-private partnership to address the impact of the globalization of innovation to the economic vitality and national security of the United States is unparalleled.

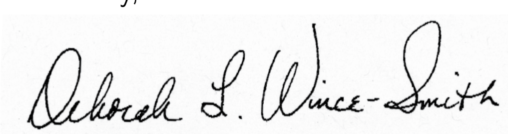
Charles O. Holliday, Jr., DuPont; Ray Johnson, Lockheed Martin Corporation; Aneesh Chopra, Executive Office of the President; Mark Little, General Electric Company; and Deborah Wince-Smith, Council on Competitiveness.

Finally, I would also like to thank Chad Evans, vice president of the Council on Competitiveness, for his leadership in launching and shepherding the TLSI—along with Council senior vice presidents Debbie van Opstal and Cynthia McIntyre; Council research associates James Knuckles and Jon Gregorio; and the manifold contributions from Carol Anne Meares and Chris Mustain.

Although policy makers and Americans at large increasingly recognize the importance innovation and technology play in a growing economy, national security and solving most of the biggest societal challenges we face, the United States has only just begun to ensure that the policy infrastructure to capture value and deploy innovations, as well as the support for necessary investments for research, exists.

We firmly believe that the TLSI—through the thoughts and contributions of each of the distinguished experts who are leading this initiative—is the best vehicle to help craft this infrastructure and to develop a new paradigm for innovation policy and collaboration.

Sincerely,



Deborah L. Wince-Smith
President

Part 1:
Setting the Stage for TLSI Dialogue 1

Executive Summary

Innovation has taken center stage in government and industry efforts worldwide to compete and prosper. Public and private sector leaders understand increasingly that cost and quality alone do not determine economic success. The lynchpin is innovation—the ability to develop new ideas and deploy them in the real world where they create economic and societal value.

Innovation creates high-margin business, sustains high-wage jobs and drives productivity, and it is the key to solving many of the most pressing challenges and addressing many of the greatest opportunities. The reality, however, is that this country is still at the beginning of understanding the dynamics of modern innovation and how the public and private sectors can enable and manage innovation most effectively.

Conventional wisdom holds that despite various challenges, Americans are still the world innovation leaders. High-profile innovations like Google, Facebook or the iPod signal a robust overall output of new U.S. products and services. That wisdom, however, is coming under question. A June 2009 article by *BusinessWeek* Chief Economist Michael Mandel notes that many innovations touted 10 years ago as on the brink of commercial reality have not materialized as quickly as envisioned—things like fuel cells, satellite internet service, gene therapies and micro machines on chips.

While acknowledging the role of the financial sector in the current economic downturn, Mandel suggests that perhaps slower rates of innovation have contributed to the downturn's severity. With fewer breakthroughs on the market than expected, Mandel muses, Americans had little new to sell to the rest of the world, or at least not enough to sustain high growth levels. And Mandel wonders whether the United States could be in a period of "innovation interrupted" and whether during the next decade Americans will be more successful at commercializing new technologies.

The Technology Leadership and Strategy Initiative (TLSI) brings together chief technology officers from industry, academia and government in an effort to advance understanding of how America can do better. It will pose critical questions, such as:

- In a world in which information disperses instantaneously and innovation capacity continues to diffuse globally, how does a country making an R&D investment capture the wealth creation from the resulting technology's deployment?
- What criteria influence global investment decisions in the technology space—in terms of research, talent and infrastructure?
- What are the implications of globally-dispersed research and development activities and investments for U.S. leadership and competitive advantage?
- What are the most critical barriers inhibiting development and deployment of cutting-edge technologies inside the United States—and how can they be overcome?
- What are the necessary elements for a new paradigm of collaboration between the public and private sectors to optimize America's investments in research, talent and technology?
- What is the best way for the U.S. private sector to engage the new administration and Congress and prioritize commercialization?

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 1

Introduction

In the spring of 1775, Benjamin Franklin boarded a ship sailing from London to Philadelphia. As an emissary of the American colonists, Franklin had been unable to resolve the simmering conflict with Parliament and was heading home. As he sailed, minutemen and redcoats clashed at Lexington and Concord, igniting The Revolution.[1]

While still at sea, Franklin wrote a detailed account of his failed negotiations. He then turned to another great passion—science. Working with his grandson, he lowered a homemade thermometer into the ocean three or four times per day, recording the results. Franklin had been interested in the Gulf Stream for many years, motivated by both curiosity and practicality. He produced the first map of the ocean current and believed correctly that ships could speed their passage between Europe and America by staying within the Gulf Stream when departing America, and avoiding it when going the other way. By monitoring temperatures, sailors could detect whether they had entered the warmer Gulf Stream waters.

America has always been defined by a passion for innovation and the next frontier, and as Franklin demonstrates, its founders engaged in more than political innovation. Franklin not only helped shape the Declaration of Independence and the Constitution, he invented bifocals, advanced understanding of electricity and founded the University of Pennsylvania. Thomas Jefferson, president and author of the declaration, also designed plows, invented and improved mechanical devices, delved deeply into botany and architecture, and founded the University of Virginia.

From Franklin and Jefferson to Fulton and Edison to Carver and Ford, Americans have blazed many trails in science and technology. In the 20th century, the United States built an unparalleled enterprise for innovation—from legions of individual inventors to the world's greatest concentration of corporate, government and university laboratories spanning every scientific and technical discipline. These scientific, technical and entrepreneurial assets have generated rising standards of living, unparalleled economic prosperity for Americans and national security superiority for a century.

At the end of World War II, Vannevar Bush's seminal report to President Truman, *Science the Endless Frontier,* recommended that the federal government take responsibility for promoting the flow of new scientific knowledge and developing scientific talent by funding basic research at colleges, universities and research institutes. This research and talent, coupled with proper incentives in areas such as taxes and patents, would then strengthen industrial research.

The fall of the Berlin Wall in 1989 set the stage for a profound shift in America's technology investments. For 45 years, federal investments in

1 Isaacson, Walter, Benjamin Franklin, *An American Life*, Simon & Schuster, 2003

research, engineering, technology development, human resources and facilities in industry, universities and federal laboratories drove commercial spin-offs, helping ensure America's economic pre-eminence in the second half of the 20th century in areas such as microelectronics, weather and communications satellites, global positioning systems, supercomputing, the Internet, robotics, the foundations of biotechnology, sonar technologies, composite materials and magnetic resonance imaging—to name only a few.

The end of the Cold War had significant implications for technology leadership in both the public and private sectors. First, political consensus—and the budgets—for investment in long-term, high-risk science and technology began to erode in many sectors. Second, the need to survive intense and growing international competition has driven industry toward a shorter-term, product-oriented investment focus. Third, the rest of the world has begun to copy and even build on the U.S. innovation model—investing in talent, research, education and technology. As a result, the number of innovator nations with cutting-edge capacity is growing every year. Increasingly, America has no lock on global technology leadership.

Yet today, as 20 years ago, technology leadership is key to both economic competitiveness and national security. But America has yet to find a replacement for a past technology leadership system that produced unprecedented results in the post-WWII era. And any loss of technology leadership or technological capacity at home can profoundly affect national security—as well as international competitive standing.

In addition, changes during the past two decades in the nature of innovation itself have accelerated challenges to U.S. national security and economic competitiveness.

- Technology is diffusing at ever increasing rates. It took 55 years for the automobile to penetrate a quarter of the U.S. market but only 35 years for the telephone, 22 years for the radio, 16 years for the personal computer, 13 years for the mobile phone and seven years for the Internet. That pace and volatility create competitive risks as well as opportunities.
- Innovation has become more collaborative, requiring active cooperation and communication among scientists and engineers, users and providers, and the public and private sectors.
- Research is multidisciplinary and technologically more complex—with advances often arising from the intersections of fields and spheres of activity.
- The capacity for cutting-edge research and technology deployment is now global in scope—with advances coming from centers of excellence around the world.

And many nations are replicating the American innovation model by strengthening their talent, investment and infrastructure. The challenge now is to chart the next horizon:

- Can U.S. innovation assets be leveraged more effectively?
- Can new technologies be deployed faster and less expensively to create real value that strengthens the American economy and society?
- Are there new models of public-private collaboration that will help each side address its most urgent priorities?

Asking these practical questions is both looking to the future and building on a long heritage. In 1743, Benjamin Franklin founded the American Philosophical Society for the purpose of "promoting useful knowledge." Early members included doctors, clergymen, merchants and tradesmen. The Society also counted as members George Washington, John Adams, Thomas Jefferson, James Madison and John Marshall.

At its core, the Council on Competitiveness Technology Leadership and Strategy Initiative seeks new ways to deploy useful knowledge, aiming to design a new paradigm for public-private partnerships to support America's future technology leadership and prosperity.

This paper tees up several of the issues the TLSI will cover in Dialogue I—in particular, the changing landscape for technology and innovation, and new directions for U.S. innovation and value creation.

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 1

Changing Landscape for Technology and Innovation

Changing Innovation Landscape

- Profound Technology Developments Are Reshaping the World
- R&D Capabilities Overseas Are Rising Rapidly, Driving a Global Dispersion of Innovation
- Enterprises Are Globalizing Their R&D and Innovation Efforts
- Retaining Technology Assets and Talent Is Becoming More Difficult
- Technology Is Diffusing at an Accelerating Rate
- The Scope of Innovation Is Expanding to Non-traditional Fields
- Innovation Increasingly Occurs at the Intersection of Disciplines
- New Ways to Create and Manage Innovation Are Emerging

Profound Technology Developments Are Reshaping the World

At least three profound technological revolutions are unfolding. The digital revolution has altered every industrial sector and transformed every day life. Biotechnology and nanotechnology promise to do the same. These revolutions are creating platforms for new companies, industries and markets, and they will unleash vast opportunities for innovation. Because of their expected transformative power, countries around the world are developing scientific and technical capabilities in these fields and grappling with how to promote and regulate them to the benefit of their societies.

R&D Capabilities Overseas Are Rising Rapidly, Driving a Global Dispersion of Innovation

The capacity for research and development is spreading globally. Many emerging economies are adopting innovation-based growth strategies, boosting government and private R&D spending, building research parks and regional centers of innovation, and ramping up the production of scientists and engineers.

For example, according to the OECD's Main Science and Technology Indicators:

- In about a decade, R&D in China grew from $12 billion to $86 billion, placing China in third place for R&D spending, behind only the United States and Japan.
- Brazil's four-year national plan for science and technology emphasizes R&D in fields expected to fuel future innovation such as biotechnology, nanotechnology, information technology, energy and climate change.[2]

2 Science and Innovation: Country Notes, OECD

Global Dispersion of Innovation Capacity: Countries Small and Large

LASERS IN LITHUANIA

Vilnius, Lithuania is home to firms that supply 80 percent of the world's high-energy pico-second lasers. The lasers are used for satellite ranging, plasma research, holographic work and many other applications in labs located in nearly 100 countries. The Lithuanian Development Agency credits the speed with which fundamental research was transferred into manufacturing as their advantage.

SOFTWARE IN BRAZIL

Recife, Brazil is home to Porto Digital, an information and communications technology cluster. Born in July 2000, the cluster grew through policies including infrastructure investment, skill training and tax incentives. It now boasts more than100 institutions, including companies, universities and public agencies. Firms here lead in software for finance, health care, gaming and transportation.

IT SERVICES IN INDIA

Hyderabad, India is home to HITEC City, a major global hub of IT services, engineering, business process services, entertainment and software development. Far more than a global call center, HITEC City boasts high-skill workers performing complex tasks. The region's advantage is built on collaboration and building the infrastructure and skills to serve a global market.

And emerging economies are increasing their share of foreign direct investment in high technology and R&D. Their size, rapid growth and growing sophistication mean they are prime markets for innovative products and services. This creates incentives for shifting or expanding operations of U.S. multinationals, creating opportunities for emerging economies to acquire more science and technology capabilities. For example, funding from foreign firms based in China and abroad is estimated to account for about one quarter of business R&D in China.[3]

Innovative capacity is dispersing globally in many fields. For example, the United States has long been a global leader in biomedical fields, but new centers of biomedical R&D and innovation are springing up outside traditional centers in places like Singapore. Countries as diverse as Brazil, Lithuania and India are building their own innovation hubs and moving into high-value commercial activities.

The number of innovator nations with cutting-edge capacity is growing every year. Increasingly, America has no lock on global technology leadership. Despite strong investment, U.S. share of global research has fallen in the face of a global drive by other nations to prosper and build their own innovation futures. And though their success does not equate to U.S. failure—innovation is not zero sum—Americans must ensure the domestic innovation engine (from basic research all the way through deployment in the market place) and network of global partnerships remain strong enough to drive prosperity, solve grand challenges and safeguard security.

In 1960, the United States accounted for 69 percent of global R&D—and the U.S. government alone accounted for 45 percent of global R&D. U.S. government R&D, particularly defense-related R&D which accounted for about one-third of global R&D, was the powerful driver of scientific discovery and technological advancement worldwide.

By the turn of the 21st century, the U.S. share of global R&D had declined to 33 percent, and the U.S. government's share of global R&D to less than a tenth—even as U.S. government R&D investments nearly doubled in real terms. Today, two-thirds of global R&D is performed somewhere other than the United States.

Enterprises Are Globalizing Their R&D and Innovation Efforts

Given the global rise of science and technology capabilities, and growing markets in emerging economies, global enterprises are evaluating where it makes the most sense to locate their R&D and manufacturing facilities. For example, majority-owned foreign affiliates of U.S. multinationals performed $27.5 billion in R&D abroad in 2004 after adjusting for inflation, up $4.7 billion (17.4 percent) from 2003, the largest annual increase since a 22 percent rise in 1999.[4] Although U.S.-based multinationals have invested for more than a decade at least 85 percent of their global R&D in the United States, these firms are likely to become increasingly global in the years to come.

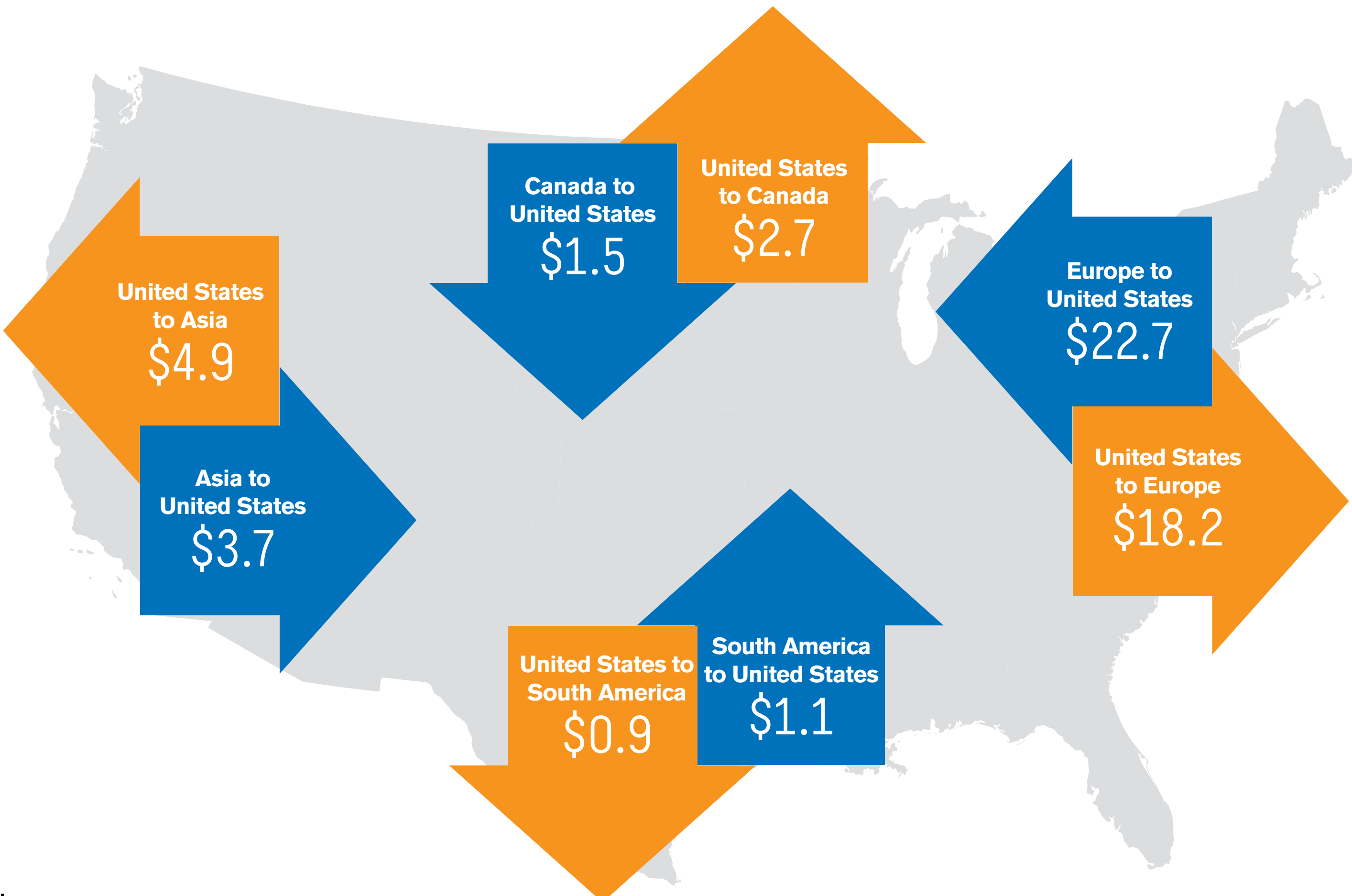
Conversely, majority-owned affiliates of foreign companies located in the U.S. performed $29.9 billion in R&D expenditures here in 2004, roughly the same

3 Science and Innovation: Country Notes, OECD

4 Science and Engineering Indicators 2008, National Science Foundation

Major R&D Flows to and from the Unites States

Source: NSF Science and Engineering Indicators, 2008



$U.S. Billions, 2004 or Latest Year

This figure represents (1) R&D performed by U.S. affiliates of foreign companies in the United States and (2) R&D performed overseas by foreign affiliates of U.S. multinational corporations. Europe is by far the largest inbound investor and outbound recipient of R&D resources, accounting for 71 percent of the U.S. global R&D flow.

as 2003 but growing at a rate faster than domestic R&D investment in the United States.[5] European parent companies accounted for three-fourths ($22.7 billion) of that inbound R&D activity, almost 60 percent of which was related to pharmaceuticals, transportation equipment, and computer and electronic products.

The globalization of R&D suggests that the United States should not only consider how to capture the highest returns on its public R&D investment, but also assess how attractive America is as a private R&D investment market versus a growing list of increasingly sophisticated competitors. The national security ramifications of a more globally diverse and globally collaborative R&D enterprise must also be considered.

Retaining Technology Assets and Talent Is Becoming More Difficult

As emerging economies offer high-skill and lower-cost scientific and technical talent, global enterprises are increasingly attracted to research centers outside of traditional centers in the United States, Europe and Japan.

Global firms consider a complex range of factors in deciding where R&D and innovation work will be done, including:

- exchange rates;
- knowledge base;
- labor rates and availability;
- regulation;
- infrastructure;
- quality of local management;
- tax treatment;
- market proximity; and
- incentives countries offer to lure global investment and business activities.

This raises the importance of maintaining an attractive and innovation-friendly business environment in the United States, because many countries compete well today for investment and knowledge work, including R&D.

In a recent survey[6], companies identified different factors driving their decisions about future R&D sites. While market access and proximity to production facilities were deemed important, the most cited factor was access to qualified staff.

So not only must America compete for investment dollars, but also for the talent that draws that investment. For many years, the United States has relied on foreign-born science, technology, engineering and mathematics (STEM) talent as too few Americans enter these fields to replace the baby boom generation of scientists who are retiring. This problem is particularly acute in defense-related industries that often require high level security clearances.

Compounding the problem of too few U.S.-born students in STEM fields are the hurdles to retaining foreign-born students trained at American universities. At a time when the U.S. should be competing for their skills, these students face daunting immigration restrictions, burgeoning opportunities in their home

5 Science and Engineering Indicators 2008, National Science Foundation

6 *Innovation: Is Global the Way Forward?* A Joint Study by Booz-Allen Hamilton and INSEAD, 2006.

countries and incentives offered by other nations—particularly in Europe. Consider this—in the last 15 years, immigrants have started 25 percent of U.S. venture-backed public companies, concentrated in cutting-edge sectors like high-tech manufacturing, information technology and life sciences.[7] A recent study found that immigrant-founded companies produced $52 billion in sales and employed 450,000 U.S. workers in 2005.[8]

The STEM talent issue in America goes beyond the number of available workers. American students scored lower than their international peers in the latest OECD Program for International Student Assessment (2006). U.S. 15-year-olds scored below the average in both math and science. In math, U.S. students ranked 32nd out of 52 jurisdictions surveyed. In science, U.S. students ranked 23rd out of 45 jurisdictions surveyed.

Technology Is Diffusing at an Accelerating Rate

It took 55 years for the automobile to penetrate a quarter of the U.S. market, but only 35 years for the telephone, 22 years for radio, 16 years for the personal computer, 13 years for the cell phone and seven years for the Internet. This accelerating pace of technology diffusion creates opportunities, but also a volatile marketplace and competitive risks.

Similarly, a great deal of science, technology and know-how are codified as they mature. And, as they are codified, they globalize rapidly. For example, when many companies introduce new products, complementary technical training with standard curricula and skill certification is quickly disseminated in classrooms and online worldwide. This creates opportunities for fast-follower strategies and global labor arbitrage at an earlier stage of the innovation process. This means the nation cannot capture as many jobs as it once could as science and technology innovations diffuse throughout the global economy.

The Scope of Innovation Is Expanding to Non-traditional Fields

Twenty years ago, the concept of innovation revolved largely around science and technology embedded in hardware, products and processes. But the birth of the Internet, web-enabled businesses, novel approaches to service delivery, new media and high-value lifestyle products and services are expanding the scope of innovation, and some of these innovations are game changing.

For example:

- Apple's iPod, iPhone and iTunes have revolutionized the distribution of music, broadcasting and movies. They are more than a form of product innovation—they also illustrate innovation in business process and business models.
- Facebook is a service innovation that is revolutionizing how people connect, communicate, network, socialize and do business.

These new forms of innovation expand the base of talent needed to develop and deploy innovative products and services. For example, these new forms of innovation include information technology workers, service delivery designers, entertainers and

7 Anderson, Stuart and Platzer, Michaela, *American Made, the Impact of Immigrant Entrepreneurs and Professionals on American Competitiveness*, Study for the National Venture Capital Association, 2006

8 Wadhwa, Vivek; Saxenian, AnnaLee; Rissing, Ben; and Gereffi, Gary, *America's New Immigrant Entrepreneurs*, Duke University, 2007.

Time to Reach a Market Audience of 50 Million People
Source: Karl Fisch, Scott McLeod, Jeff Brennan—Video: *Did You Know?*

artists. Much of this innovation, however, is seemingly invisible because it occurs between businesses and/or government agencies, such as the use of radio frequency identification tags to manage supply chains. This type of innovation drives productivity, keeps firms competitive, opens new service opportunities, makes government more efficient and lowers prices for consumers.

The growth of the service economy also brings more skill sets into the earliest stages of innovation. The service sector accounts for almost 80 percent of U.S. employment and gross domestic product. America has run a trade surplus in services since 1971. High-skill service innovation requires more than isolated scientists and engineers to succeed in the marketplace. The human element of service innovation requires technical interfaces to be designed in tandem with experts in behavioral sciences and business disciplines like management, marketing and design.

Innovation Increasingly Occurs at the Intersection of Disciplines

R&D has generally been the province of individual research investigators, focused on specific disciplinary specialties such as chemistry or biology. In contrast, innovation today is becoming more technologically complex and multidisciplinary, occurring at the intersections of disciplines and different spheres of activity. There are even entirely new combinational disciplines such as nano-biology, network science, bioinformatics, and agro-energy biotechnology. Biomaterials melds design, fabrication and life sciences, while digital animation brings together the skills of computer graphics specialists, story tellers, ethnographers, anthropologists and actors.

Potential Game-Changing Technologies

Source: SRI Consulting Business Intelligence and Toffler Associates

Ubiquitous Computing: widespread tagging and networking of mundane objects such as food packages, furniture, room sensors and paper documents. Such items will be located and identified, monitored, remotely controlled through enabling technologies such as RFID, sensor networks, tiny servers and energy harvesters—connected to the Internet using low-cost, high-power computing.	Demand for greater efficiency in a wide range of operations from food safety to more efficient supply chains. A wide range of institutions, individuals, and processes will become more efficient and secure.
Energy Storage: range of materials, techniques and technologies for storing energy needed for the viability of many alternative sources of energy, for example, battery materials and hydrogen storage. Needed to support deployment of alternative energy technologies such as wind and solar power, and low emission vehicles.	High cost of fossil fuels, the need to reduce dependency on foreign oil and pressure to use cleaner sources of energy to mitigate global climate change.
Biogerontechnology: science related to the cellular and molecular basis of disease and aging, applied to the development of new technological means to identify and treat diseases and disabilities associated with old age. Supporting technologies include biosensors for real-time human health monitoring, ubiquitous DNA sequencing, DNA-specific medicines and targeted drug-delivery mechanisms.	Aging populations, rising medical costs and the desire to keep older workers in the workforce.
Biofuels Technologies: used to produce ethanol from crops such as corn and sugar cane, and biodiesel from grape-seed and soy. Next generation technology will convert lignocellulosic materials to fuels. Work is also underway to cultivate micro-algae that can be converted to biofuels.	High crude oil prices, the need to reduce dependency on foreign oil and pressure to use cleaner sources of energy to mitigate global climate change.
Human Cognitive Augmentation Technologies: drugs, implants, virtual learning environments and wearable devices to enhance cognitive abilities. For example, wearable and implantable devices could improve vision, hearing and memory. Bio- and information technologies could enhance human mental performance at every life stage.	Desires for improved military planning, combatant performance, treatment of Alzheimer's disease, increased educational effectiveness, enhanced personal entertainment and improving job performance.

Development and deployment of technologies limited by material science, the unknown cost of large-scale manufacturing and the cost of energy storage infrastructure.	Ability to store and use energy from a variety of alternative energy sources offers the potential for a major energy transformation, resulting in significant global economic and social advantages to those first to the market. Widespread deployment could have political repercussions involving economies dependent upon sales of fossil fuels.
Development and deployment of the technologies are restricted by land use, water availability, competition from food production, production scale up and high production costs.	Large-scale move to biofuels could reduce demand for oil and reduce global competition for world oil supplies and reserves. Would alter the energy dependence of some nations reliant on imported fossil fuels, shifting national interests. Biofuels that avoid land use changes could reduce net CO_2 emissions significantly.

The multidisciplinary field of biomimicry is a new driver for innovation, in which features of the biological world are mimicked in technology applications. Examples of biomimicry-based innovation include: strong, light-weight steel sheets inspired by bird bones; competition swimsuits and ship haul coatings that replicate a shark's skin, and vehicle anti-collision systems based on the way locusts swarm without running into each other. The QUALCOMM iMoD information display mimics the way butterfly wings and peacock feathers cause light to interfere with itself, creating shimmering iridescent colors.

In addition, many innovations fuse manufactured hardware with services. For example, every 30 days, General Motor's On-Star on-board diagnostic system automatically checks a vehicle's operating system, and e-mails a report and maintenance schedule to the vehicle owner. On-Star also detects vehicle accidents and can summon emergency personnel if needed.

Recognizing the potential for multidisciplinary innovation, Singapore's Fusionopolis research center brings together teams of researchers from different disciplines, including materials science and engineering, data storage, microelectronics, manufacturing technology, high performance computing, and information and communications. Singapore believes that this integrated approach will give them a competitive advantage to create future industries in areas such as energy technology, aerospace, health care and future living.

New Ways to Create and Manage Innovation Are Emerging

The traditional view of innovation—the quirky inventor or the lone scientist working in a lab toward that "aha" moment—is giving way to co-creation, the global innovation team and even peer production.

Customers and producers are engaging in co-creation, working together in the design and development process. Innovations also are increasingly the product of teams in which researchers and engineers, marketing personnel, designers, production and service delivery managers, key vendors and others collaborate to rapidly develop innovations and bring them to market.

As science, research and technology development capabilities rise around the world, collaboration on innovation is increasingly global. Firms tap talent for their teams from around the world, and from inside and outside of the company. Patterned after global manufacturing supply chain networks, high value-added service companies are building global innovation networks for assembling the right combination of knowledge and skills needed to develop and/or deliver a particular product or service innovation.[9]

For example, a recent IBM software development project included research scientists from New York and Texas; software developers from India; engineering and quality control experts from Florida and New York; and other experts and software workers from Pennsylvania, California, Illinois and North Carolina.[10] The team developing a new version of the company's Lotus Symphony software spanned China, Texas, Massachusetts and translation centers in

9 Scouring the Planet for Brainiacs, Worldwide Innovation Networks are the New Keys to R&D Vitality and Competitiveness, Business Week, October 11, 2004; At IBM, A Smarter Way to Outsource, New York Times, July 5, 2007.

10 At IBM, A Smarter Way to Outsource, New York Times, July 5, 2007.

seven other countries.[11] By operating teams globally around the clock, companies can accelerate innovation, and bring new products and services to market faster and in greater variety.[12]

Peer production is another emerging form of collaborative innovation. Hundreds, thousands, even millions of individuals contribute to building a product or service. Wikipedia is a well-known example. Millions of customers help Amazon.com—and most online sales sites today—by rating products. The video game industry, LEGO, eBay, NASA, and even the U.S. Patent and Trademark Office are exploiting this novel Internet-enabled co-creation model.

External collaboration plays a key role in nearly 50 percent of Procter & Gamble's products. Open to anyone, P&G's Connect + Develop initiative seeks innovations and collaborations on packaging, design, distribution, business and marketing models, consumer research methods, technology research and more. P&G is interested in all types of high-quality, on-strategy business partners, from individual inventors or entrepreneurs to smaller companies and those listed in the FORTUNE 500. Connect + Develop has already resulted in more than 1,000 active agreements.[13]

Center For Innovation

Lockheed Martin's Center for Innovation is a model of collaborative innovation. Based in Virginia, the Center brings the company's researchers and specialists together with customers and partners to tackle a variety of national security challenges.

Current initiatives focus on Net-Centric Operations; Joint Force Projection; Homeland Defense and Security; and Logistics and Material Readiness. The Center houses specialists in areas such as operations analysis, modeling and simulation, and visualization.

LOCKHEED MARTIN

11 http://www-03.ibm.com/press/us/en/pressrelease/23360.wss

12 Scouring the Planet for Brainiacs, Worldwide Innovation Networks are the New Keys to R&D Vitality and Competitiveness, Business Week, October 11, 2004

13 https://secure3.verticali.net/pg-connection-portal/ctx/noauth/PortalHome.do

Recent Efforts to Spur U.S. Innovation

2004

The National Innovation Initiative

In 2004, the Council on Competitiveness engaged more than 400 thought leaders in workshops across America to discuss the role of innovation in competitiveness and to propose solutions to the country's most urgent needs. The National Innovation Initiative (NII) issued a call to strengthen U.S. talent, investment and infrastructure. It included steps for businesses, universities and government at all levels.

2005

The final NII report, *Innovate America*, would not just collect dust on a shelf. In 2005, the Council and its members worked with a bipartisan team of senators to craft legislation based on the report's recommendations.

2006

Democratic Innovation Agenda and American Competitiveness Initiative

Spurred by calls to reverse troubling trends in U.S. basic research and education in science, technology, engineering and mathematics (STEM) fields, leaders in both political parties took action. In late 2005, House Minority Leader Nancy Pelosi unveiled the House Democrats Innovation Agenda. In early 2006, President George W. Bush announced the American Competitiveness Initiative in his State of the Union Address. The agendas were remarkably similar. Soon after her election to Speaker of the House, Pelosi and Bush pledged to cooperate on this agenda and to double key research agency budgets over 10 years.

2007

The America COMPETES Act

In addition to the legislation based on the Council's Innovate America report, a second bipartisan team in the Senate began drafting based on the report *Rising Above the Gathering Storm*, a collaboration between prominent members of the NII steering and advisory committees and the National Academies. The two legislative efforts merged to become the America COMPETES Act, passed by overwhelming majorities in the House and Senate and signed by President Bush in November 2007.

2008

The COMPETES Act echoes the reports on which it was based and authorized actions to strengthen America's innovation ecosystem. The three main components would 1) invest in physical science basic research, 2) train teachers in math and science, and 3) assist students in STEM fields. Despite this success, Congress and the Bush administration struggled in 2007 and 2008 to enact meaningful appropriations to make the programs of the COMPETES Act a reality.

2009

Obama Administration Agenda and Budget

President Obama made clear in his campaign that he endorsed the bipartisan pledge to double key research agency budgets over 10 years, namely the National Science Foundation, the Department of Energy Office of Science, and the National Institute of Standards and Technology.

He placed a high priority on achieving this goal once in the White House, lending strong support for science funding in the economic recovery legislation and in the regular appropriations cycle. The end result was a substantial investment in America's scientific enterprise, particularly for infrastructure, research and student support. The president has also appointed a chief technology officer to advance policies and technology platforms that will drive innovation in the public and private sectors. President Obama has also signalled that new investments in alternative energy and health care technology will be national priorities.

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 1

New Directions for U.S. Technology and Innovation

Challenges in the U.S. Innovation System

- Scientists and engineers often receive training disconnected from how they will work in the real world.
- More disciplines must be attuned to innovation opportunities.
- The research enterprise has been slow to resond to the rise of multidisciplinarity.
- Features of the U.S. research system impede the deployment of new knowledge and technology, and create barriers to rapid innovation.
- The United States frequently does not set clear priorities for its public research investment.
- Today's game-changing, enabling technologies sometimes require new approaches to regulation.
- Modeling and simulation with high performance computing could accelerate and multiply U.S. innovation, but there are relatively few users.
- Strong leadership is needed to address many factors that affect U.S. innovation.
- The United States may not capture an adequate return on its public investments in R&D.

So, although policy makers and Americans at large increasingly recognize the roles that innovation and technology play in a growing economy, national security and solving most of the biggest societal challenges, the United States has only just begun to act to ensure both the support for seedcorn investment as well as the policy infrastructure and public-private partnerships to deploy innovations, capture value and create new wealth in the United States in the 21st century. The nation is making a substantial federal investment in research, teacher training and student assistance in fiscal year 2009—the first year of a 10-year commitment. That commitment must be sustained to make it meaningful. But even if that is done, it will only have rebuilt the important post-World War II foundation on which 21st century innovation enterprise must stand. To compete and prosper, the United States must adopt fundamental new approaches to optimize its innovation assets.

Scientists and engineers often receive training disconnected from how they will work in the real world. Many research universities train scientists and engineers as if they were going to work in an academic research setting. But the vast majority of individuals whose highest degree is in science and engineering do not work at a four-year college or university. In fact, less than one in ten do. Fifty-nine percent work in the private sector, as do one third of those with doctorate-level science and engineering degrees.

Private sector needs and working environments are very different than those in academic research. Entrepreneurial, business and management skills are valued in business broadly, and such skills are vital for science, engineering and technology professionals who work to develop new innovations or start-up high-tech businesses.

Scientists and engineers who work in the business sector must operate in fast-paced, goal-driven environments; understand the connection between R&D projects and the business bottom-line; and communicate their ideas to non-technical staff such as financial professionals.

In addition, as markets globalize, researchers and product developers need a greater understanding of the different cultures they will serve. And, as scientific and technical capabilities spread worldwide, scientists and engineers need to be hunter-gatherers as well as creators of new knowledge and technology.

Stronger links between business needs and the education and training of scientists, engineers and technology professionals would help ensure that the academic community is fully in tune with the skills businesses need to innovate and compete.

More disciplines must be attuned to innovation opportunities. Today, the development of many innovations relies on a cadre of professionals that goes beyond scientists and engineers—designers, artists, service and business model experts, social scientists and others. Yet, universities generally do not offer learning environments that bring these fields together with traditional science and engineering, even though increasingly no one organization or discipline has all the necessary resources for high-value innovation.

So in addition to engineers who are familiar with business and social science disciplines, business professionals and social scientists trained with a firmer footing in technology and a deeper understanding of the entrepreneurial process that takes new technologies and services to market are needed. The teaching of innovation must be improved and expanded.

The research enterprise has been slow to respond to the rise of multidisciplinarity. Traditional single discipline, single investigator-driven projects remain the overwhelmingly dominant model of university research, underpinned by federal R&D investment.

Multidisciplinary innovation may require a different research model, in which different disciplines cluster around a challenge or goal and integrate their diverse knowledge and skills. In addition, many of today's big challenges—from food and water shortages to energy and climate change—are complex and cut across disciplinary fields. No matter how excellent they may be, small single-discipline R&D projects are too small in scale and scope for many of today's research challenges and opportunities for innovation.

Numerous barriers impede multidisciplinary research within the academic community—single-discipline organizational structures, reward systems, too few academic researchers collaborating with disciplines other than their own, the relatively small size of most grants, traditional peer review, publication practices and career paths within academia. Federal policy and funding have been slow to respond to more complex science, technology and innovation scenarios, and to the need for more multidisciplinary innovation. For example, only about 5 percent of

Multiple Disciplines to Tackle a Grand Challenge

Launched in May 2009, GE's healthymagination initiative will invest $6 billion across its business units and engage many partners to improve health care cost, quality and access.

The initiative draws on engineers, researchers in multiple fields, doctors, government leaders and business process experts. Healthymagination will offer lower cost technologies, streamlined and more accurate records, new services in underserved areas, and smarter outreach to consumers on health issues.

healthymagination

imagination at work

the National Science Foundation's investment in research goes for its research center programs, which are the principal means by which NSF fosters interdisciplinary research.

Features of the U.S. research system impede the deployment of new knowledge and technology, and create barriers to rapid innovation. Since Vannevar Bush envisioned a framework for the U.S. science and technology system 50 years ago, the United States has built a university-based research enterprise unparalleled in the world. However, challenges arise when the generators of new knowledge and technology are in universities and users are in industry.

This arrangement often creates a cumbersome, time-consuming technology transfer gap, as new science and technology are conceived in academic labs, and then industry has to figure out how to commercialize them. For example, limited dissemination of knowledge, skill and expertise in nanotechnology is a continuing barrier to the commercialization of cutting-edge ideas that come out of the lab. Transfer of nanotechnology know-how and ideas from universities to industry occurs primarily when students are hired by existing companies or start new ones.[14]

This feature of the U.S. research system also creates "readiness for application" gaps. R&D results and technologies that emerge from academic labs are often too immature to attract private financing for further development, creating a "valley of death" problem.

In addition, there are significant cultural differences between universities and businesses that impede collaboration. For example, time horizons at universities are often incompatible with the fast pace of innovation in the private sector. Since enactment of

14 The National Nanotechnology Initiative: Second Assessment and Recommendations of the National Nanotechnology Advisory Panel, President's Council of Advisors on Science and Technology, April 2008.

the Bayh-Dole Act of 1980 and similar policies, academic and government researchers have been urged to consider the commercial value of their work, and to collaborate more with industry partners. Such collaboration would be enhanced if these researchers better understood the needs of business and the marketplace, the constraints under which the private sector operates and the need to protect valuable intellectual property.

To be clear, this should not be construed as denigrating the absolutely essential role played by university basic research as a source of new ideas. It is to say that as ideas mature, there is a need to consider how to translate more of them into actual products, services and practices—and to do so more efficiently. A growing number of universities overseas are building cooperative relationships with industry to achieve precisely that objective.

The allocation of U.S. research funds may be emblematic of the divide between industry and U.S. research universities. Industry conducts only a small share of applied research at U.S. universities because companies need to commercialize as quickly and cost effectively as possible, and they seek to maximize the return on their investment. About 6 percent of academic research is funded by industry, about $2.3 billion (in 2007). But, that $2.3 billion represents a mere 1 percent of industry's more than $220 billion in R&D spending (in 2007).[15]

In addition, while public research funding is often fragmented in smaller increments, some technologies are large in scale, such as many renewable energy technologies. Pilot scale demonstrations may be needed to generate the performance and cost data private investors require before they will invest the substantial funds needed to bring such technologies to market. Pilot scale demonstrations can be expensive, and there are few public programs to fund them.

Different models for conducting federally funded R&D are beginning to emerge, like at the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), the primary government office responsible for supporting the development of new, renewable energy technologies and cleaner, fuel-efficient vehicles. They convene industry and academic experts to explore R&D challenges, and to identify R&D priorities; set outcome goals (such as cost and performance goals); develop roadmaps, identify milestones and develop multi-year research plans to achieve these goals; invest in competitively-selected projects with industry, universities and partnerships to meet these goals; drop less promising approaches and increase support for better ones; and fund some demonstrations and pilots to generate the performance and cost data needed to close the valley of death and attract commercial financing for private sector commercialization.

The United States frequently does not set clear priorities for its public research investment. There has been little effort to examine the totality of the federal R&D portfolio against national needs, goals, priorities and opportunities for innovation. In the traditional peer-review process, proposed projects in a single discipline are evaluated against each other, rather than against a national need or goal to which such projects could contribute. In addition,

15 NSF data in constant dollars.

there is little attempt to look across disciplines to identify projects or areas of research that could contribute most to national needs or goals.

In light of the growing capacity to innovate overseas, Americans should take stock of public R&D investment with a broad participation among stakeholders. Americans should ask ourselves, "are we striking a reasonable balance today between traditional peer-reviewed projects, multidisciplinary research and national priority projects?" "Are we maintaining a reasonable mix between basic and applied research?"

Today's game-changing, enabling technologies sometimes require new approaches to regulation. Digital technology, biotechnology and nanotechnology impact daily life and innovation enterprise in many ways—in basic and applied research, product development, manufacturing, standards, human resource development and instrumentation. These technologies cut across disciplines, the branches of government, the missions of government agencies, committee jurisdictions in Congress and even the borders of countries. For example, the courts, Congress and consumers are still hashing out the myriad of economic, social and legal issues brought about by rapid global deployment of the Internet.

Regulations frequently lag behind scientific and technological advancements. If regulations in the United States do not keep up, emerging economies may move to rapidly exploit the economic value of these advancements without regard for the need for appropriate regulations or safeguards.

Regulations can cut both ways, either hindering or enabling innovation. Many venture capital firms believe that the Sarbanes Oxley regulations put in place in 2002 have played a significant role in the dramatic decline of initial public offerings (IPOs) in the United States. Critics cite the higher compliance costs as forcing potential start ups to launch outside the United States, seek a merger or acquisition, or raise private capital.

Conversely, the lack or obsolescence of regulations also can create market risks and uncertainty that discourage investment in cutting-edge technologies. For example, while the effect of nanoscale materials on health or the environment are not known or are poorly understood, numerous nanotechnology-based products are already in the marketplace. However, no nano-specific regulation exists anywhere in the world,[16,17] and there is no international regulation of nano-products or the underlying nanotechnology. In the United States, the Food and Drug Administration regulates products based on their statutory classification rather than the technology they employ. As a result, FDA's regulatory consideration of an application involving a nanotechnology product may not occur until well after the initial development of that nanotechnology.

The President's Council of Advisors on Science and Technology has identified a diversity of barriers to nanotechnology commercialization that have little do with R&D or technology, including: lack of standards;

16 Nanotechnology & Regulation, A Case Study using the Toxic Substance Control Act, Woodrow Wilson International Center for Scholars, Foresight and Governance Project.

17 2nd Annual Conference on Nanotechnology Law, Regulation, and Policy, Food and Drug Law Institute.

questions about environmental, heath and safety effects that may create unknown risks, give insurers pause, or cause manufacturers to avoid labeling their products as nano-based; an investor community uncomfortable with many nano-material start-ups due to their relative early stages of development and long product application timelines; and insufficient education and workforce preparation.[18]

Addressing in parallel the wide range of impacts that may arise from a revolutionary enabling technology may be essential to capture fully the economic benefits through full and timely commercialization of that technology in its many applications. The U.S. National Nanotechnology Initiative is one attempt at such an integrated approach.

Modeling and simulation with high performance computing could accelerate and multiply U.S. innovation, but there are relatively few users. Modeling and simulation with high performance computing (HPC) can be a force multiplier for innovation. These tools are innovation accelerators, offering an extraordinary opportunity for the United States to design products and services faster, minimize the time to create and test prototypes, streamline production processes, lower the cost of innovation and develop high-value innovations that would otherwise be impossible.

Unfortunately, the United States has only scratched the surface in harnessing HPC, modeling and simulation, which remain largely the tools of big companies and researchers. While there are world-class government and university-based HPC users, there are relatively few experienced HPC users in U.S. industry, and many businesses do not use it at all. Driving HPC, modeling and simulation throughout the supply chain would put these powerful tools into the hands of companies of all sizes, entrepreneurs, innovators and inventors to transform what they do.

Strong leadership is needed to address many factors that affect U.S. innovation. A wide range of factors—from R&D and capital availability to manufacturing and regulation—affect a nation's ability to innovate. These diverse factors cut across the stove-piped missions of government and academic expertise. But effective policy development requires an integrated view and expertise of how R&D, technology, economic, trade, education and international policies may affect innovation. The United States lacks a government office or agency whose sole mission is fostering innovation in America, with an overarching and integrated view, funding adequate to continually assess what is a rapidly evolving global landscape for innovation, and to serve as an innovation advocate across the broad range of domestic and international policy fora.

The Obama Administration appears to be taking a step in this direction with the appointment of a new "chief technology officer" (CTO) for the United States. As CTO, Aneesh Chopra has noted: "My job is to serve as the innovation platform champion in addressing private market opportunities in support

18 The National Nanotechnology Initiative: Second Assessment and Recommendations of the National Nanotechnology Advisory Panel, President's Council of Advisors on Science and Technology, April 2008.

of public priorities." He has listed his objectives as: (1) economic growth through innovation, (2) addressing presidential priorities through innovation platforms, (3) building the next-generation digital infrastructure, and (4) fostering a culture of open and innovative government."[19]

The United States may not capture an adequate return on its public investments in R&D. The federal government invests more than $140 billion annually in R&D. This R&D produces research results and new technology that can be incorporated into commercially valuable products, services and processes that could generate U.S. economic growth, business formation and expansion, and job creation. However, there is no guarantee that U.S.-based multinationals will locate the bulk of commercialization activities in the United States, but may instead locate in countries with low cost manufacturing or in proximity to large and lucrative emerging markets.

19 Hansell, Saul. "The Nation's C.T.O. Lays Out His Priorities," The New York Times (italicized), June 3, 2009.

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 1

Revisiting Policies, Systems and Models to Ensure Future U.S. Innovation Leadership

The potential of game-changing technologies and the profound changes they could bring about, coupled with the changing and challenging landscape for technology and innovation, suggest that the United States should re-examine the contours of its policies, systems and "ways of doing business" that support science, technology development and innovation in both the public and private sectors.

Key questions the Technology Leadership and Strategy Initiative should explore include:

- In your view, what are biggest potentially game-changing technologies on the horizon (10-20 years)? What are their potential economic, political and social implications?
- To what degree and in what time frame should the federal government and industry address these technologies? In what kinds of structures and processes should the government and industry deal with the implications of these game changing technologies?
- What technology and innovation-related criteria influence global investment decisions by CTOs?
- What does the global distribution of corporate research and development imply for U.S. technology leadership?
- What gives/would give the United States a competitive advantage in attracting R&D and innovation-related investments?
- What kind of investments should the United States try to attract?
- How would the prospect of public-private technology partnerships affect that calculation?
- What barriers inhibit (and what incentives drive) investment and deployment of cutting-edge technologies in the United States?
- How does the globalization of research and technology affect U.S. national security?
- Would greater public-private-academic coordination and cooperation in game changing enabling technologies be valuable (spanning the range of issues from science and R&D, to instrumentation, regulation and standards)? What models might be employed?
- How should the United States organize efforts to address large, multi-disciplinary and/or complex technologies and grand challenges with potential technology solutions? How should such efforts be funded?

- What are the key strengths and weakness of U.S. universities in supporting private sector R&D and innovation-related activities? How would you change what universities do in this regard?
- What are the key strengths and weakness of federal policies, programs and investments in supporting private sector R&D and innovation-related activities? How would you change what the federal government does in this regard?
- What are the key strengths and weakness of state and local programs designed to generate economic growth and development through geographic proximate private sector innovation? How would you change what state and local programs do in this regard?
- Do U.S. academic and government policies and practices related to R&D and innovation need to reflect differences between large and small firms/innovators? How would the policies be different?
- How can the United States ensure that it captures an adequate return on public investments in R&D?

Part 2:
Findings from
TLSI Dialogue 1

PART 2: FINDINGS FROM TLSI DIALOGUE 1

Executive Summary

Innovation has taken center stage in government and industry efforts worldwide to compete and prosper. Public and private sector leaders understand increasingly that innovation—the ability to develop new ideas and deploy them in the real world—is the lynchpin of economic success. Innovation creates high-margin business, sustains high-wage jobs and drives productivity. It is central to solving many of the most pressing challenges in realms such as health care, energy and national security.

The reality, however, is that America and the world are only at the beginning of understanding the dynamics of modern innovation. A myriad of public policies affect the ability of private firms to move ideas from laboratories to market. Research and education policy are universally recognized as critical components to spurring innovation, but less attention has been paid to the impact of policies related to export controls, liability, highly-skilled immigrants and intellectual property/technology transfer. The private and public sectors are grappling with how they should innovate in a new global environment, including how to collaborate best with each other, with their customers or citizens, with suppliers, across scientific and business disciplines, and with entities overseas.

The Technology Leadership and Strategy Initiative (TLSI) will convene a series of dialogues that pose critical questions, such as:

- In a world in which information disperses instantaneously and innovation capacity continues to diffuse globally, how does a country making an R&D investment capture the wealth creation from the resulting technology's deployment?

Chad Evans, Council on Competitiveness; Mark Little, General Electric Company; Ray Johnson, Lockheed Martin Corporation; Chad Holliday, DuPont; and Deborah Wince-Smith, Council on Competitiveness.

- What criteria influence global investment decisions in the technology space—in terms of research, talent and infrastructure?
- What are the implications of globally-dispersed research and development activities and investments for U.S. leadership and competitive advantage?
- What are the most critical barriers inhibiting development and deployment of cutting-edge technologies inside the United States—and how can they be overcome?
- What are the necessary elements for a new paradigm of collaboration between the public and private sectors to optimize America's investments in research, talent and technology?
- What is the best way for the U.S. private sector to engage the new administration and Congress and prioritize commercialization?

On June 22, 2009, the TLSI brought together chief technology officers from industry, academia and government. The dialogue covered two broad themes: (1) the challenges and opportunities faced by the United States in the current global landscape and (2) how the private and public sectors can collaborate more effectively so that each can achieve its innovation objectives. The keynote address was delivered by Aneesh Chopra, the chief technology officer and associate director of technology at the White House Office of Science and Technology Policy.

Participants generally agreed that the innovation capacity of the United States remains among the best in the world, but that many trend lines are moving in the wrong direction. Other nations are making rapid progress relative to the U.S. in talent, investment and infrastructure. Furthermore, a number of U.S. policies designed for a different era and different global landscape impose a drag on U.S. innovation today.

The TLSI will identify a limited number of priority issues, develop recommendations and press for action.

PART 2: FINDINGS FROM TLSI DIALOGUE 1

Perspectives from the TLSI Co-Chairs

In kicking off the inaugual TLSI Dialogue, co-chairs Ray Johnson and Mark Little shared their vision for the initiative—to re-ignite debate and action over a fundamental competitiveness driver: the public-private partnership at the heart of technology-based competitiveness.

Ray Johnson
Senior Vice President and Chief Technology Officer
Lockheed Martin Corporation

As we put the TLSI together I asked, "How are we going to differentiate this review of innovation from the others?" We have all filled out surveys, and most of them look the same. We are going to try hard to make TLSI different—to focus on how the public and private sector can partner more effectively, and to ensure that our policy and technology keeps up with global reality. I believe that we can achieve something very important.

We lived in an asymmetric world, an unnatural state, for about 60 years. The Marshall Plan after World War II created huge economic engines alongside America in Western Europe and Japan, while the Soviet Union, its satellites and the developing world struggled. With the end of the Cold War and thanks to the beauty of information technology, the world is flat, and technology is leveling that asymmetrical world of our recent past.

Invention and innovation, I think, are two very different things. When we consider who is around the table today, we have a wonderful group in academia, government and industry working together. We should think about the role each plays in invention, the creation of ideas, and each party's role in innovation, the application of ideas to products and services.

Policy is important to create an environment for innovation. Companies like Boeing or Lockheed Martin work very hard to achieve flawless execution. We talk about it all the time. Innovation, however, is different—if you try to execute flawlessly, you'll manage it to death. It is commonly said that innovation is supported, not managed.

So as we think about policies and risk tolerance, and how do we support an environment for innovation, I have a couple of recent examples that lead me to believe that we can be successful.

About a year ago, I was contacted by a serial entrepreneur, Larry Bock, who had an idea. He attended the Cambridge Science Festival and wanted to hold a similar event on the West Coast, a San Diego Science Festival. He asked if I would participate, and I accepted gladly.

Within a week, Larry had seven Nobel laureates signed up. During the next few months, the idea began to swell, and we were planning the event to be in San Diego's Balboa Park, hoping that 15,000 kids would come and hear about science. By the day of the event, there were 350 exhibitors. The park is supposed to hold 50,000 people. As the crowd grew to more than 100,000 people, they closed the gates due to safety concerns, and there was a six mile long backup trying to get in.

Especially in today's economic environment, this event tells you that there is a desire, a hope and an interest in science and technology. Of all the things we talk about, rebuilding America's passion for STEM education is perhaps the most important.

The second example occurred in India. Working with the Indian Department of Science and Technology, Lockheed Martin is sponsoring a program called the India Innovation Growth Program.

The program is a partnership between the University of Texas, the Chamber of Commerce of India and Lockheed Martin. The University of Texas offers instruction in how a person with a bright idea can develop a business plan and make the necessary connections to execute the plan. The Indian Chamber of Commerce acts as a match-maker between the idea, the invention and the people who need the idea to become an innovation.

The program is in its third year. The goal is to have business tie-ups, as they're called, among the stakeholders. The first year, there were seven or eight. In the second year, there were probably 20. We've already put together about 40 this year.

A person in the program once came in and said to us, "I apologize. I'm not wearing a suit because I can't afford one." But he had a great idea, centered on enzymes that can be used to turn plastic back into petroleum products. He is now opening plants all over the world, and his company is valued at $400 million U.S. dollars. Suffice to say he now wears a suit.

So it does happen. We need to find ways of turning on the creativity, the ingenuity and the competitiveness that's so vital in America, because quite literally our future depends on it.

"Policy is important to create an environment for innovation. Companies like Boeing or Lockheed Martin work very hard to achieve flawless execution. We talk about it all the time. Innovation, however, is different—if you try to execute flawlessly, you'll manage it to death. It is commonly said that innovation is supported, not managed."

Ray Johnson
Senior Vice President and Chief Technology Officer
Lockheed Martin Corporation

"I believe very strongly that the United States still has…an innovation spirit that has not died, has not diminished and really can carry us forward."

Mark Little
Senior Vice President and Director of GE Global Research
General Electric Company

Mark Little

Senior Vice President and Director of GE Global Research
General Electric Company

I came here in the spirit to learn from each other as much as possible about this important subject. From my perspective as the leader of a global technology group, it is obvious that brainpower is spread evenly across the globe, and that the world outside America is rising economically in very important ways.

But even within that context, I believe very strongly that the United States still has some incredible advantages and strengths, and an innovative spirit that has not died, has not diminished and really can carry us forward. We must become more innovative. As you know, GE is a global company. For the first time last year, more than 50 percent of our revenues came from outside the United States.

That change is not because we're selling low-cost, low-tech products. It's because we're selling very high-technology products, and we're bringing to the world better things that they cannot get anywhere else. I fully well appreciate that driving forward technology and innovation is the way to make a better world and to keep the United States strong.

I look forward to sharing our ideas openly and candidly, so we can really get something meaningful to share with our government, with our colleagues in industry, and to make this world a better place.

PART 2: FINDINGS FROM TLSI DIALOGUE 1

Dialogue Proceedings

Landscape for Technology and Innovation: Challenges and Opportunities Facing the United States

Eighty-five percent of respondents felt that the United States is the current leader in R&D, but only 36 percent believe that this will be the case in five years under current trends.

Findings from the Council on Competitiveness/ Seed Media Group CTO Survey
Seed Media Group partnered with the Council on a survey of Council members and of subscribers to *R&D* magazine. The aim of the survey was to learn about how American CTOs and R&D directors think about their companies and the state of U.S. research, and how they measure innovation and success. Most important, the survey examined what kinds of environments and what factors are critical for spurring innovation in the future.

The findings demonstrate a consensus that the United States continues to possess many strengths as an innovator nation, but that the trends point to advancing capabilities overseas, greater global collaboration among researchers and a need to strengthen the U.S. Innovation system. The findings also shed light on important emerging and interdisciplinary fields and the impact of the current economic downturn.

Eighty-five percent of respondents felt that the United States is the current leader in R&D, but only 36 percent believe that this will be the case in five years under current trends. Outside the United States, respondents believe that the EU will be the greatest source of research and innovation in the next five years, followed by China, Japan and India.

Talent and investment in research were identified as most crucial to innovation performance. Ninety percent of the CTOs ranked education and skills as a top-5 factor in the growth of competitiveness overseas—with 34 percent ranking it No. 1 (see Figure 1).

In fact, the importance of talent runs throughout the survey responses. Improving K-12 education was flagged as the top policy priority for innovation. CTOs named access to skills as the top factor in global research investment decisions. Respondents identified talent as the biggest threat to America's long-term viability as an innovator, with more answers on that topic than any other, roughly doubling the next most frequent response (research investment).

US-based firms still conduct most of their research at-home and in-house, but the global and outsourced share is poised to grow. Respondents reported that 88 percent of their research today is conducted at home and 86 percent in house. In five

Figure 1. Factors CTOs Rank as Most Crucial to Innovation Performance
Source: Council on Competitiveness/Seed Media Group CTO Survey

Factor	CTOs Ranking this a Top-5 Factor	CTOs Ranking this as the No. 1 Factor
Education and Skills	90%	34%
Public R&D Investment	76%	26%
University/Lab Infrastructure	74%	17%
Economic Stability	63%	13%
Public Policy—IP, Tax, Regulations	55%	3%

years, however, the respondents expect the share of research conducted overseas to increase by about five percent. They also expect to outsource about three percent more research in five years to third party organizations, both at home and abroad.

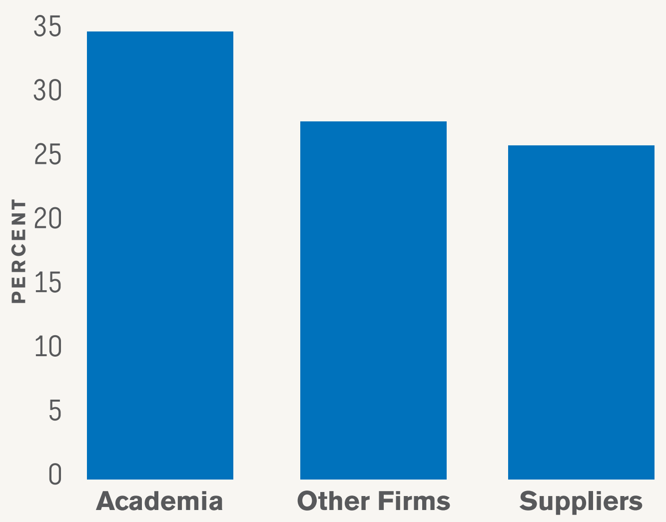
The CTOs identified some of their concerns when considering offshore R&D. Seventy-nine percent indicate that they are very concerned about intellectual property protection. Many respondents also are very concerned about data security (67 percent) and loss of control over operations (51 percent).

Collaboration is important. Eighty-nine percent of private industry respondents said that their firm collaborates with academic researchers. Most of the CTOs indicate that their researchers already collaborate with other companies, suppliers and academic researchers (76, 80 and 89 percent, respectively). During the next three years, most respondents expect this collaboration to grow.

Nanotech/biotech hold great potential. The survey asked respondents to identify the most important emerging and interdisciplinary fields. Nanotechnology in a variety of forms was named most frequently. Respondents named biotechnology/bioengineering second most frequently. Materials research, which draws on both nanotechnology and biotechnology, also was flagged frequently. Other commonly cited fields included (1) software for systems and knowl-

Figure 2. CTOs Expecting "More Collaboration" in Three Years With:

Source: Council on Competitiveness/Seed Media Group CTO Survey



edge management, including service-oriented architectures; (2) alternative energy development; and (3) health-related fields.

The United States can make many public policy improvements. The survey revealed public policy steps to improve the U.S. innovation ecosystem and insight on the priorities. As noted, education and workforce skills are the top priorities for the CTOs, followed by public and private R&D investment. Other priorities include tax policy, intellectual property law and immigration rules.

A Public Sector Perspective

Government agencies represented at the first TLSI Dialogue included the departments of Defense, Homeland Security and Energy, including top officials from the Defense service laboratories and the national laboratories administered by Energy. Officials expressed an interest in hearing from companies and universities about what areas offer the highest potential for basic research investment and whether new processes are needed to allocate such investment wisely. They also want to understand more fully the changes occurring in the global research landscape and how federal research agencies should respond.

It was acknowledged that in many research areas, the United States has gone from the global leader to a leader. Government officials often struggle to stay abreast of technology progress outside U.S. borders and work to draw a balance between the need to collaborate overseas and their charge to achieve national missions. These challenges are particularly acute in national and homeland security missions.

There also is a natural tension, especially with wars on the ground, as to how the Department of Defense should sustain long-term research while remaining conscious of how science and technology can aid us with current conflicts.

Government leaders also exchanged ideas on policies that hinder or enable their ability to leverage the expertise of the private sector, tap the world's best talent and address grand challenges in areas like health care, energy, education and security.

Innovation Landscape Issues Raised by TLSI Dialogue 1 Participants

In addition to the survey results and initial perspectives from public sector leaders, seven core "innovation landscape" issues were addressed during the course of Dialogue 1: talent; multidisciplinary research; progress on the America COMPETES Act; liability; incentives to drive long-term, private sector research; efforts to spur even greater entrepreneurial activity; and an exploration of open innovation models as a driver of future competitiveness.

Talent

Consistent with the findings of the CTO Survey, dialogue participants raised talent issues in many forms. The need to educate and train Americans, attract and retain overseas talent, and collaborate with top talent anywhere in the world will be central to the future ability develop new technologies and commercialize them.

Math and science education, from elementary to graduate school, remains a pressing concern. American students perform below their international peers, and the number and diversity of graduates entering technical fields is less than most believe is necessary. Students also need curriculums that are interdisciplinary and convey richer collaboration and problem-solving skills.

Companies rely on leveraging top talent everywhere in the world if they are to compete. Participants noted a number of U.S. policies that hinder firms from conducting research activity in the United States because they do not have access to that talent. Immigration policies discourage or prevent highly-skilled foreign graduates of American universities from remaining in the United States. International Traffic in Arms Regulations (ITAR) and limits on foreign nationals participating in a broad range of classified research prevent public and private sector organizations from working with some of the world's best talent, at home or abroad.

"The Department of Defense (DOD) is very pleased to be a partner with the Council on Competitiveness and those of you participating in the Technology Leadership and Strategy Initiative. The partnership offers a great opportunity to identify critical science, technology and policy roadmaps to assure that the United States sustains the innovation and technology advantage required for both national security and economic competitiveness."

Robin Staffin

Acting Deputy Under Secretary of Defense for Laboratories and Basic Sciences, Department of Defense

Multidisciplinary Research

Many participants noted that solving big challenges require multiple disciplines. The policy implications are wide ranging, and the dialogue raised issues such as: (1) higher-education curricula, (2) training for workers to operate effectively in teams, (3) research budgets and university programs that allow for collaboration across silos, (4) organizing more research dollars around particular challenges than in disciplinary buckets, and (5) ensuring a more balanced federal research portfolio across health, physical and social sciences.

Most corporations have already moved to multidisciplinary research and innovation teams because the problems faced by their customers and the opportunities presented by the market require it.

The COMPETES Agenda: Investment in Research and STEM Education

Federal investment in science, technology, engineering and mathematics (STEM) education and research is a fundamental building block on which other efforts to spur innovation rests. Participants expressed concern with the level of funding appropriated by Congress for the America COMPETES Act, a law to (1) invest in basic research in the physical sciences, (2) train teachers in math and science instruction, and (3) help students complete degrees in STEM disciplines.

In 2006, President George W. Bush and Speaker Nancy Pelosi agreed on a plan to double funding for these purposes at the National Science Foundation, the National Institute for Standards and Technology and the Department of Energy's Office of Science. The doubling was to occur over ten years beginning on a fiscal year (FY) 2006 baseline. In FY 2007, approximately half the increase in funding pledged for this purpose was appropriated. In FY 2008, approximately a third of the funding was enacted.

President Barack Obama embraced the bipartisan plan in his campaign and his FY 2009 budget. For FY 2009, Congress and the administration not only fully funded the target agencies in the normal budget process, they exceeded the overall target by $5.2 billion dollars through the economic stimulus and recovery legislation. The additional funding will be spent over two fiscal years.

Participants requested that the Council monitor action on this agenda and offer updates at the TLSI dialogues.

Limiting or Waiving Liability Where it Hinders Key Innovations

Liability remains a significant barrier to introducing new technologies. Experts noted the negative impact, for example, on the pharmaceutical and aerospace industries. In many cases, firms decline to pursue technologies when they perceive the liability risks to be too high.

Under the Safety Act, the Department of Homeland Security (DHS) has authority to offer liability protection for companies that have unique technologies, products or services that meet critical needs of the

"I've been traveling quite a bit recently, talking in other countries about how we can support each other in coalition operations by providing forces and also by providing the material and the infrastructure necessary to support those forces. How are we going to help them help us develop the technologies that will help protect our forces in an environment where commercial technology greatly exceeds the pace of defense technology?"

Sydney Pope
Acting Deputy Under Secretary of Defense for Industrial Policy, Department of Defense

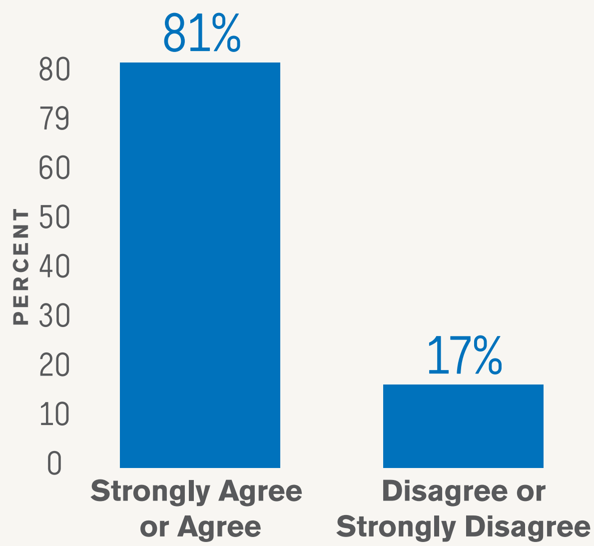
"If you look at the history of this country since World War II, never did the United States have enough indigenous American citizens to develop the technology and create the standard of living that we have today. It was always done with a whole lot of immigration.

We need to look at how we attract the best and the brightest from all over the world. We need to offer them an opportunity that they don't have anywhere else. That should be a pillar of our innovation policy."

Pradeep Khosla
Dean, College of Engineering and Dowd University Professor, Carnegie Mellon University

(*Pictured at right: Cynthia McIntyre, Council on Competitiveness.*)

Figure 3. Response of CTOs as to Whether Their R&D Teams are Interdisciplinary
Source: Council on Competitiveness/Seed Media Group CTO Survey



Department. Until such indemnification was granted, firms were not moving forward on essential technologies required by DHS to fulfill its missions.

One participant suggested that TLSI consider supporting similar authority at the Department of Commerce and/or other agencies. Such agencies could grant indemnification or limited liability in key areas where the risk of litigation and damages deter new technologies and services from moving to market.

Incentivize Long-term Private Sector Research
Participants urged that the TLSI examine how private sector firms might be incentivized to engage in more long-term research. Pressure from financial markets for quarterly returns makes it difficult for private sector researchers to take on projects with a 10-15 year horizon before they are commercially viable.

Potential steps to ease this problem could include tax incentives that target private sector research rather than research and development. Intellectual property and technology transfer rules could be revised to encourage the private sector to collaborate more with universities on long-term research. Helping financial markets to value intangible assets more effectively could change the way that investors respond to longer-term corporate strategies.

Figure 4. Analysis of FY 2010 Funding for Agencies in Doubling Plan
Dollars in millions, excluding earmarks—August 2009
Source: Innovation Advocates, LLC

Agencies	FY 08	FY09 (Final)		FY10 (Pending)		
	Final	Omnibus	ARRA[2]	Budget	House	Senate
National Science Foundation	$6,084	$6,490	$3,002	$7,045	$6,937	$6,917
Department of Energy Office of Science	$3,959	$4,679	$1,600	$4,942	$4,906	$4,858
National Institute of Standards & Technology[1]	$549	$597	$580	$652	$587	$637
Totals	$10,592	$11,766	$5,182	$12,639	$12,430	$12,412

1 Refers to NIST core accounts -Scientific & Technical Research and Services, plus the Construction of Research Facilities.
2 ARRA—American Recovery and Reinvestment Act (note: some ARRA funding will be obligated in FY 2010).

Small Business Startups/Venture Capital

Fewer small businesses and spin-outs from university labs receive early-stage capital than had been the case a few years ago. This is partly due to the economic downturn, but venture capital firms are investing a smaller share of their resources in early-stage innovations, mergers and acquisitions are down in number and value and the market for initial public offerings (IPOs) has virtually dried up.

Participants suggested that the TLSI dialogues consider the impact of the Sarbanes-Oxley law on IPOs and examine whether funding levels are adequate for the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. One problem with SBIR/STTR may be that there is inadequate administrative funding to manage them effectively.

How do you create a culture of creation versus one of consumption? This is a long-term issue.

Thomas Halbouty
Vice President and Chief Information Officer
Pioneer Natural Resources Company

"If you look at the origins of today's companies, 12 million U.S. jobs exist because of venture-backed companies that are generating almost $3 trillion in revenue and about 20 percent of our national GDP."

Tom Uhlman
Founder and Managing Partner
New Venture Partners

Use of Open Innovation Models

A Perspective from: Wayne Delker
Senior Vice President and Chief Innovation Officer
The Clorox Company

Clorox is about a $5 billion company, relatively small compared to some larger organizations here today. We're a largely U.S.-based consumer products company, connected to American consumers a million times a day. They decide whether our innovations are working or not.

Clorox is in a variety of businesses beyond bleach, including bread, water filtration, Glad wraps and bags, food businesses, litter and Kingsford charcoal. Our innovation is focused on public health and disinfecting, a tremendous issue around the world, and around sustainability—having natural products that are good for the environment.

Because Clorox is a smaller company, we adopted the concept of open innovation. We try to work with the best technology and the best people, which many times will not be inside of Clorox.

How a company uses an open innovation process and networks to access technology, but still gets competitive advantage from it, comes down to this idea: access to people who can really do the synthesis, understand the technology, and marry that with an understanding of what are the unmet needs in the world. That must be coupled with another piece of innovation, which is how you create a business model that brings together the technology and unmet needs in a way that creates long-term value.

Companies employ open innovation very frequently, and I believe the model is extendable to the country. It is something that we should think about as we move forward.

We are seeing in real time the inability to get top technical talent. U.S. students are not as motivated to go into the sciences as they used to be. In addition, international students are more likely to go home than stay, creating a void that we have to address. Open innovation models that access talent anywhere in the world is part of bridging that void.

That being said, Clorox is an Oakland, Calif.-based company. If you know about Oakland, it is a city with many problems. One of the things Clorox tries to do is to encourage K-12 science education in the Oakland schools, and it's very challenging.

I am optimistic, however, that we can turn this around. If we can create in the United States an environment of policies, culture and regulations that really drive innovation, it will allow us not only to be more competitive as companies and as a country, but will also have tremendous benefit for many of our citizens. This includes citizens in tough inner city areas like Oakland's that are struggling right now. So from my perspective, we must have a passion not only for driving U.S. competitiveness, but also for helping the citizens of this country.

The Role of the White House CTO

A Keynote Presentation: Aneesh Chopra

Chief Technology Officer and Associate Director of Technology,
White House Office of Science and Technology Policy

A premise of this group is that although America has been consistently at the top of the heap on driving innovation globally—we captured 60 percent of the share of the IPO market the first quarter of 2009—we can no longer take our leadership in this area for granted.

I will talk to you today about my role as the White House CTO, our partnership opportunities and then make some final remarks.

There are challenges in front of us. I am concerned, for example, about certain benchmarking data. One study benchmarked 40 countries on global competitiveness using 25 measures. The United States ranked sixth overall. The statistic that troubled me was that if you measured the rate of change from 1999 to 2005 across the 25 measures, America ranked dead last among the 40 countries. So the concern I have is that relative to the progress underway in the rest of the world, we are standing still.

On no measure is this more acute than the skills of our workforce. In every meeting I've ever had with CEOs, this is a key priority. It is a top concern of the governors and obviously a priority for the president.

When you think about a key metric to track on workforce, higher education attainment rate is a good one. We have been remarkably flat on higher education attainment over the last couple of decades, and we used to sit atop the world by a leap-frog percentage. We were at roughly 40 percent and others were in the teens or below ten. Nine countries have now passed us on higher education attainment rate. Depending on the metrics you track, our capacity to grow our two- and four-year degree candidates will require a lot of work by our universities to catch up.

The president said by 2020, we need to be atop the world again. So of all the measures of concern, this one strikes me as particularly important.

I have been asked by the president to help harness the power and potential of technology and innovation to drive transformation of our economy. That's a lot of buzzwords, but I'm going to break that down into three very tangible things and link them to the priorities of this initiative.

- First, I see a critical opportunity to address presidential priorities through what I'm referring to as innovation platforms or game-changing innovation. Let's take three: health care, energy and education. How do we bring game-changing ideas to our current approaches to these issues?
- Second, I care deeply about the digital infrastructure of this country. As the president said, our challenge is to protect the nation's digital

infrastructure with our cybersecurity work, and to ensure that we have a platform for 21st century growth. My role in this will be to help spearhead the president's National Broadband Plan, which under the stimulus is led by the SEC but with active involvement from the White House.

In the cybersecurity realm, my focus has been on critical infrastructure in the energy and financial services sectors. I've been meeting with key stakeholders to explore how we can collaborate.

- The third pillar of my responsibility is to make sure that the government eats its own dog food. That is, we bring innovation to government itself. That's the president's Open Government Initiative. We've asked the American people to tell us what policy recommendations they want us to adopt. Not individually with memos coming in silos, but in an online wiki-like platform where folks get to weigh in, debate with each other and, at the end of this process, hand in the American people's voice on what public policies should be on open government.

What are the implications for TLSI? On innovation platforms, there are two key questions. Number one, what can we do to bring public, private and academic resources together for R&D? I was shocked to read in a recent Boston Consulting Group survey that two-thirds of the CEOs say innovations are a top three priority, but only half of them are satisfied with their firm's return on innovation and investment.

We may debate whether that's the best measure and whether CEOs get it or not. But I'd like to pose a broad question. What would a 90 percent satisfaction rate on a firm's investment and innovation translate to for the nation's GDP growth long-term? What would it mean to health care, for example, if we had collaborative opportunities to change the game and get the right data into doctors' hands?

> "So the concern I have is that relative to the progress underway in the rest of the world, we are standing still."

On infrastructure, we have an opportunity to look at all the roadblocks and the barriers. So what does it mean to balance economic growth with security? We're having that debate, and I welcome your input.

On transparency, of all the things we could talk about during the course of this initiative, I would say the one that has vexed me most is my inability to measure the outcomes of innovation and investment. We largely know what goes into innovation, but we haven't closed the loop on the output side. I would welcome a debate on this topic, and hope that the survey and benchmarking work planned by the Council on Competitiveness might help advance our ability to measure outputs in at least a modest sense.

The administration also is bringing resources to the table. The Patent and Trademark Office, for example, plans to provide all the data that's publicly available today on the White House's data.gov platform, so that it is as easy to find as possible.

We hope that step will increase some liquidity in the marketplace by reducing how much of a firm's R&D investment today goes into litigating R&D challenges. Whatever that number is, it's probably too high. So to the extent that we can bring more transparency to the current regulatory framework, we'd love to do that.

I'll end with an example of the global marketplace giving us opportunities for innovation. It meant something to me on a personal level that months after the terrorist attack in India, in the lobby of the very same hotel that suffered the attack, Ratan Tata, the chairman of Tata, launched the world's cheapest car, the people's car, the Nano. What a spirit of resiliency.

What does it mean to build a $2,500 car, and what are the innovations that might apply to our next wave of defense or space challenges? Our global strategy is now saying we, the American research and innovation enterprise, will develop on a global basis the products and services that are at price points for the world to consume, and we will bring those innovations home, for example, to bring down the cost of hearing aids in Appalachia.

The TLSI is a multi-part series, and I commit that I want to be as engaged as possible. If we have low-hanging fruit along the way where we can make an impact, tell me today what we can do tomorrow. We don't have to wait for the fancy report and glossy paper to tell us these are the recommendations.

You can hold me accountable for ensuring that we've got the right policies in place. I'll bring my voice to the table inside the White House to support what we're trying to do together. Hold me accountable for results, results, results. If there's a data set to make available, if there's a policy to roll out on which we can engage, let's make incremental improvements along the way, so we don't just rely on the end point here to make a difference.

Q&A with Aneesh Chopra—Spotlight on Health Care Innovation

Q: Paul Hallacher, Pennsylvania State University—If there were an area like electronic medical records that you would like to see universities and corporations get behind to help the administration achieve an important objective, what would it be?

A: Aneesh Chopra, White House Office of Science and Technology Policy—For health care, I have three game-changing platforms to suggest. The first would be the products themselves. Estimates are that the average physician adopting electronic health records incurs roughly $50,000 in costs between the software and the implementation.

It would be game-changing if we were to build out what doctors actually want at price points 10 times less. There is a market failure in that a $20 billion market for health IT software is mainly about the large, integrated health systems. There hasn't been as much R&D on infrastructure for solo practitioners.

So the emergence of a lightweight system delivering health outcomes capability would be of high importance. We need a public-private-academic collaborative to dramatically lower the price points for physicians and make the devices and software as easy as using the iPhone. Remember, almost every doctor has downloaded the Epocrates platform. So that's one example.

The second platform was illustrated by Atul Gawande's recent article in *The New Yorker*, where he found through publicly available data that health costs in McAllen, Texas, are twice as expensive as El Paso, with no real benefit in terms of medical outcomes.

One of the most fascinating parts of the article is that each person Gawande spoke to in McAllen was shocked by the data. Somehow this data, although publicly available, was not in a really accessible format. So people didn't know about it.

Contrast this to the retailing industry. I don't know how many retailers are represented here today, but for the most part, if the Redskins lose on a Sunday, it's 40 degrees outside and raining, and I'm going to the store, the Best Buy folks know exactly what promotion they should run to get me to buy a plasma TV.

That level of data is produced in retail, but not in health care. The variability in health care decisions is astonishing. So this post-market research concept is one that is of great interest.

Last but not least, a third game-changer in our medical system would be improving the sheer inefficiency of our billing and administrative apparatus. The McKinsey Institute pegs this at 17 cents on a dollar. What does it cost to process a Visa transaction—two, three cents on the dollar? We've got to close the gap from 17 cents to a more reasonable number. This is an estimated $29 billion dollar issue.

So game-changing ideas in any of those areas would be welcome as we proceed.

21st Century Collaboratory: New Ways for the Public and Private Sector to Cooperate and Achieve Their Commercialization Priorities

21st Century Collaboratory Issues Raised by Participants

International Traffic in Arms Regulations (ITAR)
Industry and university participants asserted that ITAR, a regime enforced by the State Department to control the trade of defense-related goods and services, has a significant chilling effect on innovation. Two principle concerns emerged.

The first concern is that ITAR "puts a technology bubble" around the United States at a time when some of the best technologies in the world are being developed offshore. Because ITAR policy in many cases lags behind the pace of global technology diffusion, the regime diminishes the competitiveness of U.S. technology firms by restricting or barring them from selling worldwide. It also can (a) unnecessarily limit industry's ability to utilize defense innovations in commercial products and services and (b) encourage them to develop new technologies outside of the United States.

The second concern is that ITAR hinders access to the top talent in the world. Foreign students are barred by ITAR from participating in many Defense-sponsored projects, and too many projects are classified, said participants. Although foreign nationals can work on Defense basic research (6.1 projects), they are restricted from working on Defense applied research (6.2 projects) that receive a much higher level of funding.

Many participants called on TLSI to establish a multi-agency/industry/university working group on ITAR. The group would explore how the United States can meet its security needs but react more nimbly to changes in the global technology landscape. The objectives would be to ensure that U.S. soldiers continue to benefit from the best technology in world and that economic prosperity and competitiveness are not sacrificed unnecessarily.

Intellectual Property/Technology Transfer
Current intellectual property (IP) and technology transfer laws and practices create significant barriers to industry-university collaboration. The dialogue produced a number of suggestions to lower those barriers, including:

- Cooperation in forums like the University-Industry Demonstration Project of the National Academies;
- Creating model master agreements that offer greater flexibility for different industries and types of projects;
- Including technology transfer discussions at the beginning of industry-university collaborations;
- Revising the Bayh-Dole Act to improve the incentives for commercialization;
- Utilizing open IP collaboration agreements between multiple companies and universities, similar to what has been established for certain information technologies;
- Encouraging universities to pool their IP portfolios with other universities globally, enabling faster bundling and more commercialization opportunities as firms can locate relevant IP through fewer portals; and

- Consideration of how to close the gap between the time it takes to aggregate multiple patents that go into a product with increasingly short product cycles.

Participants noted that many universities employ master agreements that are "one-size-fits-all," despite vast differences in the market realities of different industries. Company-university collaboration also suffers, said some, from current laws that incentivize universities to pursue more rigid profit-making IP strategies than would be best for commercialization. The Council was encouraged to collect data that might help bridge the divide between industry and university perspectives on the probability of success and work required to move from patent to product.

Most research universities overseas—India was cited as an example—have a greater bias for commercialization and far fewer IP barriers to collaboration. Participants expressed concern that more corporate-university partnerships will move offshore in the future if this difference remains unaddressed. In fact, the United States should think more aggressively about how its laws and practices should be revised to make American-based firms the world's best integrators of IP globally.

Organizing Around Grand Challenges

Addressing grand challenges is linked in many ways to the problems of encouraging more multidisciplinary research and education. Devoting a greater share of resources around major challenges rather than in smaller, traditional disciplinary buckets was encouraged. Another tactic suggested was to offer more competitions along the X Prize model to spur competition around key goals.

Participants believe that the federal government needs a better mechanism/organization to set national research priorities and to drive the investment and policies needed to achieve them. Major challenges discussed included energy, health, education and security.

Communicating Government Operational Requirements and Market Potential

Thomas Cellucci of DHS reported on important steps the Department has taken to improve its collaboration with the private sector. DHS found that it could leverage the private sector more effectively to develop technologies if they improved two aspects of their communication.

The first aspect was giving more details about the operational requirements of the Department. Doing so honed industry's ability to develop technologies more quickly that met DHS needs. The second aspect was to communicate the market potential of a particular technology to industry so firms could make more intelligent ROI decisions—usually in favor of engagement.

Cellucci also noted that DHS is moving more frequently into commercialization rather than acquisition relationships with industry. Commercialization relationships typically imply more of a partnership than purchaser arrangement, where agency personnel are involved in the development of a technology.

Leveraging National and Defense Labs More Effectively for Commercialization

A Perspective from: Steven Ashby
Deputy Director for Science and Technology
Pacific Northwest National Laboratory

The DOE national laboratories—and federal laboratories more broadly—are remarkable facilities with tremendous intellectual capital. Collectively, they have much to offer in accelerating innovation and enhancing our nation's economic competitiveness. When we talk about private-public partnerships, however, I believe that one of the problems is how difficult it can be for the laboratories to interact effectively with industry and academia in the area of technology commercialization. If we can figure out how to do this better, we have an opportunity to seize a competitive advantage vis-a-vis the rest of the world.

A successful public-private partnership requires that we respect the differences between the participating institutions. Academia, the labs and industry have different value systems and cultures—and we need to apply their collective abilities in a more coordinated way to address the pressing national and global challenges facing us. With this in mind, I suggest three essential elements for a successful partnership:

1. A shared sense of purpose;
2. Enhanced technology transfer mechanisms; and
3. An ability to share our intellectual capital and the resulting intellectual property across institutional boundaries.

Let us talk first about a shared purpose. We have to ask, "What are we collaborating on and toward what end?" In past efforts to commercialize more from the labs, they were asked to wander too far from their missions. If the public and private sectors are going to collaborate successfully, it should be a win-win proposition in which each party benefits and all work together on a well-defined project.

Choosing the right problem is important. It would be helpful if we had a national R&D agenda. At present, various agencies and organizations put forth their own research agendas. Can we cooperate across organizational boundaries to define a national agenda? Perhaps the TLSI can provide a forum for doing this.

A national research agenda would not have to be conducted exclusively within the United States, but we should clearly state our priorities and determine how we want to engage the rest of the world in solving problems that matter to us. That's a shared sense of purpose—one that should be paired with clear expected outcomes.

The second element of a successful public-private partnership is figuring out how we can make these engagements more productive by improving our tech transfer mechanisms and policies. This topic has come up a lot in our conversations. The national labs have much to offer, and often have been called national treasures. Unfortunately, we are saddled with a set of antiquated policies and laws that make them as inaccessible as the crown jewels.

In general, tech transfer is too difficult and too slow. The rules and procedures are often confusing and vary by lab. If we wish to realize the potential of the labs, we must improve the tech transfer process. The good news is that this administration and the secretary recognize the need for change. So there is an opportunity and cause for optimism. The real question is what we want do with this opportunity.

In my view, it is time to address several of the limitations that hinder the effectiveness of tech transfer. Rather than guess what these might be, we have asked companies, "What attributes would you like to see in a revamped approach to tech transfer?" Three come to the fore:

1. Labs need to be able to engage industry on commercial terms. With only one exception, the DOE laboratories can only engage industry on a "best effort" basis. Industry is used to dealing with entities on a commercial basis, which means that each party is held accountable for its performance. Why not allow a laboratory's contractor to work on such terms? If it chose to do so, presumably in exchange for a greater fee, it and not the government would accept the risk. I'm not suggesting anything earth-shaking, but it is not typically done.
2. We need industry-friendly payment terms and flexible contracting mechanisms. Advance payment is the current requirement. That is a hindrance not only to industry, but also to the labs' ability to work effectively with state and local governments.
3. We need greater consistency across the laboratory system. This does not mean a one-size-fits-all contract with rigid government-imposed terms and conditions. Instead, we need consistency in the approach that the labs are allowed to take when working with the private sector to meet the needs of the marketplace. We also need simplified access mechanisms and tech transfer practices that enable industry to engage laboratories on commercially reasonable terms.

So what are the next steps in this area? There is a working group within the DOE, largely self-organized by the laboratories, that is looking at these issues. TLSI could take a leading role in advancing this examination into new practices. In particular, TLSI could convene a forum to discuss the desired future state of technology transfer within the context of accelerating innovation.

Finally, let me briefly address the third element of a successful public-private partnership: the ability to share intellectual capital and intellectual property across organizational boundaries. With respect to the former, we need to make it easier to share people. When a lab wants to do a joint appointment with a company or university, the current mechanisms make it difficult for money to flow between the two organizations without the risk of double taxation. This results in too much overhead relative to conducting research, and potentially drives people away from partnership opportunities. Regarding the latter, it is essential that we find ways to bundle the intellectual property produced by a 21st Century Collaboratory to facilitate commercialization.

Thank you for the opportunity to share my thoughts.

PART 2: FINDINGS FROM TLSI DIALOGUE 1

TLSI Dialogue 1 Postscript—The Path Forward

During the course of TLSI Dialogue 1, participants expressed a desire to create a process to dig more deeply into several of the Dialogue's emergent themes. Co-chairs Ray Johnson and Mark Little, along with Council president Deborah Wince-Smith, suggested the creation of several working groups to tackle a couple of the burning issues in advance of —and beyond—Dialogue 2, autumn 2009.

TLSI participants were asked to prioritize areas they would be interested in pursuing further—many of which are already reflected in this report—and leading as working group chairs or members. A matrix of more than a dozen responses highlights several potential working group themes (and potential leaders):

- Mega Projects: Identifying and catalyzing action to address 21st century national grand challenges and goals.
- 21st Century U.S. Talent Pool: Creating the U.S. talent pool for the 21st century—focusing on immigration, diversity, education and opportunity.
- 21st Century Collaboratory: Improving technology and IP transfer between industry, academia and the public sector to create a robust 21st century U.S. "collaboratory" within a global innovation ecosystem.
- Risk/Reward Continuum: Boosting the tolerance for risk, mitigating liability that hinders innovation, and developing strong commercialization strategies for key research areas.

"The people in this room represent the knowledge and the ability to make recommendations that can change things. We talked about evolutionary versus revolutionary. It is time for revolutionary thought."

Ray Johnson
Senior Vice President and CTO
Lockheed Martin Corporation

"I did not come here for interesting conversation, although we did have that. I hope the TLSI is the beginning of something that's powerful. I hope that our collective voice can make a difference."

Mark Little
Senior Vice President and Director of Global Research
General Electric Company

These potential working group themes will be refined and launched in autumn 2009, with initial findings/results integrated into Dialogue 2.

The Council would like to express its deep appreciation to all who participated in TLSI Dialogue 1 for their active engagement, thoughtful contributions, good will and for committing their valuable time to this Initiative.

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Explore.

TLSI Dialogue 2:
Exploring New Frontiers

November 9, 2009
Washington, D.C.

Letter from the President

On behalf of the Council on Competitiveness, I am pleased to release the second report of the Technology Leadership and Strategy Initiative (TLSI).

Led by Ray Johnson, senior vice president and chief technology officer of the Lockheed Martin Corporation, and Mark Little, senior vice president and director of GE Global Research for the General Electric Company, the TLSI is a multi-year engagement of technology leaders from America's premier companies, universities and laboratories. The TLSI seeks to identify and establish more effective methods for the private and public sectors to collaborate on research and to commercialize technologies.

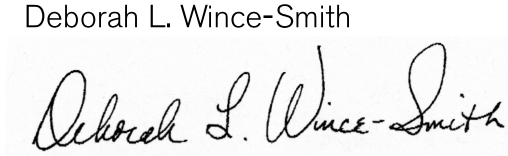
Our work focuses both on what must be done within the United States and how Americans should respond strategically to the global dispersion of research talent, facilities, knowledge and resources. The TLSI examines how government can harness research and innovation to overcome America's greatest challenges and achieve specific missions. At the same time, TLSI participants recognize the importance of generating even more economic value from research investments so the private sector creates more U.S. jobs, generates wealth, and remains globally competitive.

This report has two sections. Part 1 sets the stage for the second dialogue by offering empirical information on certain "mega projects"—namely health care, energy and security—and suggests the role of innovation in addressing them. Part 1 also includes briefs on issues like education, immigration, diversity, tech transfer, litigation and risk capital. Finally, part 1 presents tools available to map innovation that we hope someday will enable a rigorous benchmarking of where innovation is occurring globally.

Part 2 reviews the second dialogue held November 9, 2009, in Washington, highlighting the issues and ideas raised by participants. We discussed accelerating the rate of commercialization, building the U.S. talent pool and pushing technology frontiers. I would like to thank Larry Bock for speaking with the TLSI on how we can contribute to the national science and engineering festival slated for October 2010. I also would like to thank Chris Scolese, NASA associate administrator, for sharing his views on technology and innovation at NASA and for engaging TLSI participants on a range of topics.

The Council recognizes and sincerely thanks the U.S. Department of Defense for its partnership and generous support of the TLSI. The Council is committed through the TLSI to help the Department build more effective public-private partnerships and navigate a changing global research environment—thereby strengthening our national and economic security.

Deborah L. Wince-Smith



President

Executive Summary

This report presents the second dialogue of the Technology Leadership and Strategy Initiative.

Part 1 offers information from the pre-dialogue report that set the stage for TLSI Dialogue 2 and analyzed many topics raised in the first dialogue. Part 1 also introduces new topics, such as a survey of tools that map innovation insights and begin to benchmark where innovation is happening globally. Part 1 breaks down some of today's "mega projects"—namely health care, energy and security—and suggests the role of innovation in addressing them. It also offers insights on issues like education, immigration, diversity, tech transfer, litigation, and risk capital.

The purpose of Part 1 is to offer TLSI participants a more robust empirical background on the issues of the dialogue so that those issues can be accurately framed and their proposed solutions aligned with current conditions. Due to the number and complexity of the issues, the Council has striven to highlight the macro-metrics that are most relevant to the dialogue.

Part 2 summarizes the second dialogue held November 9, 2009, in Washington, highlighting the issues and ideas raised by participants and setting the table for the third dialogue in the series. Participants focused on accelerating the rate of commercialization, building the U.S. talent pool and contributing to a national science and engineering festival slated for 2010. The dialogue also reviewed how to push technology frontiers and heard about innovation at the National Aeronautics and Space Administration from Chris Scolese, NASA's associate administrator.

The TLSI Dialogues to date have been successful exchanges between many of America's leading technologists who have put forward many ideas on how the United States can address its shortcomings and become more adept at productive innovation in a changing global landscape. As the TLSI progresses, the Council anticipates that these ideas will be honed into priority recommendations with a strategy to implement them.

Part 1:
Setting the Stage for TLSI Dialogue 2

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 2

Introduction

In February 2005, three men working at PayPal hatched an idea to start a new company. Each in his twenties, one had been born in Taiwan, one in Germany and one in Pennsylvania. They acquired a domain name, began constructing a website, and set up shop above a pizzeria and Japanese restaurant in San Mateo, CA.

Visitors grew rapidly to the beta stage of their site that offered users for the first time a place to easily upload, share and watch videos online. By September 2005, the first installment of $11.5 million in venture capital by Sequoia Capital helped establish YouTube as the world's leading online video service. YouTube is now the fourth most viewed site on the Internet, trailing only Google, Facebook and Yahoo.[1]

The story of Chad Hurley, Steve Chen and Jawed Karim illustrates the importance of many issues under review by the TLSI—issues like tapping global talent, encouraging education in scientific and technical fields, and incentivizing risk capital. Chen and Karim, for example, immigrated to the United States with their families in the 1990s and studied computer science at the University of Illinois at Urbana-Champaign.

In October 2006, just 20 months after YouTube was conceived, Google acquired the firm for $1.65 billion. Google itself illustrates the importance of TLSI issues like federal research investment. The company grew out of the Digital Library Initiative funded at six institutions in 1994 by the National Science Foundation. One of those institutions was Stanford University where students Larry Page (from Michigan) and Sergey Brin (born in Moscow) began collaborating on an innovative method to map out links between web pages and rank their significance. By 1998, the pair acquired funding and incorporated Google, Inc.

American innovation encompasses many fields, virtually every industry and people from all over the world. It is central to job creation and quality of life. The United States should strive to be the most favored place for innovation and the most skilled at collaborating internationally. The TLSI hopes to reform key U.S. policies so people in this country can continue to tackle the greatest innovation opportunities known today and create opportunities that will drive future prosperity.

1 Alexa. http://www.alexa.com/topsites.

PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 2

TLSI Dialogue 2: Exploring New Frontiers

Mega Projects and Innovation

In TLSI Dialogue 1, participants surfaced and discussed the importance of devoting innovation resources to our greatest challenges and opportunities—or mega projects—and how those resources could be applied most effectively. Three mega projects, in particular, stood out where innovation would have profound economic and societal benefits: health care, energy and security.

Health Care

A dominant issue of the day is health care. Although the prescription to improve health care in America is hotly debated, there is little debate that it is a mega project that should be addressed by multiple means. The TLSI will focus on those means that are relevant to the mission of the initiative—to enable the strategic and effective development and application of technology and innovation to create value for Americans.

Why a Mega Project? The importance of health care in human terms is obvious, in some cases being a matter of life and death. People consider their health and that of their family to be a foundation stake in their quality of life. As the saying goes—without your health, you have nothing.

The cost and efficiency of health care, however, affects an individual's quality of life in more ways than his or her physical well-being. In America today, health care costs play a large and growing role in the fiscal life of governments and their ability to offer services without raising taxes. Health care costs affect the competitiveness of companies and the attractiveness of the United States as a place for foreign firms to invest and create jobs. The National Coalition on Health Care correlates rising U.S. health care costs to (1) significant drops in health care coverage, (2) 62 percent of bankruptcies and (3) approximately 1.5 million home foreclosures annually.[2]

Spending for health care in the United States is growing faster than the economy, posing a challenge not only for the federal government's two major health insurance programs, Medicare and Medicaid, but also for the private sector. Measured as a percentage of the nation's gross domestic product, total spending for health care increased from 4.7 percent in 1960 to 15.2 percent in 2007 (figure 1).[3]

The U.S. Congressional Budget Office (CBO) projects that health care spending under current policies will grow to 31 percent of gross domestic product by 2035.[4] The main source of this increase is the growing cost of health care per person (figure 2), driven by multiple sub factors. In addition, an aging baby boom generation that is living longer will strain the system as fewer working-age Americans are relied upon to support a larger aging population. Innovation in health care efficiency (fewer dollars providing equal or superior care) is an essential part of the solution.

According to the Organization for Economic Cooperation and Development (OECD) the United States spends much more on health care as a percentage of GDP and on a per capita basis than the next highest spending nations (figure 3).[5] Despite this spending, the United States ranks 50th in life expectancy, generally considered a good measure of health outcomes.[6]

It should be acknowledged that the matter is not quite that simple. Factors such as dietary habits and smoking rates could explain differences in life expectancy between nations at least as well as

2 National Coalition on Healthcare. http://www.nchc.org/facts/cost.shtml.

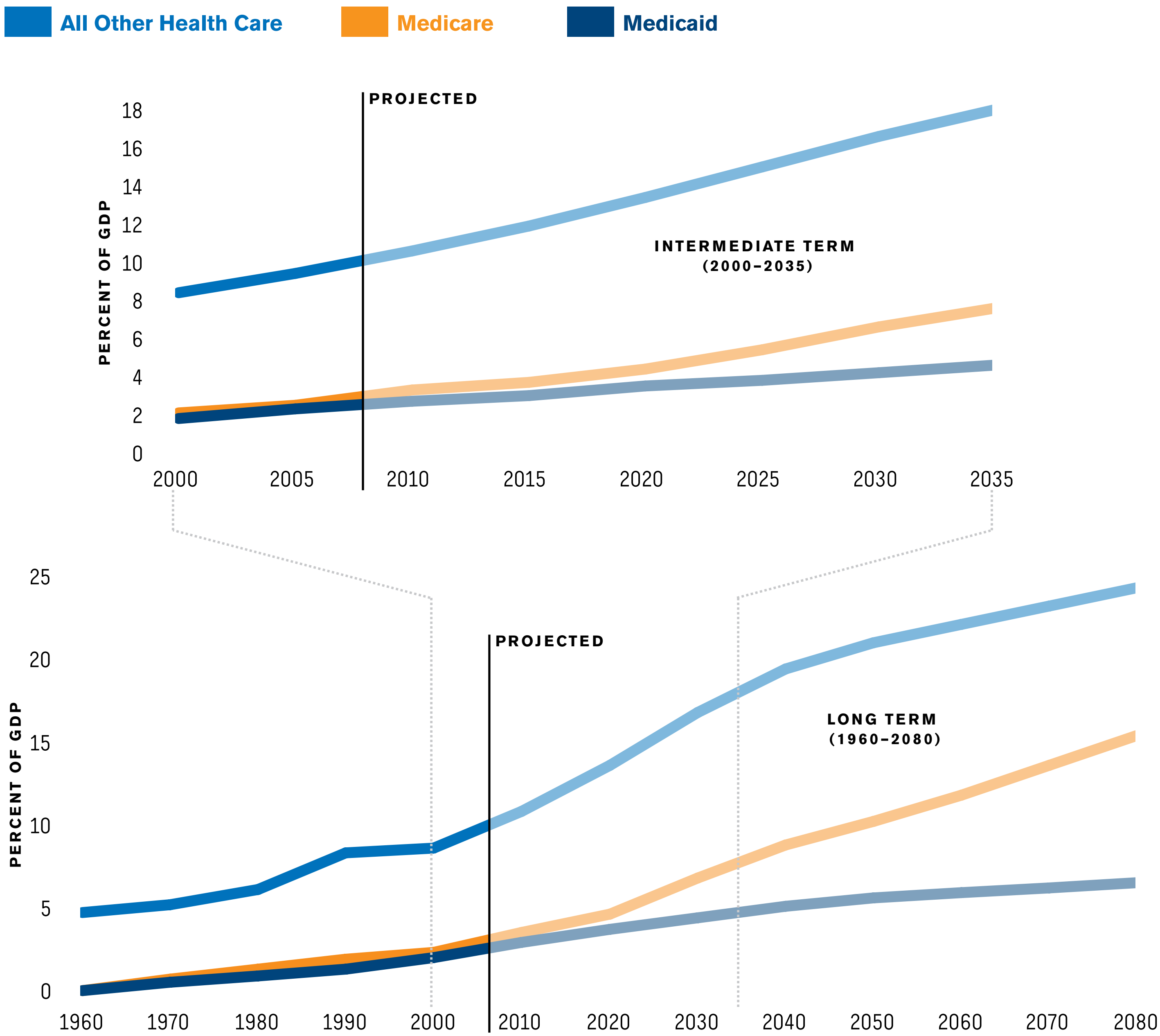
3 Congressional Budget Office. The Long Term Budget Outlook. June 2009. p. 35.

4 Ibid.

5 Organization for Economic Cooperation and Development. *OECD Health Data 2009*. June 2009.

6 Central Intelligence Agency. *CIA Factbook*. 2009.

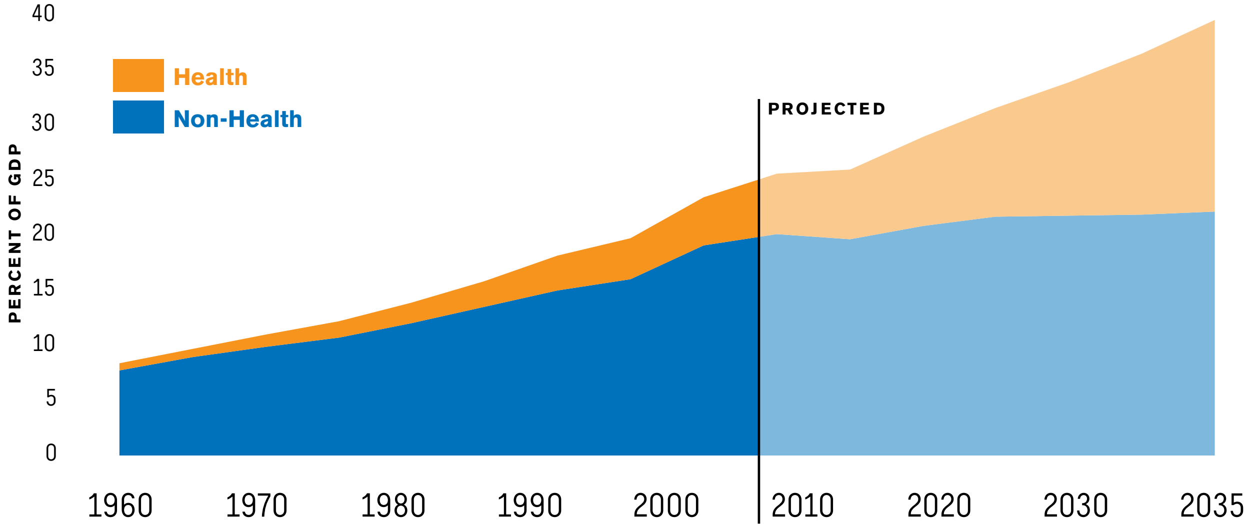
Figure 1. Total Spending for Health Care Under CBO's Extended-Baseline Scenario
Source: Congressional Budget Office



Note: Total spending for health care comprises spending for health services and supplies as defined in the national health expenditure accounts maintained by the Centers for Medicare and Medicaid Services. Amounts for Medicare include beneficiaries' premiums and amounts paid by the states representing part of their share of the savings from shifting some Medicaid spending for prescription drugs to Part D of Medicare. Amounts for Medicaid including spending by states.

The extended-baseline scenario adheres closely to current law, following CBO's 10-year baseline budget projections from 2009 to 2019 and then extending the baseline concept for the rest of the projection period.

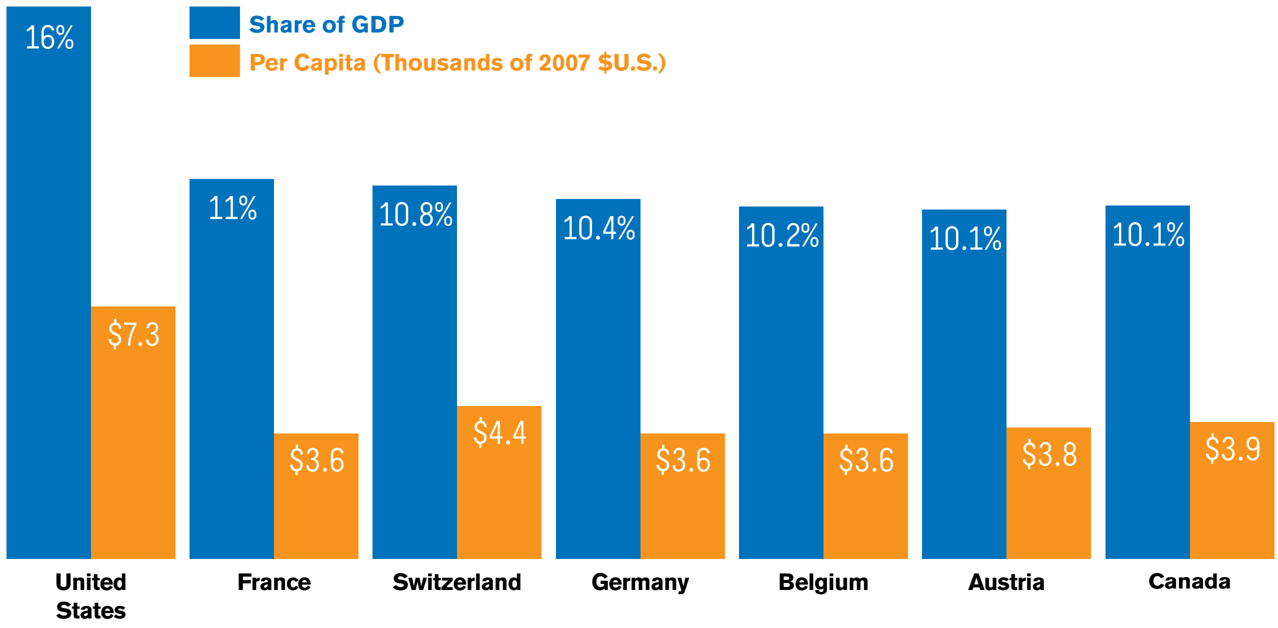
Figure 2. Total Health and Non-Health Spending Per Capita Under CBO's Extended-Baseline Scenario
Source: Congressional Budget Office



Note: Total spending is equal to the sum of personal and government consumption as defined by the Bureau of Economic Analysis. Total spending for health care comprises spending for health services and supplies as defined in the national health expenditure accounts maintained by the Centers for Medicare and Medicaid Services.

The extended-baseline scenario adheres closely to current law, following CBO's 10-year baseline budget projections from 2009 to 2019 and then extending the baseline concept for the rest of the projection period.

Figure 3. Total Health Care Expenditure
Source: : OECD (latest data available)



health policy choices or spending differences.[7] Furthermore, higher spending can be linked with higher quality of care and the introduction of new treatments, drugs and devices.[8]

Role of Innovation. Innovation should factor into many elements of a new system. TLSI Dialogue 1 offered ideas about the role of innovation in health care. White House Chief Technology Officer Aneesh Chopra suggested three platforms as high priorities:

- Reducing the cost incurred by physicians to adopt technology and software for electronic health records—perhaps as much as 10-fold from today;
- Making health data more accessible to citizens, officials and researchers in order to gain insights that would lead to better treatment, preventive care and public policies; and
- Improving the efficiency of the billing and administrative system that accounts for 17 cents of every health dollar spent.

Chopra's suggestions illustrate the diversity of innovation required:

- Technology innovation that lowers cost;
- Policy and technology innovation to draw greater value from information; and
- Service innovation that blends management disciplines, public policy and technology disciplines.

This type of innovation supplements what is traditionally considered health care innovation in devices, drugs and treatment. Inventor Dean Kamen explains the importance of such advances this way, "Diabetes alone, if you include all of the long-term, insidious consequences of a lifetime of diabetes, is responsible for about 30 percent of the federal reimbursement for health care . . . but what if tomorrow we could wipe out diabetes, suddenly everybody takes a pill and it cures the people that have it . . . Forgetting what a great life that would give people and their families, you take care of 30 percent of what now we project as this insurmountable problem of health care." [9]

Even so, Kamen acknowledges that high rates of innovation can contribute to a rise in costs, as is common when new products and services enter the market and demand higher prices before they become commoditized. Intellectual property law plays an important role by enabling a period for a return on investment before lifting protection and ushering in greater competition and lower costs.

TLSI Dialogue 1 raised the issue of balance in the federal research investment portfolio. Presently, the largest share of federal research (figure 4) is devoted to medical research and life sciences through the National Institutes of Health (NIH). Few question the value of such research. NIH notes that death rates from heart disease and strokes fell by 40 and 51 percent, respectively, between 1975 and 2000; and the childhood cancer survival rate rose to nearly 80 percent in the 1990s from a rate below 60 percent in the 1970s.[10]

The question is whether adequate resources are being devoted to other important research challenges and whether enough is being invested in improving the health care delivery system. The priorities put forward by Chopra may require new approaches and policies to launch greater action.

Other policies like tort law and privacy law can hinder innovation. Like intellectual property, these regimes should strike a balance. They should protect citizens from harmful actions while still enabling innovators to devise new products, services, treatments and administrative systems to serve individuals more effectively.

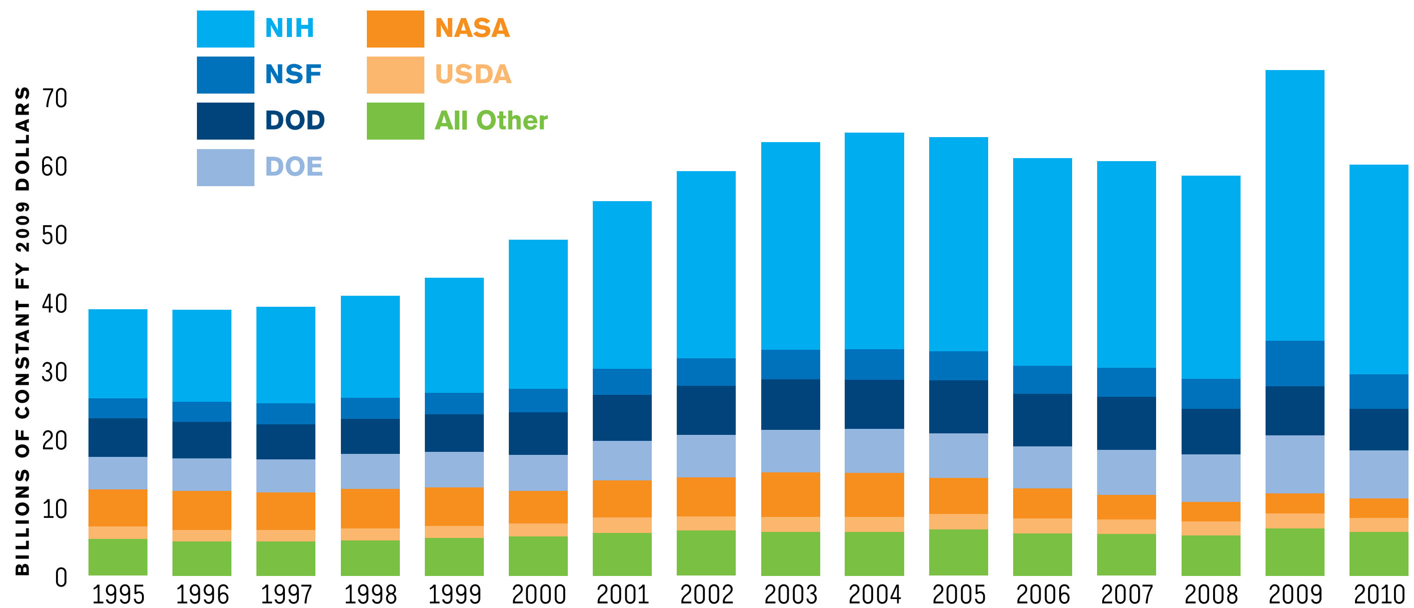
7 Tierney, John. *The New York Times*. "To Explain Longevity Gap, Look Past Health Care System." September 2009.

8 *Popular Mechanics*. "Inventor Dean Kamen Says Healthcare Debate Looking Backward." August 2009.

9 Ibid.

10 National Institutes of Health. http://www.nih.gov/about/NIHoverview.html.

Figure 4. Trends in Research by Agency, FY 1995–2010
Source: OSTP, May 2009



FY 2009 figures include Recovery Act appropriations. Research includes basic research and applied research.

The TLSI can serve as a forum to discuss these balances and offer suggestions on how they might be improved.

Energy

Like health care, the debate on energy issues is not whether it is a grand challenge. The debate centers on the policies, resources and trade-offs that are best suited to turn the challenge into an advantage and a better future. The TLSI mission to speed innovations from ideas to labs to practical use is a very important part of the solution.

Why a Mega Project? As part of the September 2009 National Energy Summit and International Dialogue hosted by the Council on Competitiveness, the Council leadership made the case for energy as a mega project in terms of jobs, the economy, the environment and national security:

In the United States, growing dependence on imports to meet our energy needs is a major factor in the trade deficit and results in the loss of precious capital from our economy. Increases in energy prices erode the competitive cost structure of energy intensive industries, increasing the risk that these industries and the jobs they represent will move offshore.

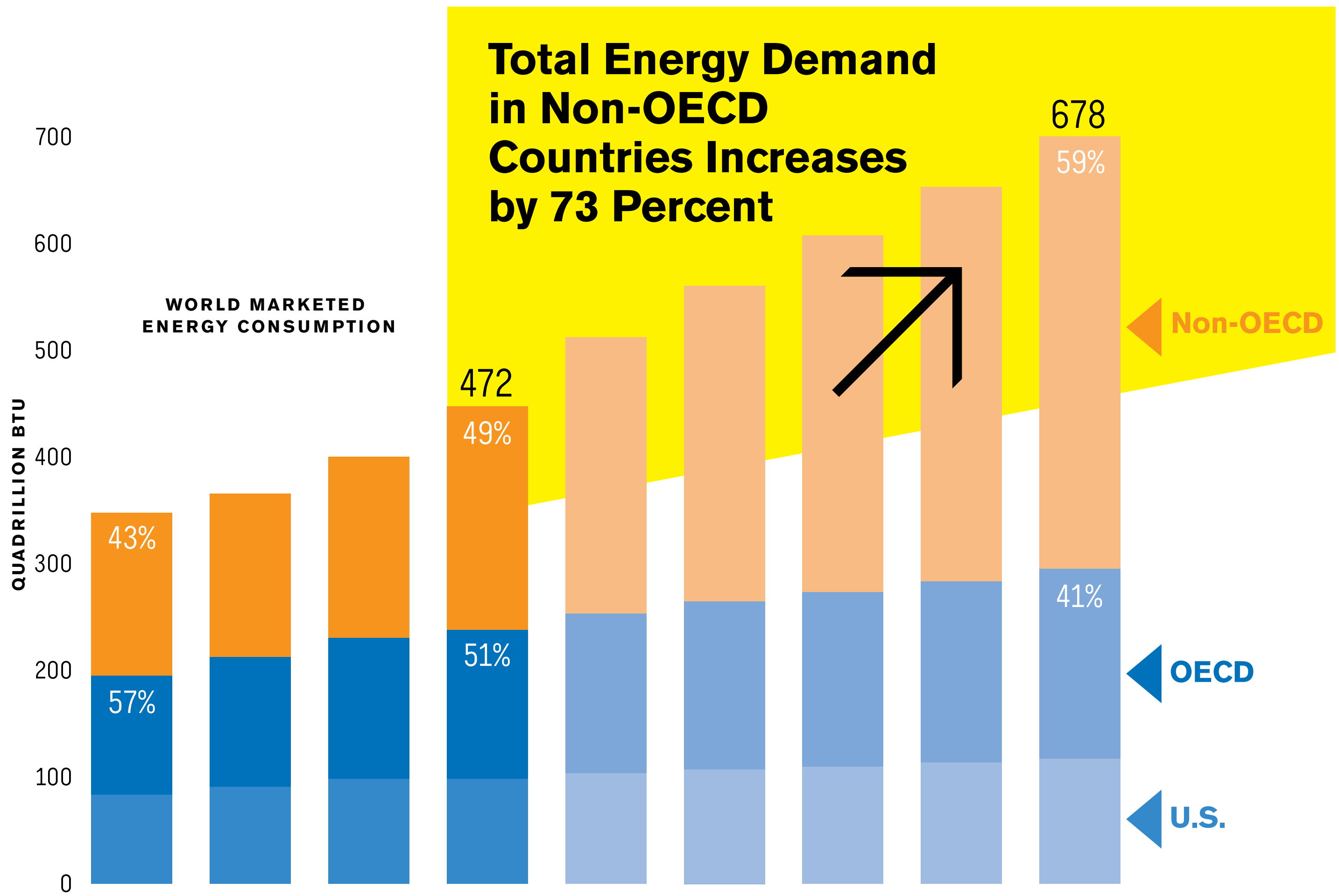
Our growing dependence on foreign sources of natural gas and petroleum also poses a serious challenge to U.S. national and economic security… our dependence on foreign oil translates into an outflow of $439 billion dollars annually that accounts for 45 percent of the U.S. trade deficit… In 2008, America imported more than 66 percent of its oil, much of it from areas of the world that are insecure and not always friendly to American interests.[11]

11 Council on Competitiveness. *Drive. Private Sector Demand for Sustainable Energy Solutions.* September 2009. p. 5.

Moreover, the United States must work with other countries to lower the risk of climate change by reducing carbon dioxide (CO_2) emissions resulting from the combustion of fossil fuels. This will require greater use of alternative energy sources and the development of cleaner, more efficient ways to produce and use energy.

The challenges posed by energy demand are not limited to the United States. Global demand is projected to grow 44 percent by 2030 (figure 5) and U.S. growth is projected to grow approximately 11 percent during the same period (figure 6). If current trends continue, humans will use more energy in the next 50 years than in all of previously recorded history.[12]

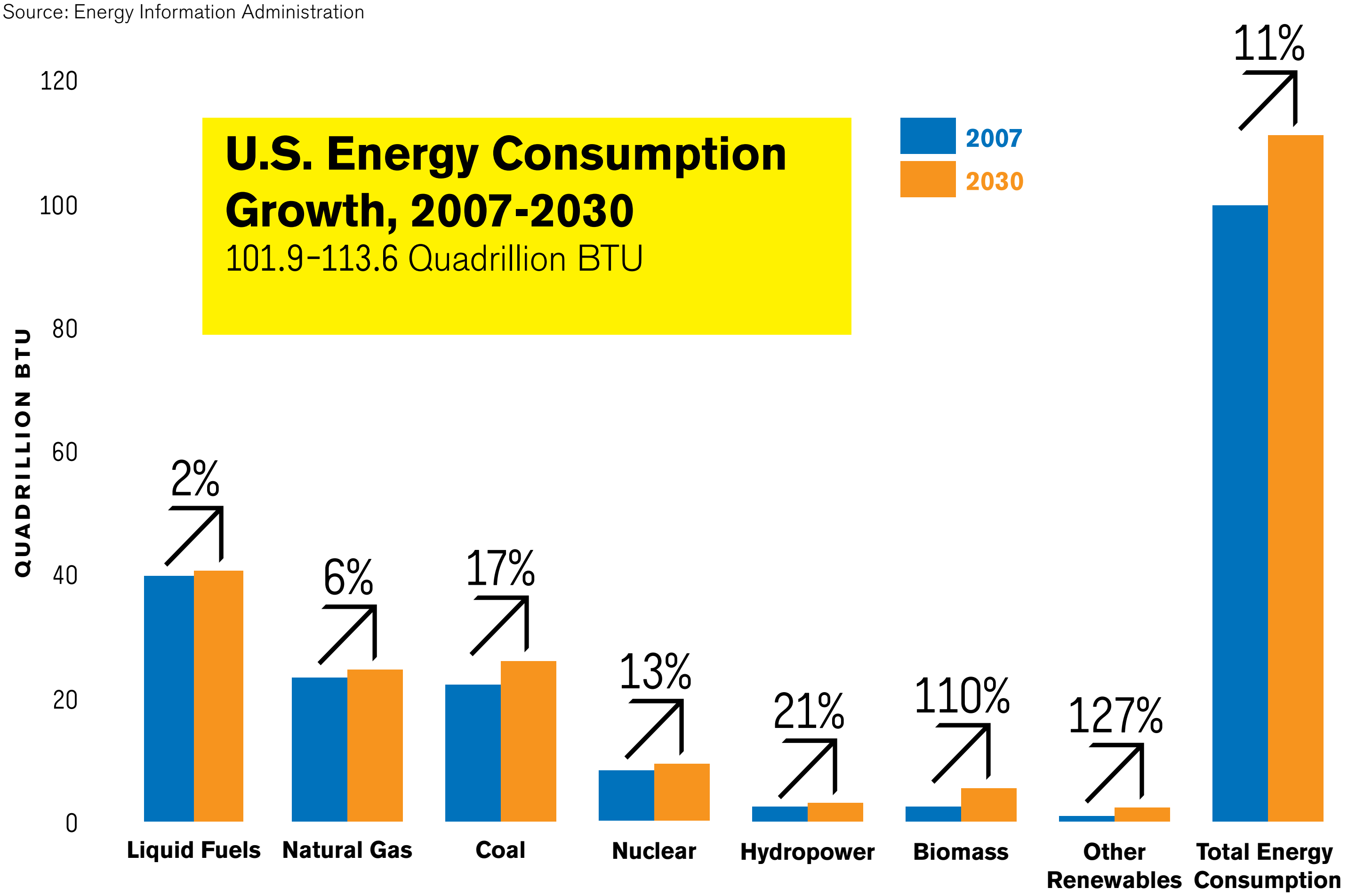
Figure 5. Global Energy Demand Projected to Increase 44 Percent by 2030
Source: Energy Information Administration



Note: 2030 international energy consumption is projected to be 678 quadrillion BTU, a 44 percent increase over 2006 levels of 472 quadrillion BTU. Non-OECD countries are expected to contribute to 83 percent of this growth.

12 Council on Competitiveness. *Drive. Private Sector Demand for Sustainable Energy Solutions.* September 2009. p. 5.

Figure 6. Projected Growth of US Energy Consumption
Source: Energy Information Administration



In sum, many trend lines for America contribute to energy as a mega project—higher energy prices and demand, growing CO_2 emissions, greater foreign dependency, and an infrastructure in need of modernization and efficiency.

There is no single solution to providing abundant, secure, clean and reasonably-priced energy. It will require legal, regulatory, policy and tax changes at the federal, state and international levels. These changes must help establish markets for alternative energies, expand domestic production of all sources and support technological advances that improve energy efficiency, production and usage.

The Council's recommendations include changes to reward energy efficiency, incentivize investment, rationalize federal and state regulatory policies, improve energy transmission, develop talent and spur technology breakthroughs. The TLSI should embrace a number of these recommendations that have a direct bearing on its mission.

The Role of Innovation. The Basic Energy Sciences Advisory Committee, an expert group advising the Department of Energy, asserted in December 2008, that:

Existing energy approaches—even with improvements from advanced engineering and improved technology based on known concepts—will not be *enough to secure our energy future. Instead, meeting the challenge will require new technologies for producing, storing and using energy with performance levels far beyond what is now possible. Such technologies spring from scientific breakthroughs in new materials and chemical processes that govern the transfer of energy between light, electricity and chemical fuels.*[13]

The Committee identified three strategic areas in need of transformational breakthroughs:

- Making fuels from sunlight;
- Generating electricity without carbon dioxide emissions; and
- Revolutionizing energy efficiency and use.

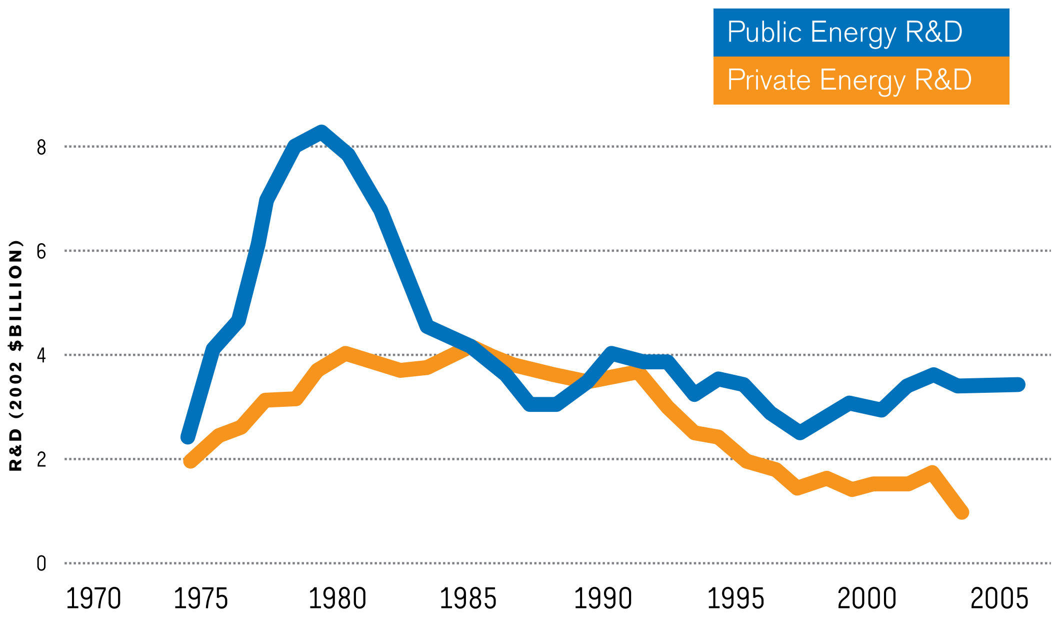
Similarly, the Council on Competitiveness has identified three technology areas that are crucial for America to fully exploit its renewable resources, coal and nuclear resources:

- Energy storage, including batteries;
- Carbon capture and storage; and
- Advanced nuclear reactors.

In order to achieve these objectives, the federal government must invest more in R&D, develop and retain scientific talent, and implement policies that encourage the private sector to invest. Public and private investment in energy R&D has declined significantly since the 1980s (figure 7).

Figure 7. Public and Private Energy R&D Investment Declined Significantly Since the 1980s

Sources: Kammen, Daniel M. and Gregory F. Nemet. "Reversing the Incredible Shrinking Energy R&D Budget," Real Numbers, 2005; "Major Functional Categories of R&D," American Association for the Advancement of Science, 21 March 2008.



- Between 1991 and 2003, U.S. private sector investments in energy R&D fell by 50 percent.
- Energy R&D as a percentage of total U.S. R&D fell from 10 percent to 2 percent between 1980 and 2005.
- Federal funding for energy R&D received just 2 percent of total federal R&D funds in 2009, compared with 21 percent dedicated to health R&D.

13 Basic Energy Sciences Advisory Committee. *New Science for a Secure and Sustainable Energy Future.* December 2008.

Public and private sector leaders also must work to bring experts from more disciplines around these problems. The report from TLSI Dialogue 1, for example, noted how Singapore's Fusionopolis research center brings together teams of researchers from many disciplines, including materials science and engineering, data storage, microelectronics, manufacturing technology, high performance computing, and information and communications. Singapore believes that this integrated approach will give them a competitive advantage in industries like energy and health care.

The Basic Energy Sciences Advisory Committee stated that key solutions are likely to be found at the intersection of advanced materials, chemistry and control science (the manipulation of matter and energy at the electronic, atomic or molecular level).[14]

In addition to breaking down disciplinary silos, TLSI Dialogue 1 noted that new forms of collaboration that supplement the peer review model should be established or expanded. One example is the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. This office convenes industry and academic experts to (1) explore R&D challenges and identify priorities; (2) set outcome goals (such as cost and performance); (3) develop roadmaps, identify milestones and develop multi-year research plans; (4) invest in competitively-selected projects with industry, universities and partnerships; (5) drop less promising approaches and increase support for better ones; and (6) fund demonstrations and pilots to generate the performance and cost data needed to attract commercial financing for private sector commercialization.

Security

Since 9/11, Americans at multiple levels of government have taken steps to make the nation more secure at home and to support U.S. military and intelligence missions overseas. Technology and innovation are crucial components of homeland and national security. To equip our military men and women, law enforcement personnel and emergency response teams, the United States relies on technology and complex systems to deploy them. America needs global best of breed technology to stay ahead of our adversaries at home and abroad—detecting and deterring threats, limiting vulnerabilities, responding effectively when attacks occur and earning success on the battlefield.

Why a Mega Project? Defending citizens from violence is perhaps the original and ongoing mega project for any society. The preamble to the United States Constitution makes clear that providing for the common defense is a fundamental reason to establish government. For much of America's history, the country relied on a small professional army and state militias in times of need. In the wake of two world wars and the onset of a cold war, however, America changed from an insular country with reservations about standing armies to one that saw its security linked to a larger global order.

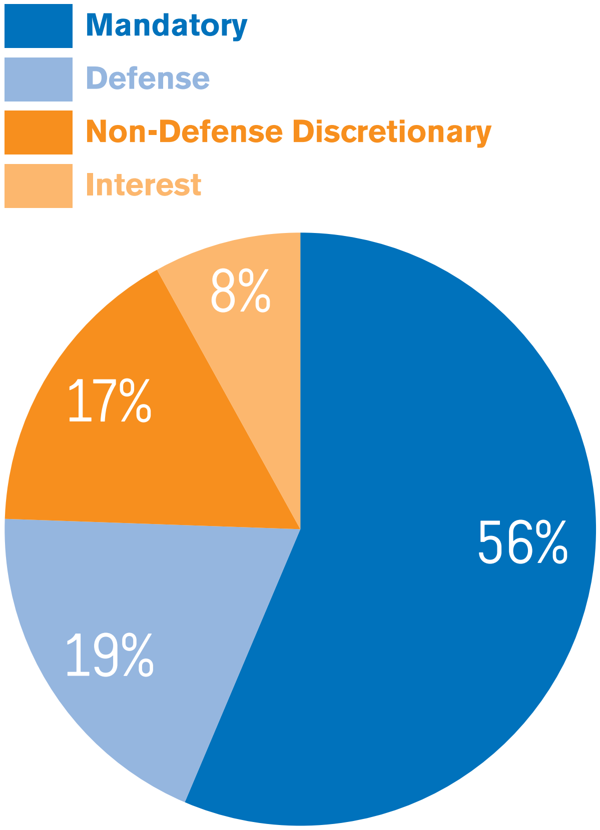
This larger concept of security requires significant investment. Like health care, defense spending accounts for a large share of what our society invests in as a nation. In fiscal year 2008, the defense budget accounted for 19 percent of all federal spending (figure 8). Adding the budget of the Department of Homeland Security would raise that figure to 20 percent.

Federal spending is often analyzed in three categories. Mandatory programs are not subject to annual funding approvals by Congress and accounted for 56 percent of all federal spending in fiscal year 2008. If an individual qualifies for benefits under a mandatory program, the government is obligated to pay for those benefits under the rules of the program. Major mandatory programs include Social

14 Ibid.

Security, Medicare and Medicaid, which accounted for 80 percent of all mandatory spending in fiscal year 2008. Discretionary programs are subject to annual budget approvals by Congress and may only spend amounts appropriated each year. The defense budget is the largest component of the discretionary budget, accounting for 54 percent ($612 billion) of all discretionary spending in fiscal year 2008. The final spending category is interest paid on the national debt.

Figure 8. U.S. Federal Spending, FY 2008
Source: Congressional Budget Office, Historical Tables, March 2009



Achieving America's defense and security needs in a cost conscious manner is a difficult but necessary mega project. Along with the mandatory programs, the defense budget plays a significant role in America's fiscal health and how much the nation must borrow to finance its expenditures—thus impacting the national debt and related factors like interest, exchange and tax rates. Along with mandatory programs, defense spending impacts how much the federal government can invest in other challenges like energy and education.

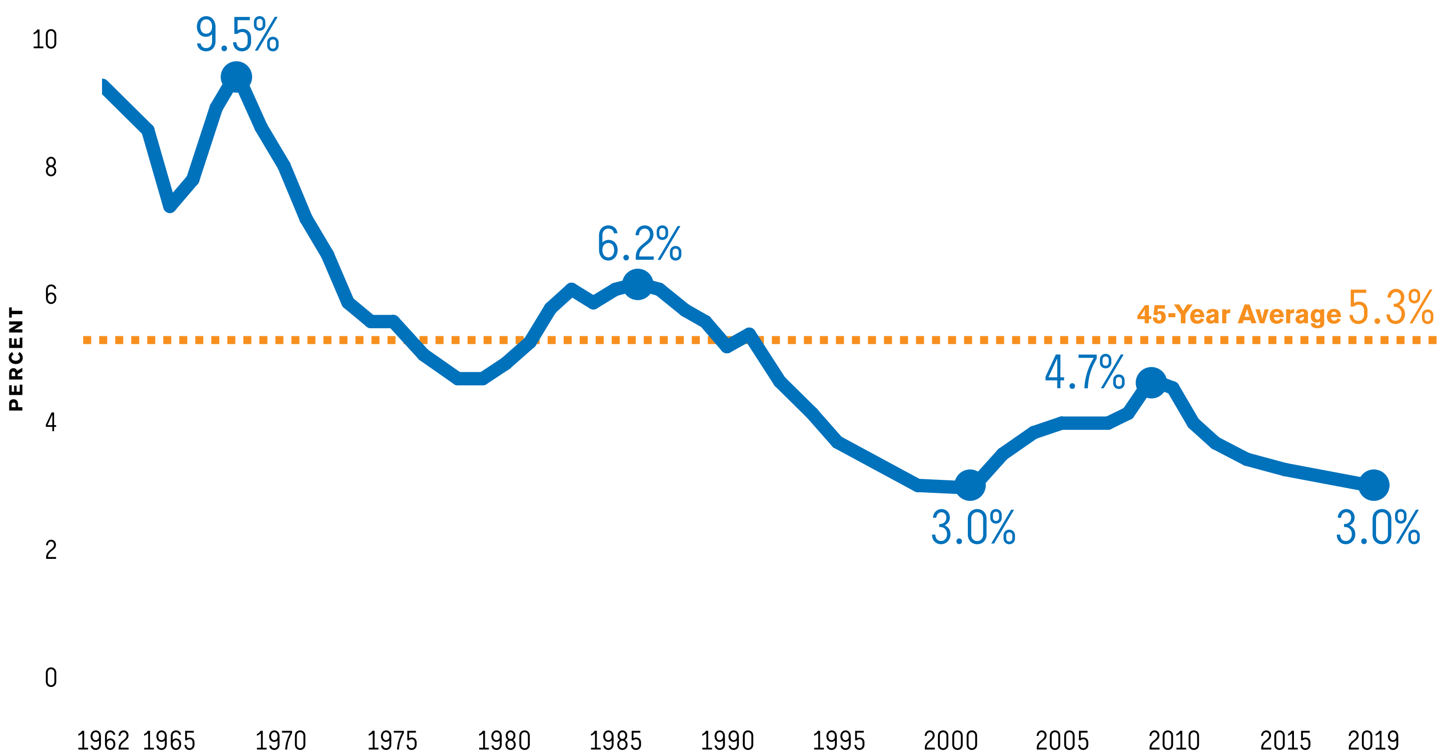
By some measures, however, defense spending remains at a fairly modest level. As a share of the nation's wealth (gross domestic product), defense spending stands at 4.7 percent, below the historical average of the past 45 years despite increases due to wars in Iraq and Afghanistan (figure 9). Mandatory programs are growing most rapidly as a share of total federal spending. As mandatory costs grow, they restrict discretionary budgets (including defense) and drive up debt in the absence of spending cuts, tax increases, cost-cutting reforms to the mandatory programs or economic growth that increases revenue.

The Role of Innovation. Innovation and technology are essential to:

- Protect soldiers, sailors and airmen and enhance their ability to project force;
- Work in coalition with allies;
- Equip police, border patrol, customs, security, fire and rescue personnel;
- Secure strategic infrastructure;
- Detect threats through intelligence and surveillance; and
- Increase the efficiency and effectiveness of all security efforts.

Figure 9. U.S. Defense Budget as Share of GDP

Source: Heritage Foundation from Office of Management and Budget data



Advancing these objectives would make America safer and more resilient. They also offer potential economic and quality of life benefits. Defense innovations such as sonar, lasers, global positioning, materials and the Internet have proven to have wide ranging applications for commercial and everyday life.

TLSI Dialogue 1 reviewed some of the challenges and potential solutions to a more productive innovation system for defense and security. Participants noted that some of the most promising technology and talent rest in the private sector and outside the United States. This new reality means that a greater share of defense and security advancements will be driven by individuals outside of the public sector defense establishment, requiring new approaches for public-private and global collaboration.

Concerns were raised about international traffic in arms regulations and the impact those rules have on domestic technology development and participation by talented non-U.S. scientists. Participants also suggested steps to encourage more flexibility between defense labs and the private sector and to communicate public sector needs and market potential more effectively to companies.

21st Century U.S. Talent Pool

TLSI Dialogue 1 made clear that chief technology officers value talent as the most crucial element of innovation performance. Talent rated highest in importance on multiple queries made in the Council on Competitiveness 2009 CTO Survey.[15] Dialogue participants emphasized the need to educate and train Americans, attract and retain overseas talent, and collaborate with top talent anywhere in the world.

Education

Math and science education, from elementary to graduate school, remains a pressing concern.

American students continue to perform below their international peers, and the number and diversity of graduates entering technical fields is less than most believe is necessary.

Every three years since 2000, the OECD has issued data under its Program for International Student Assessment (PISA) that compares the performance of 15-year-olds on measures of reading, math and science literacy. The latest data available is from 2006. PISA 2009 data is being collected between September and November 2009, with a report to be released in December 2010.

The 2006 PISA data for 15-year-olds shows the average score of American students ranked 21st in science and 25th in math out of 30 OECD countries. Looking at all countries participating in PISA, the average score of the United States ranked 29th in science and 35th in math out of 57 countries (selected scores in figure 10). Equally disconcerting is that the relative performance of American students has declined over the last three PISA studies. In science literacy, the OECD rank for the United States has fallen from 14th in 2000 to 19th in 2003 to 21st in 2006. In contrast, Germany's ranking in science literacy over the same period has improved from 20th to 8th (figure 11).

One interesting feature of the PISA report is that it breaks down student performance into six levels, with Level 6 being the highest. The percentage of U.S. students performing at Level 6 in science literacy (1.5 percent) ranks 10th among OECD countries—above the OECD average of 1.3 percent. This means that the United States performs somewhat well at producing very high performers, but that a significant disparity exists in the performance of American students that lowers the average score and indicates that many students are not being taught to their potential.

A second set of math and science data for 4th and 8th grade students is collected under the Trends in International Mathematics and Science Study (TIMSS). The TIMSS assessment is made every four years. The latest available data is from 2007.

American 4th and 8th grade performance in math and science as measured by TIMSS ranks better than the performance of American 15-year-olds as measured by PISA. In math, American 4th graders ranked 11th out of 36 countries measured and were above the average score. U.S. 8th graders ranked 9th out of 48 countries measured and were above the average score. The results are more impressive when one considers that for each math ranking, three of the entities scoring above the United States are city states (Hong Kong, Singapore and Taipei) rather than large nations with many more people and multiple government jurisdictions operating under different economic conditions and policy systems.

In science, the 2007 TIMSS ranked U.S. 4th graders 8th out of 36 countries. American 8th grade students ranked 11th out of 48 countries. As with

15 Council on Competitiveness. *Change. The Changing Global Landscape for Technology Leadership*. 2009. pp. 44-45.

Figure 10. United States Below OECD Average in Math and Science Assessments
Source: OECD

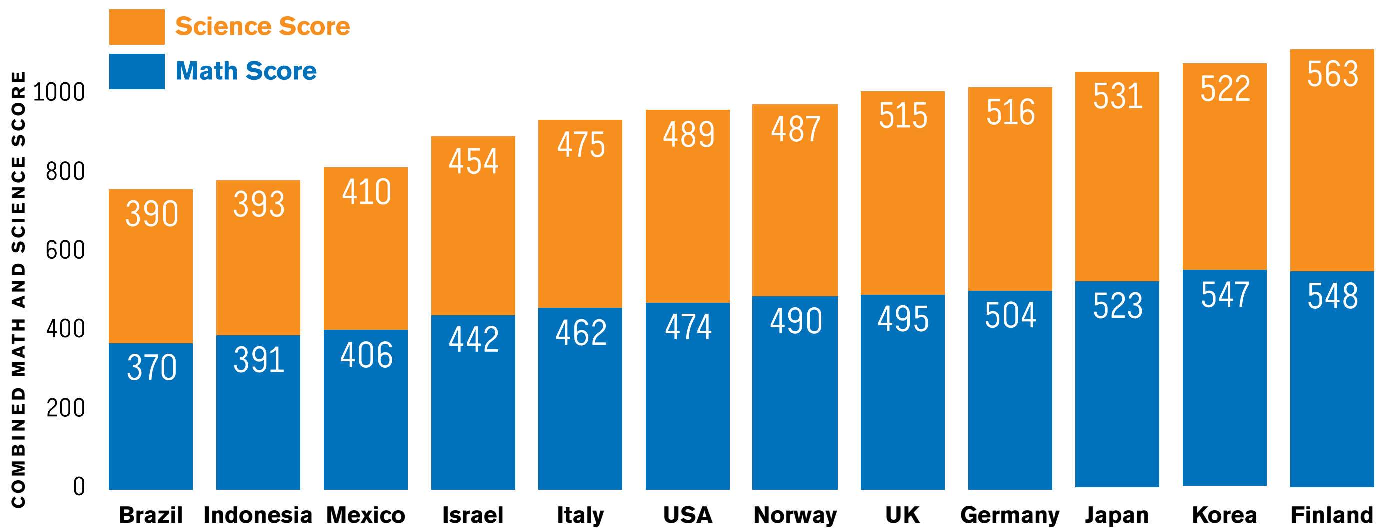
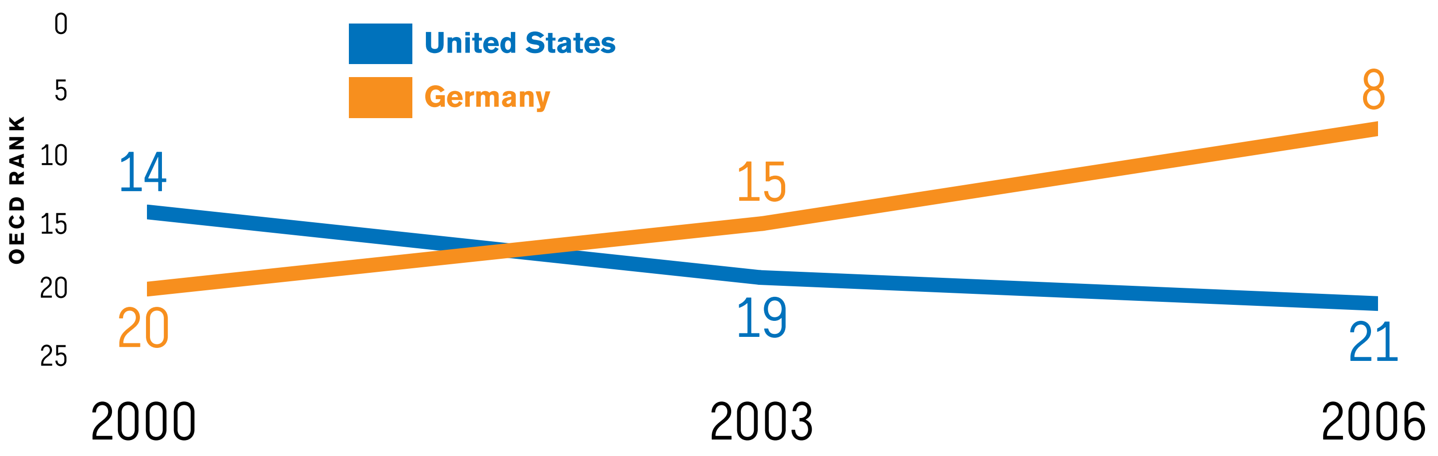


Figure 11. Comparing Trend of OECD Rank on Science Literacy Assessment
Source: OECD



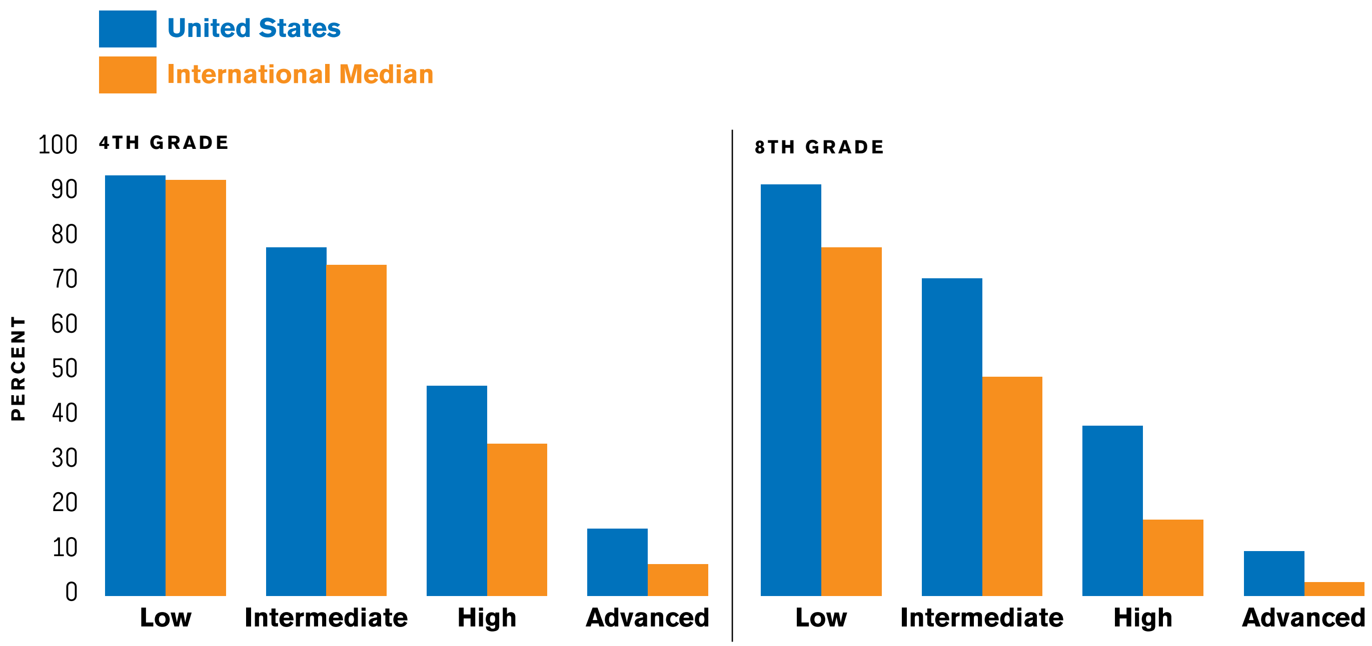
the math scores, U.S. performance was above the TIMSS average and the three city states were among the few ranked above the United States. American students also exceeded the TIMSS median in reaching a graduated series of benchmarks for performance (figure 12). Equally encouraging is that American scores and rankings have improved in math and science since TIMSS was first administered in 1995.

The positive results on the TIMSS assessment mirror domestic measurement of 4th and 8th grade performance. In both cases, performance for U.S. students is on the rise.

The U.S. Department of Education evaluates student performance in math, science and other subjects through the National Assessment of Education Performance (NAEP). The 2009 NAEP Math report card showed that proficiency has improved significantly (figure 13). The 2009 NAEP Science assessment was administered to students in grades 4, 8 and 12 between January and March 2009, with results to be reported in the spring of 2010. In the 2005 NAEP science assessment, 4th grade scores improved from 1996-2005, while over the same period 8th grade scores plateaued and 12th grade scores declined.

The signature U.S. education reform of the past decade is the No Child Left Behind Act (NCLB), a law enacted in 2002 that requires states to assess

Figure 12. Percentage of U.S. 4th- and 8th-Grade Students Who Reached Each TIMSS International Science Benchmark Compared with the International Median Percentage, 2007



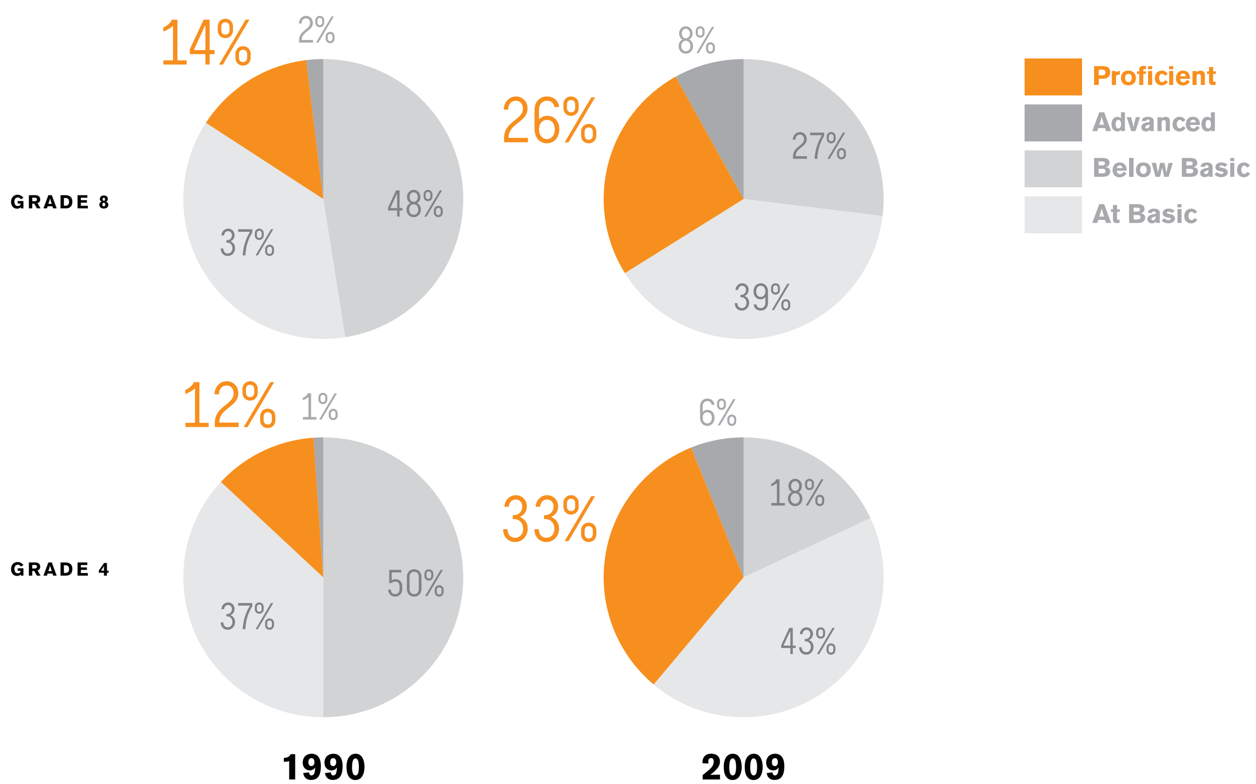
students' basic skills if those states are to receive federal funding for schools. Schools are evaluated for the results of their students and subject to accountability measures. Although NCLB has only been implemented for a few years and some aspects of the law remain hotly debated (such as the quality of state standards), most observers credit the law at least in part with improving performance in the areas tested.

The TIMSS and NAEP results show that American students are capable of improving and competing with their international peers, but the PISA results show that reforms are urgently needed at the high school level in order for more Americans to move from talented youngsters to skilled adult innovators.

Even if the United States improves high school performance in math and science over the next several years, that success will bear little fruit if performance and graduation rates in institutes of higher learning fail to improve. TLSI Dialogue 1 participants noted that America needs not only more students completing advanced degrees in science, technology, engineering and mathematics (STEM), but innovation also requires graduates with business and entrepreneurial skills, expertise in social sciences and design, and a variety of emerging multidisciplinary degrees.

Unfortunately, the American higher education system graduates just over a third of its enrollees and is being outpaced by our global competitors. In 1995, the OECD ranked America first in tertiary gradua-

Figure 13. U.S. Math Proficiency Improvement
Source: NAEP 2009 Math Report Card



Note: Detail may not sum to totals because of rounding.

tion rate among its member countries. By 2007, the United States fell to 10th among OECD countries as other nations grew their rate of graduation at a more rapid pace (figure 14).

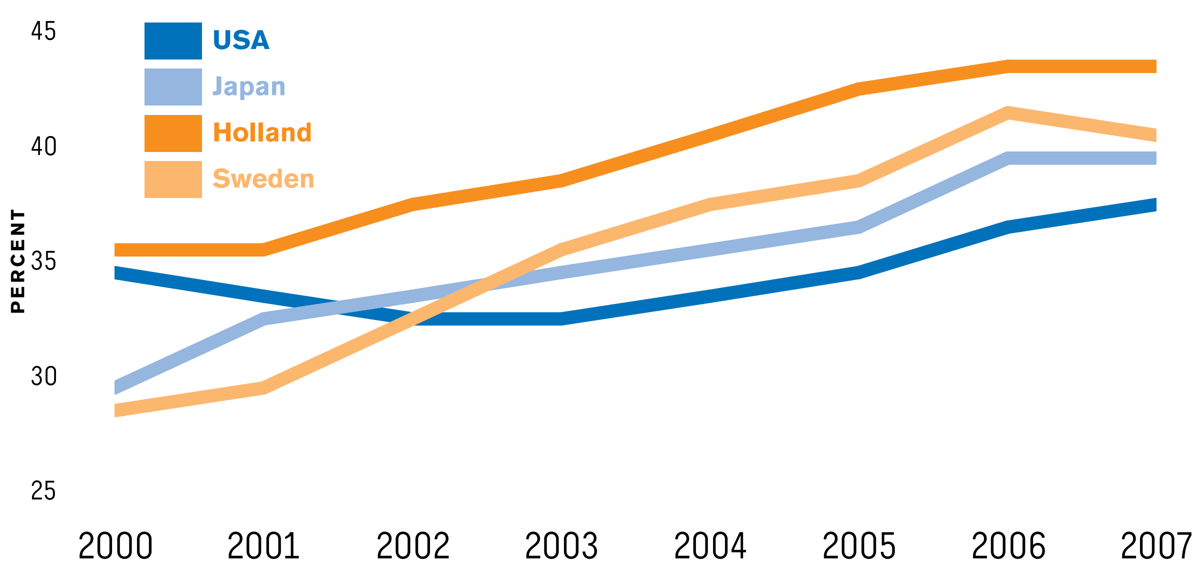
In fact, U.S. higher education has a substantially lower graduation rate (37 percent) than U.S. high schools (between 70-75 percent).[16] Mark Schneider, former commissioner of the U.S. Department of Education's National Center for Education Statistics, refers to many institutions as "failure factories" based on their low graduation rates. Schneider notes that although the United States has some of the world's best institutions and that Americans invest more in higher education than any other OECD nation (in aggregate terms and as a share of GDP), the system as a whole has significant shortcomings.[17]

The New York Times columnist David Leonhardt compares higher education spending to health care, noting that "policy makers hand out money based on how many students a college enrolls rather than on what it does with those students…we pay doctors and hospitals for more care instead of better care, and what do we get? More care, even if in many cases it doesn't make us healthier." [18]

In 2006, a commission composed of academic and industry leaders issued a report that praised the success and strengths of American higher education, but warned of complacency and noted a number of trouble signs, including:

- Students not entering college because of inadequate information and rising costs, combined with a confusing financial aid system that spends too little on those who need help the most;
- Large numbers of high school graduates who

Figure 14. Higher Education Graduation Rates, Selected Countries
Source: OECD Education at a Glance, 2009



16 Schneider, Mark. *The Cost of Failure Factories in American Higher Education*. American Enterprise Institute. 2008.

17 Ibid.

18 Leonhardt, David. "Colleges are Failing in Graduation Rates." *The New York Times*. September 8, 2009.

enter postsecondary education without mastering English and math skills that they should have learned in high school;

- Many students who do earn degrees have not actually mastered the reading, writing and thinking skills expected of college graduates. Literacy among college graduates actually declined over the past decade;
- A trend of these problems being most severe for students from low-income families and for racial and ethnic minorities; and
- A lack of clear, reliable information about the cost and quality of postsecondary institutions, along with a remarkable absence of accountability mechanisms to ensure that colleges succeed in educating students. The result is that students, parents and policymakers are often left without answers to basic questions, from the true cost of private colleges (where most students do not pay the official sticker price) to which institutions do a better job than others not only of graduating students but of teaching them what they need to learn.[19]

The TLSI is not an effort to reform American education, but participants were emphatic that improving education is the most important ingredient for America to improve its competitive position and generate better, more prosperous lives through productive innovation. The TLSI can add its voice to the larger debate and identify education reforms that are most strategic to strengthen America's innovation capacity.

Immigration

The introduction to this report notes that two of the three founders of YouTube and one of the two founders of Google are sons of immigrants. Foreign-born individuals, in fact, account for more than 40 percent of America's science and engineering workforce with doctorate degrees (figure 15). That share is almost double what it was in 1990. The data also show that the higher the degree level earned, the larger is the share of foreign-born workers.

These talented individuals contribute more than an average worker. A Duke University study determined that the chief executive or lead technologist for more than 25 percent of the U.S. science and technology firms founded between 1995 and 2005 were foreign-born (figure 16). In 2005, these companies generated $52 billion in revenue and employed 450,000 workers.[20]

The same study found that immigrants in that period founded 26 percent of the startups in Washington, D.C.; 36 percent in Chicago; 44 percent in New York; and more than half of the startups in Silicon Valley (figure 17).

Immigrant innovators are not a recent phenomenon or limited to technical fields. America's history is studded with immigrant pioneers who have contributed to innovation in many ways. Many consider French immigrant George Doriot to be the father of modern venture capital practices. Doriot was an educator and entrepreneur, founding the American Research and Development Corporation in 1946—the first publicly-owned venture capital firm.

Another titan of American finance was A.P. Giannini, son of Italian immigrants and founder of a bank in 1904 that would become Bank of America. Giannini's main innovations were to (1) cater to ordinary people, particularly immigrants, rather than to established wealthy clients and (2) establish a nationwide network of banks for the same purpose, creating the practice of branch banking.

19 Secretary's Commission on Higher Education. *A Test of Leadership, Charting the Future of U.S. Higher Education.*United States Department of Education. September 2006.

20 Wadhwa, Vivek; Saxenian, AnnaLee; Rissing, Ben; and Gereffi, Gary; *America's New Immigrant Entrepreneurs*, Duke University. 2007.

Figure 15. Foreign-born Individuals in U.S. S&E Workforce by Degree Level, 1990, 2000 and 2005
Source: National Science Board, Science and Engineering Indicators, 2008

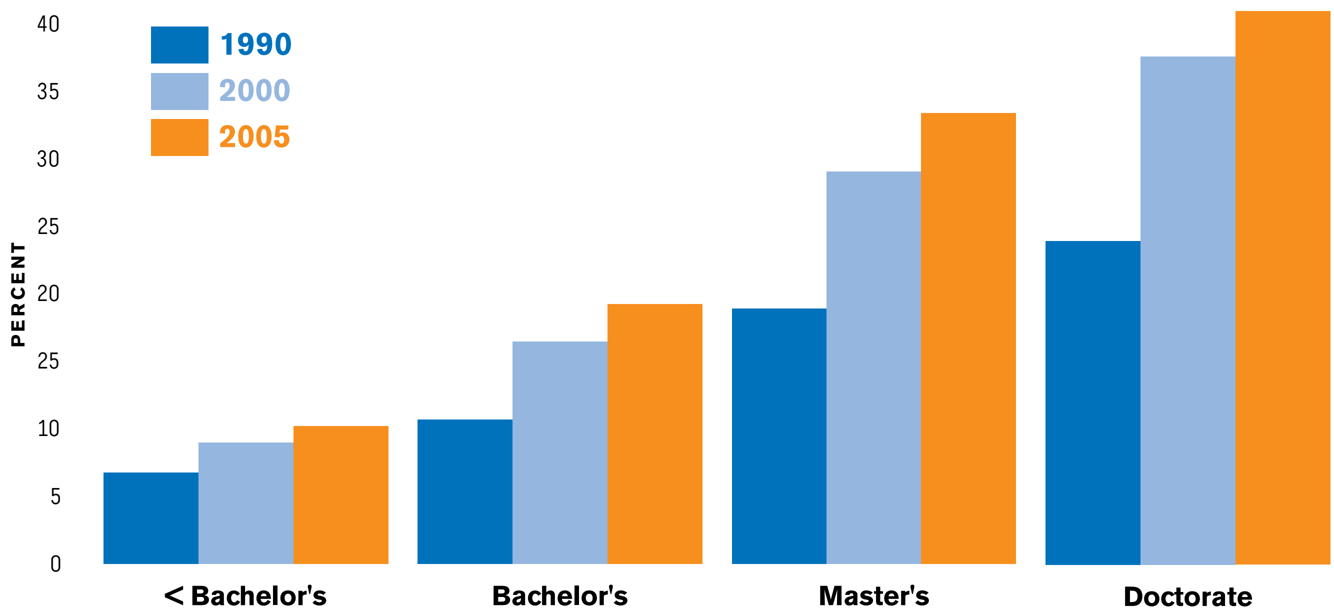
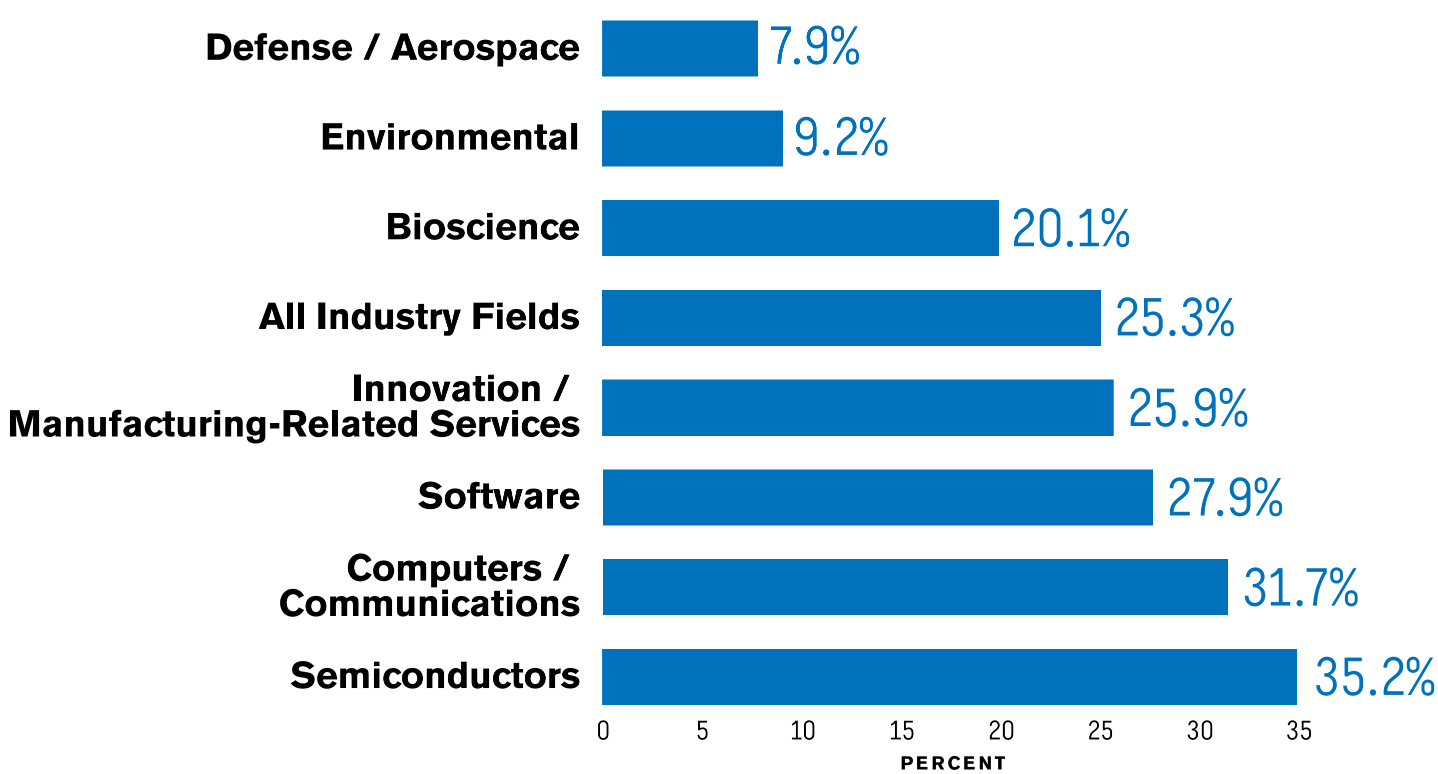


Figure 16. Percent of Immigrant-Founded Companies by Sector, 1995–2005
Source: America's New Immigrant Entrepreneurs



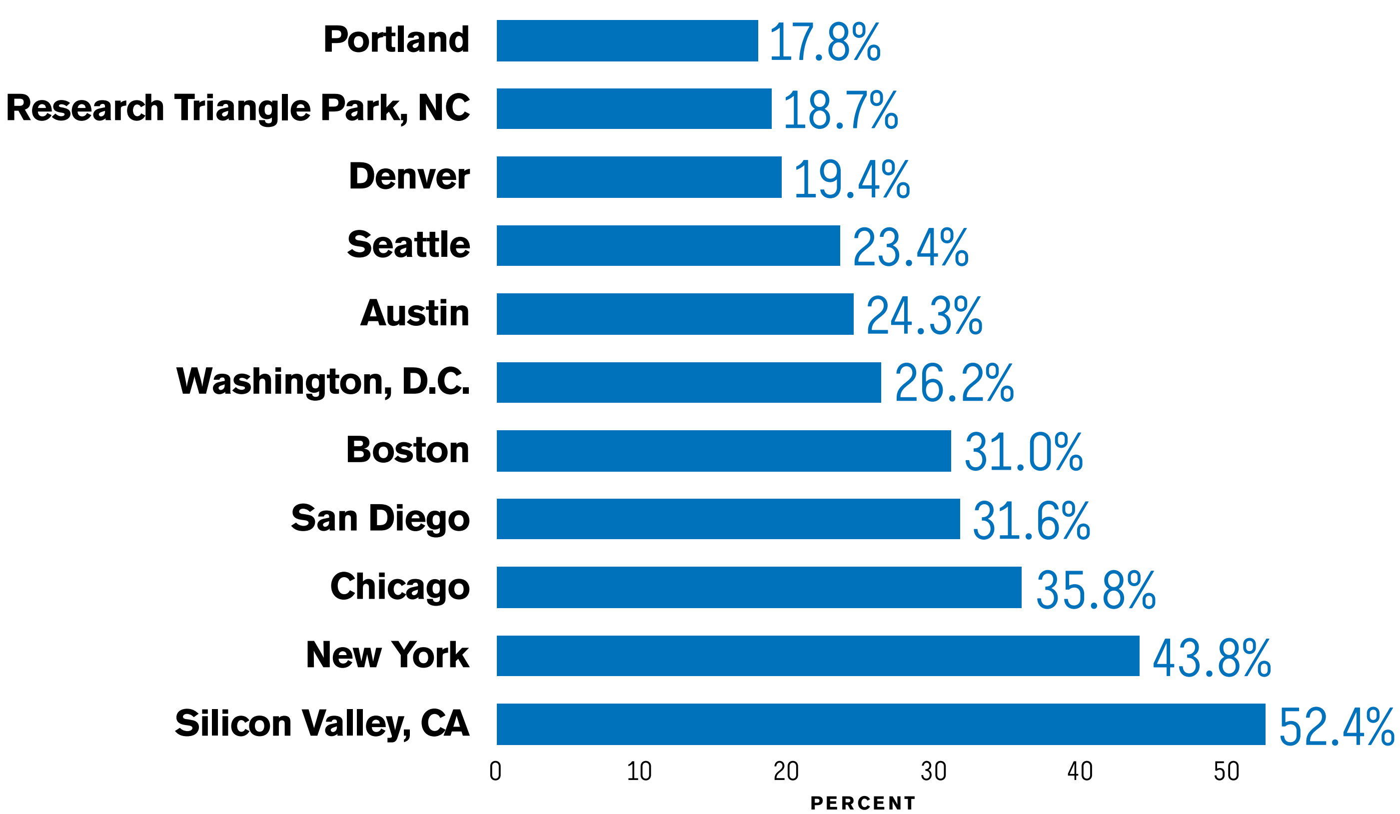
Despite overwhelming evidence that highly-skilled immigrants and foreign-born graduates of U.S. universities make tremendous contributions to American economic innovation and growth, a number of U.S. policies hinder firms from tapping this talent for projects in the United States. Immigration policies, research restrictions, and stringent H-1B visa quotas discourage or prevent highly-skilled foreign students and workers from sparking innovation and creating jobs in the United States.

Diversity and Opportunity

Diversity issues are important to innovation for at least two principle reasons. First, any society wishing to maximize its potential should engage as many people as possible to their highest potential. Second, innovation is a creative problem-solving process that relies on fresh perspectives, insights, information and—often in today's global economy—knowledge of different cultures. The diverse population of the United States and the ability to collaborate with people worldwide is a tremendous asset to America's innovation enterprise and one that should be leveraged fully.

Engaging the full spectrum of Americans in science, technology and innovation is a challenge characterized by progress made, but representation for most minorities is below their percentage of the population. Women, too, make up a growing share of the science and engineering workforce, but remain well below their share of the population.

Figure 17. Immigrant Startups
Source: America's New Immigrant Entrepreneurs



According to the National Science Foundation's 2008 Science and Engineering Indicators:

With the exception of Asians/Pacific Islanders, racial and ethnic minorities represent only a small proportion of those employed in science and engineering (S&E) occupations in the United States. Collectively, blacks, Hispanics and other ethnic groups (the latter includes American Indians/Alaska Natives) constitute 24 percent of the total U.S. population, 13 percent of college graduates, and 10 percent of the college-educated in S&E occupations. Although Asians/Pacific Islanders constitute only 5 percent of the U.S. population, they accounted for 7 percent of college graduates and 14 percent of those employed in S&E occupations in 2003.

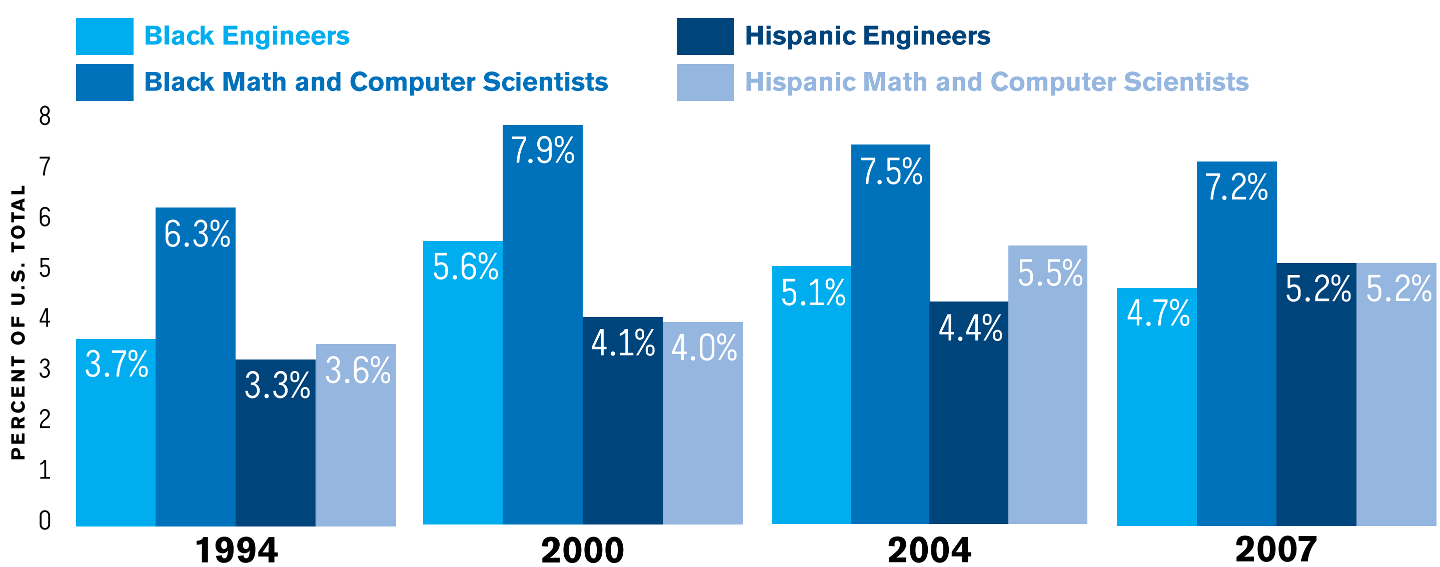
In 2003, women constituted 52 percent of social scientists, compared with 29 percent of physical scientists and 11 percent of engineers. Since 1993, the percentage of women in most S&E occupations in NSF's labor force surveys has gradually increased from 23 percent to 27 percent across all S&E occupations. However, in mathematics and computer sciences, the percentage of women declined about 2 percentage points between 1993 and 2003.

Examining two technology disciplines for which data are available—engineers, and math and computer scientists—the share of black and Hispanic professionals has risen from 1994 to 2007. Black representation in these professions, however, has declined from high marks in 2000. Hispanic representation grew steadily from 1994 to 2004, but saw a slight decline in the number of math and computer scientists from 2004 to 2007 (figure 18).

Progress also is being made by minority students as measured by their NAEP proficiency scores for math and science. Gaps remain between them and their peers, but math proficiency rates for 8th grade minority students have more than doubled between 1990 and 2009, and the share of students perform-

Figure 18. Representation in Selected Technical Fields

Source: Bureau of Labor Statistics Population Surveys, 1994-2007



ing below basic levels has shrunk dramatically (figure 19). Similar progress is evident in scores for 4th grade students and in the scores for science.

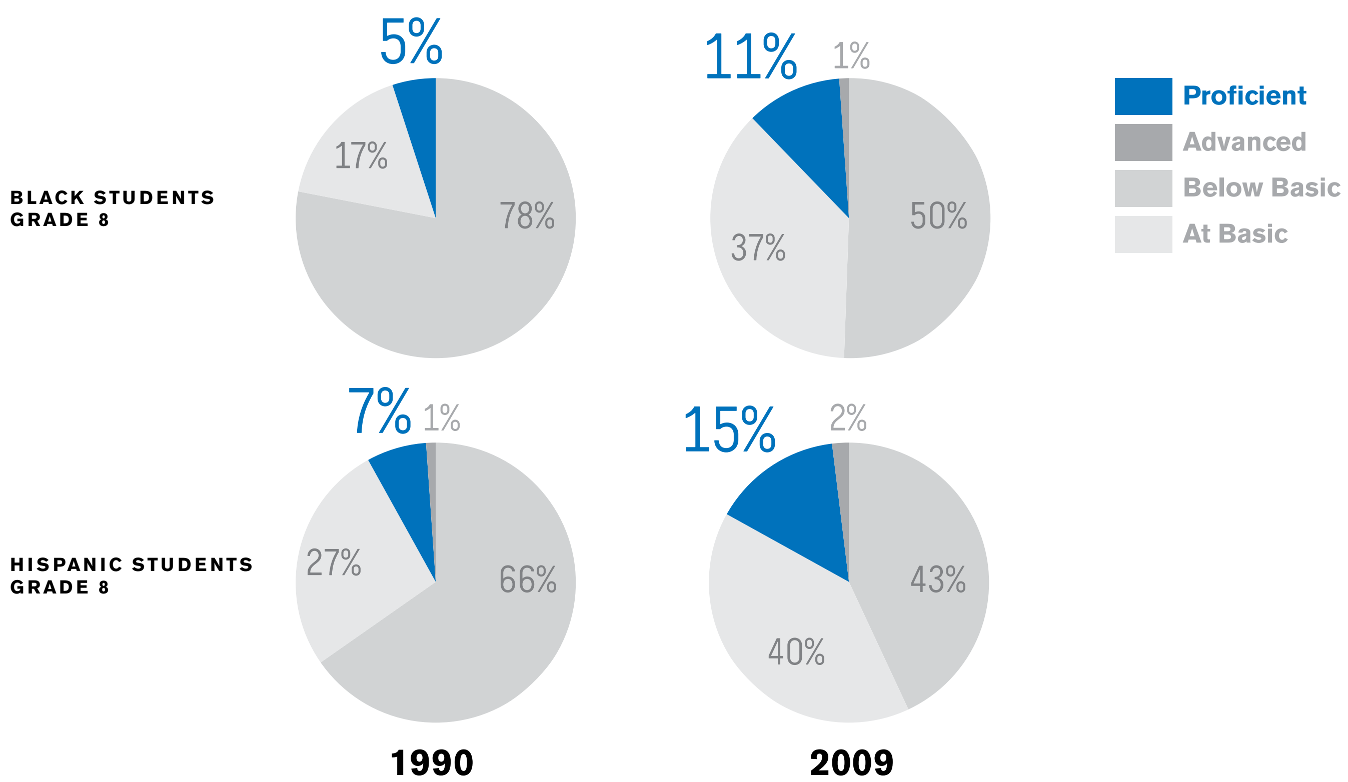
As policy makers continue to strive to close gaps and create opportunities for all U.S. citizens, they also should enable their citizens to work more effectively with diverse talent across the world. A great deal of global collaboration takes place independent of any government role, but TLSI participants noted International Traffic in Arms Regulations and limits on foreign nationals from participating in a broad range of research as overly stringent roadblocks to working with some of the world's best talent.

21st Century Collaboratory

U.S. Collaboratory Engaged with a Global Ecosystem

In May 2009, General Electric announced that it will spend $3 billion over six years to create health care innovations that substantially lower costs, increase access and improve quality. Two products touted as examples—a $1,000 handheld electrocardiogram device and a portable ultrasound machine that sells for as little as $15,000—are remarkable not just for their small size and low price. They are also remarkable

Figure 19. Improvement in Math Proficiency, 1990-2009
Source: NAEP Math Report Card



Note: Detail may not sum to totals because of rounding.

because they were developed for emerging markets in rural India and China, and are now being sold in the United States.[21]

GE calls the process used to develop the two machines reverse innovation, because it is the opposite of the approach that firms have employed for decades. Companies typically develop products at home and then distribute them worldwide, with some adaptations to local conditions—a process known as glocalization. However, as emerging economies offer more opportunity and become more adept at innovation themselves, companies need to expand in those markets and compete with new firms there that can develop and export innovative products to established markets. Companies like GE believe that if they are to prosper, they must become as adept at reverse innovation as they are at glocalization. Success in developing countries is a prerequisite for continued vitality in developed ones.[22]

By many indicators, emerging markets are growing their share of the innovation pie. China has grown rapidly as a research powerhouse, more than tripling its share of global R&D between 1996 and 2005. China, India and Brazil also account for a growing share of scientific publications, while the share from traditional leaders in Europe, the United States and Japan has declined (figure 20).

The GE example illustrates an effort to leverage global capacities to innovate. Companies like GE, however, are doing more than reaching across borders. They are also reaching outside of their companies for ideas and more productive innovation—a growing phenomenon known as open innovation, popularized in a 2003 book of the same name by Henry Chesbrough. Chesbrough's central theme is that companies are moving from closed (supply side) innovation systems where R&D is performed in-house and pushed to market, to open (demand side) innovation models where external actors offer greater input into the R&D process and more avenues are created for ideas to be pulled to market.

Management experts began to examine various open innovation models. As early as 2004, efforts were well underway at companies as diverse as Hewlett Packard, Procter & Gamble, Philips, Adobe and Shell Chemical.[23] At TLSI Dialogue 1, participants learned how Clorox has embraced open innovation. IBM, with one of the world's largest research functions, also is a practitioner. IBM actions include engaging the open source software community and offering parts of its patent portfolio to develop open standards.

IBM's biggest open innovation effort, however, is the establishment of collaboratories where IBM researchers co-locate with a university, government or commercial partner to share skills and resources for a common research goal. In addition to collaborative projects in the United States like a chip manufacturing hub in New York, IBM has inked deals for collaboratories in Saudi Arabia, Switzerland, China, Ireland, Taiwan and India. Four more deals are in the works.[24]

IP / Tech Transfer Impact on Innovation

IBM and other companies pursuing open strategies must negotiate contracts that spell out responsibilities and protect each side's interests. One major potential hurdle is dealing with intellectual property (IP) ownership. In a typical collaborative research agreement, IBM wants to co-own the intellectual property or have exclusive rights to it, but that is not always acceptable to universities. One potential IBM

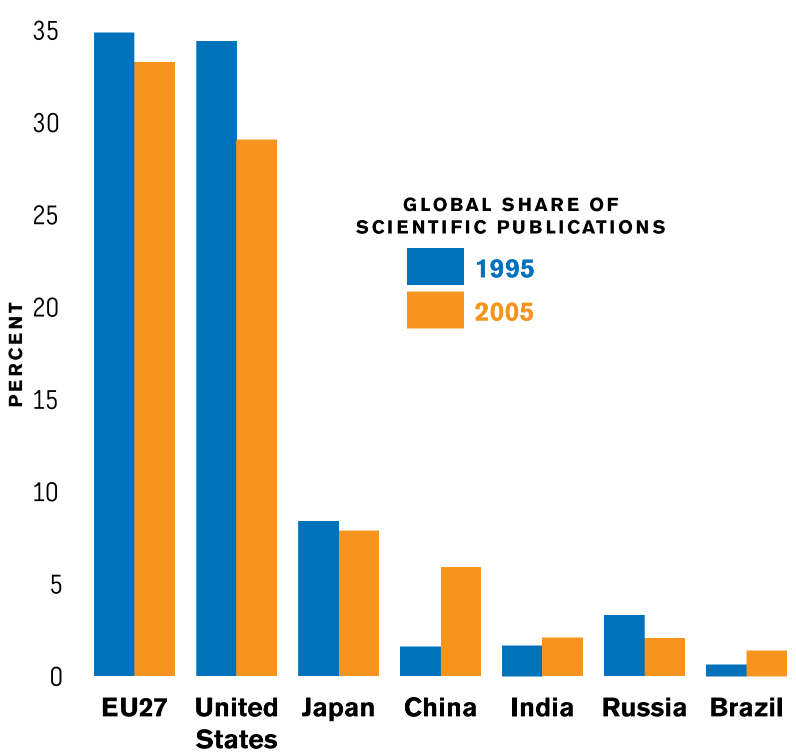
21 Immelt, Jeffrey; Govindarajan, Vijay; and Trimble, Chris. "How GE Is Disrupting Itself." *Harvard Business Review*. October 2009.

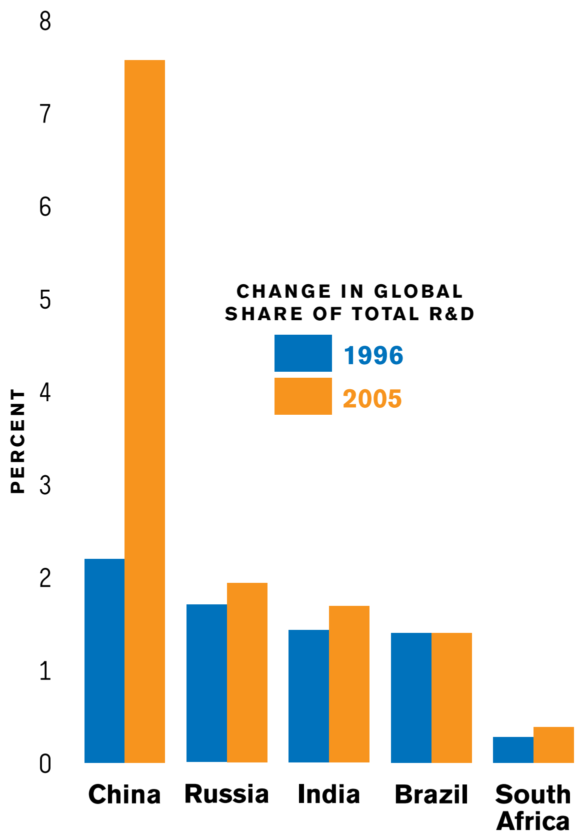
22 Ibid.

23 Hastbacka, Mildred. "Open Innovation: What's Mine is Mine…What's If Yours Could Be Mine Too?" *Technology Management Journal*. December 2004.

24 Hamm, Steve. "Big Blue's Global Lab." *BusinessWeek*. August 27, 2009.

Figure 20. Indicators of Shift in Innovation Capacity, Particularly in China





project in Eastern Europe fell apart last year because the university wanted to control both the intellectual property and research agenda.[25]

Participants in TLSI Dialogue 1 noted that many American universities employ master agreements that are one-size-fits-all, despite vast differences in the market realities of various industries. Company-university collaboration also suffers, said some, from current laws that incentivize universities to pursue more rigid profit-making IP strategies than would be best for commercialization.

Most research universities overseas, noted TLSI participants, have a greater bias for commercialization and fewer IP barriers to collaboration. As more companies employ open innovation models, the concern is that a significant share of corporate-university partnerships that would have been established with U.S. universities will move outside of the United States to take advantage of more favorable IP practices.

25 Ibid.

A recent article by Vivek Wadhwa and Robert Litan highlights a second major commercialization barrier—inadequate tech transfer operations at research universities. The authors state that:

…The vast majority of great research is languishing in filing cabinets, unable to be harnessed by the entrepreneurs and scientist-businesspeople who can set it free…

…We need to understand how broken the current system is. For starters, many universities are underequipped for the monumental task of licensing technology. Major universities have broad research complexes, ranging from anaerobic chemistry to zoology. But too often, when a scientist makes a discovery, the responsibility for finding the right partners to license the technology lies with a single office…

…Even a good-size technology transfer office would struggle to master this task effectively, much less provide sufficient industry-specific contacts for proper marketing of discoveries. When university technology licensing offices try to find an investor or licensee for a specific piece of technology, they lack the inventor's insight into the technology's potential. The upshot? According to the National Academy of Sciences, roughly 0.1 percent of all funded basic science research results in a commercial venture…

…Another hindrance to commercialization of science: Very few scientists are equipped to go into business. They do not know the difference between an S Corp and an LLC. They don't know how to navigate a state or local permitting bureaucracy. And few have a clue about marketing or managing company finances in a way that could withstand an intense audit. These mismatches ensure that stunning amounts of stellar science remains tucked in the lab forever.[26]

The amount of science, as measured by patents granted, continues to accelerate. From 1987 to 1997, the volume of patents granted annually on a global basis grew from 410,921 to 498,767—an increase of 21 percent. From 1997 to 2007, the volume of patents granted annually grew from 498,767 to 764,700—an increase of 53 percent, more than double the growth rate of the prior decade.[27] The share of non-resident patent grantees has grown as well, from 41 percent in 1997 to a high mark of 48 percent in 2004 to 44 percent in 2007 (figure 21).

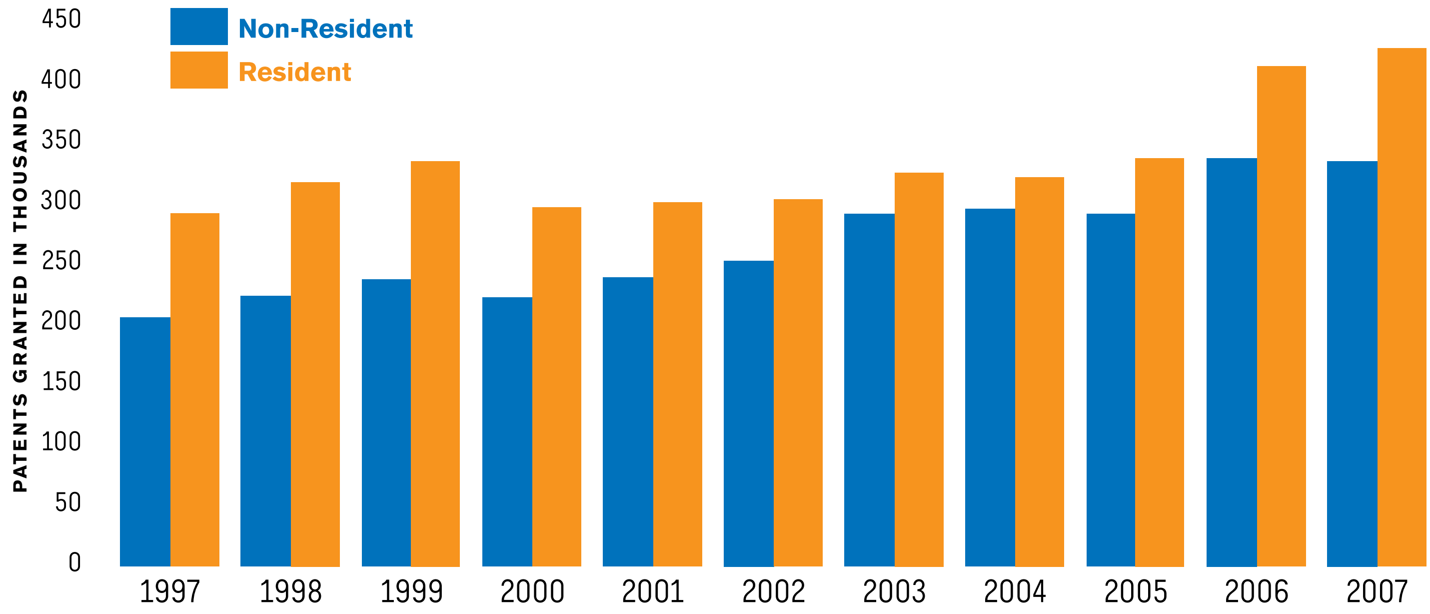
TLSI Dialogue 1 produced suggestions to overcome IP/tech transfer barriers, including:

- Cooperation in forums like the University-Industry Demonstration Project of the National Academies;
- Creating model master agreements that offer greater flexibility for different industries and types of projects;
- Including technology transfer discussions at the beginning of industry-university collaborations;
- Revising the Bayh-Dole Act to improve the incentives for commercialization;
- Utilizing open IP collaboration agreements between multiple companies and universities, similar to what has been established for certain information technologies;

26 Wadhwa, Vivek and Litan, Robert. "Turning Research Into Invention and Jobs." *BusinessWeek*. September 20, 2009.

27 World Intellectual Property Organization. *World Intellectual Property Indicators*. September 2009.

Figure 21. Patents Granted Globally, 1997-2007
Source: WIPO



- Encouraging universities to pool their IP portfolios with other universities globally, enabling faster bundling and more commercialization opportunities as firms can locate relevant IP through fewer portals; and
- Closing the gap between the time it takes to aggregate multiple patents that go into a product and to react to increasingly short product cycles.

Public-Private Sector Collaboration

Another element of the 21st century collaboratory will be how governments partner more effectively with industry and academia to achieve their missions. Participants in TLSI Dialogue 1 suggested:

- Organizing more resources around grand challenges and creating a national research agenda;
- Communicating government operational requirements in a more detailed way;
- Sharing information on market potential to entice more private sector participation;
- Moving from acquisition to commercialization relationships where agency personnel take a more active role in technology development; and
- Leveraging national and defense labs more effectively for commercialization by enabling more flexible contracting mechanisms and enabling capital to flow between labs and potential partners with less risk of double taxation.

The mega projects noted in this report—health care, energy and security—are vast undertakings that expend tremendous resources and require public and private sector leaders to work together. Harnessing the potential of innovation more effectively to meet these challenges would constitute an enormous step forward for Americans' quality of life and their economic future.

Risk/Reward Continuum

Boosting Risk Tolerance

A hallmark of the U.S. innovation ecosystem that other countries seek to emulate is its ability and willingness to take risks. Risk taking and entrepreneurship that introduces new products and services has many dimensions and players, from small startup firms, to angel investors and venture firms, to larger firms making long-term investment bets and merger and acquisition choices.

Although the U.S. system tends to fare well in international comparisons of risk taking, few observers and practitioners in the system believe that it operates efficiently or is heading in the right direction. In addition to the IP and tech transfer hurdles, TLSI participants discussed how firms might be incentivized to engage in more long-term research, perhaps through tax incentives.

TLSI Dialogue 1 also noted that venture firms are investing a smaller share of their resources in early-stage innovations, that mergers and acquisitions are down in number and value, and that the market for initial public offerings has largely dried up.

The value of reinvigorating the risk-reward continuum is substantial, as evidenced by the impact of venture-backed firms that have now matured. Venture-backed firms account for large shares of the employment and revenue generated by some of America's most dynamic sectors (figure 22). Venture-backed firms account for 81 percent of the jobs in software and 74 percent of the employment in telecommunications and semiconductors. Venture-backed firms also account for 67 percent of the revenue in electronics, 55 percent in semiconductors and 51 percent in telecommunications.

Mitigating Liability that Hinders Innovation

Liability remains a significant barrier to introducing new technologies. Experts in TLSI Dialogue 1 noted the negative impact on the pharmaceutical and aerospace industries. In many cases, firms decline to pursue technologies when they perceive the liability risks to be too high.

A recent report by the Pacific Research Institute notes that although an efficient tort system is important to promote safety, resolve disputes and build trust among market participants, a poor tort system imposes excessive costs, including foregone production of goods and services:

All of us shoulder the burden of an excessively expensive and inefficient tort liability system through higher prices, lower wages, decreased returns on investments in capital and land, restricted access to health care and less innovation. Businesses that spend more money each year on liability insurance have less money available for research and development or for health benefits for their employees.[28]

The U.S. tort system is the most expensive in the world, costing roughly double the share of GDP of other industrialized nations. In the past 50 years, direct U.S. tort costs have risen more than 100-fold. In contrast, population has not even doubled, and economic output has risen by only 37-fold. As a result, tort costs have become a larger share of our economy.[29]

Tort costs for commercial enterprises are rising even more rapidly than personal tort costs. Personal tort costs grew 3.3 percent annually on average from 1990-2007. In the decade from 1990 to 2000, commercial tort costs grew 4.3 percent annually on average. Between 2000 and 2007, the annual growth rate accelerated to 6.1 percent (figure 23).

28 McQuillan, Lawrence and Abramyan, Hovannes. *U.S. Tort Liability Index*. Pacific Research Institute.2008.

29 Ibid.

Figure 22. Impact of Venture-Backed Companies
Source: National Venture Capital Association

Venture-Backed Company Employment as a Percentage of Total Industry Employment
Top Five Industry Sectors, 2008

Industry	Venture-Backed Employment	Total Employment	Venture-Backed Companies Share of Employment
Software	817,166	1,008,929	80.99%
Telecommunications	736,961	994,862	74.08%
Semiconductors	309,437	418,998	73.85%
Networking and Equipment	392,505	668,058	58.75%
Electronics/Instrumentation	271,224	528,148	51.35%

Venture-Backed Company Revenue as a Percentage of Industry Revenue
Top Five Industy Sectors, 2008

Industry	Venture-Backed Revenue (Millions)	Total Sector Revenue (Millions)	Venture-Backed Companies Share of Revenue
Electronics/Instrumentation	$129,597	$193,427	67.00%
Semiconductors	86,776	157,660	55.04%
Telecommunications	256,136	501,729	51.05%
Biotechnology	209,358	444,028	47.15%
Computers and Peripherals	315,054	711,331	44.29%

Figure 23. Personal vs. Commercial U.S. Tort Costs
Source: Towers Perrin. 2008 Update on U.S. Tort Cost Trends

Year	Personal Tort Costs (Billions)	Commercial Tort Costs (Billions)
1990	52.0	78.2
1991	53.4	78.2
1992	56.4	83.8
1993	57.3	85.9
1994	60.1	87.8
1995	61.5	96.9
1996	62.7	91.9
1997	63.4	90.4
1998	66.3	98.9
1999	68.2	99.9
2000	72.3	106.8
2001	76.8	128.6
2002	80.0	152.9
2003	84.2	161.5
2004	86.8	173.9
2005	88.5	172.9
2006	87.4	159.5
2007	90.8	161.2
Average Annual Change		
Since 1990	3.3%	4.3%
Since 2000	3.3%	6.1%

Patent litigation is a component of tort law that has a particularly direct impact on innovation and commercialization. Patent law protects inventors from infringement of their right to fair compensation for their ideas. The complexity of modern technology innovation means, however, that it often draws on many ideas, creating a thicket of competing patent claims and costly litigation and/or negotiation in order to commercialize new products and services.

Patent reform measures in the past three Congresses have been proposed to address abuses, streamline procedures and reduce litigation costs, but enactment remains unsure as opposing entities have raised concerns that the reforms would erode patent protection.

Looking at data on U.S. patent litigation, there has been a steady rise in cases, but that rise has roughly paralleled the growth of patents granted (figure 24). The annual median damages awarded in patent cases has remained fairly consistent since 1995, when adjusted for inflation.[30] This means that although patent litigation may create costs and delays that are less than optimal for commercialization and worthy of reform, those costs are holding fairly constant over time rather than growing.

Technology Frontiers

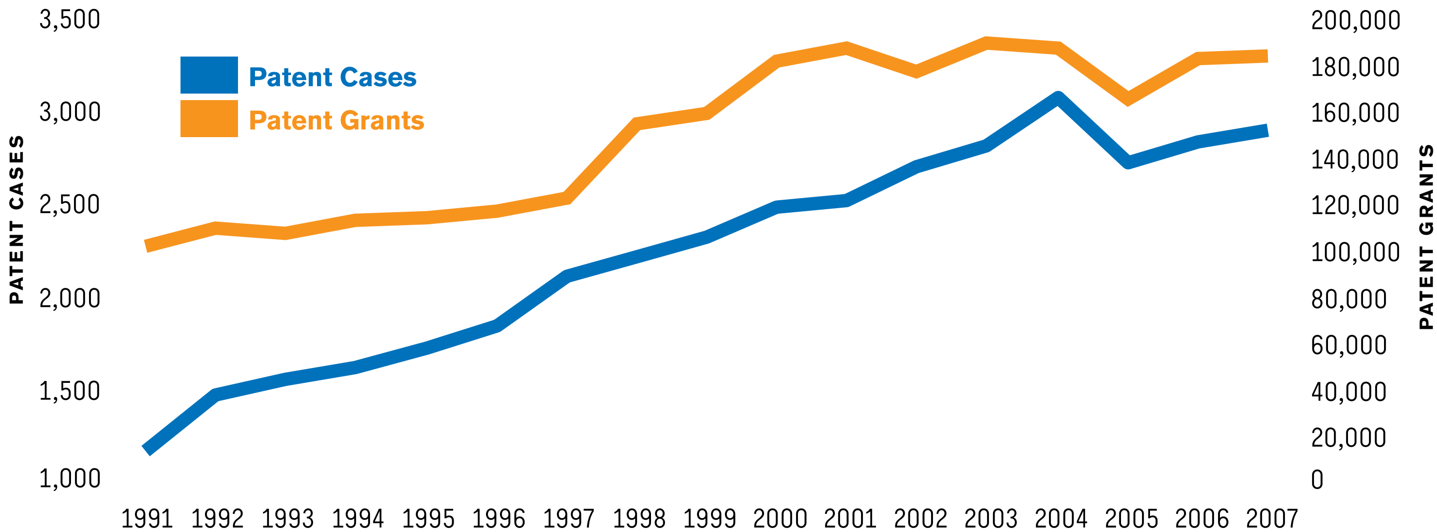
The Council on Competitiveness 2009 survey of chief technology officers asked TLSI members—and thousands of other R&D and technology leaders across the country—to identify the most important emerging and interdisciplinary fields. Nanotechnology was named most frequently, followed by biotechnology/bioengineering. Materials research, which draws on nanotechnology and biotechnology, also was cited many times. Other popular fields included (1) software

30 Levko, Aron; Torres, Vincent; and Teelucksingh, Joseph. *A Closer Look, 2008 Patent Litigation Study: Damages Awards, Success Rates, and Time-to-Trial.* PricewaterhouseCoopers. 2008.

Figure 24. Comparing Patent Cases to Patents Granted

Compiled by PricewaterhouseCoopers—*A Closer Look: 2008 Patent Litigation Study*

Sources: U.S. Patent and Trademark Office: *Performance and Accountability Report*, and U.S. Courts: *Judicial Facts and Figures*



Note: Years are based on September year-end.

for systems and knowledge management, including service-oriented architectures; (2) alternative energy development; and (3) health-related fields.

Of these frontier areas, the U.S. federal government has probably best coordinated its actions around nanotechnology through the National Nanotechnology Initiative (NNI). The NNI helps coordinate the activities of 25 agencies, 13 of which have research budgets. The proposed FY 2010 budget for nanotechnology research totals $1.64 billion, an increase from FY 2009 after subtracting $117 million in Congressional defense earmarks (figure 25).

TLSI Dialogue 1 did not include extensive conversations on technology frontiers and how government, industry and academia might work together more effectively to promote progress in strategic disciplines. This is topic, therefore, merits further attention.

Benchmarking Innovation Hotspots

Roughly a decade ago, governments began to reconsider innovation and technology as larger factors in the competitiveness of their economies than they had before. An early reflection of that awareness includes the European Union's Lisbon Agenda adopted in 2000 with the goal of making Europe the most dynamic and competitive knowledge-based economy in the world.

Many countries followed suit with similar innovation agendas, including China, South Korea, India, Canada, Australia, Japan and—most notably, the United States via the Council on Competitiveness' National Innovation Initiative (NII). Equally important, innovation has assumed a more central role in the economic development strategies of provincial and local governments all over the world. Virginia's competition might come more from Mumbai than

Figure 25. Federal Nanotechnology Investment
Source: National Nanotechnology Initiative

National Nanotechnology Initiative Budget 2008-2010 (dollars in millions)				
	FY 2008 Actual	FY 2009 Estimate	FY 2009 Recovery Act	FY 2010 Proposed
Defense	460	464		379
NSF	409	397	108	423
Energy	245	337	25	351
HHS (NIH)	305	311		326
Commerce (NIST)	86	87	7	91
NASA	17	17		17
EPA	12	16		18
HHS (NIOSH)	7	7		12
USDA (FS)	5	5		5
USDA (CSREES)	6	3		3
Justice	0	0		0
Homeland Security	3	9		12
Transportation (FHWA)	1	3		3
TOTALS	**1,554**	**1,657**	**140**	**1,640**

Maryland, as leaders strive in many places to build their own versions of Silicon Valley. Most regional innovation efforts try to develop and attract talent, encourage investment and build strategic infrastructure. They often seek greater collaboration between universities, technology companies, venture firms and government.

In 2007 the National Governors Association surveyed the 50 states to examine what actions each was taking to foster productive innovation.[31] The final report suggests six steps to get results:

- Develop a statewide research and innovation strategy that not only puts in place all the components for innovation, but also aligns them in ways that provide advantages to in-state companies;
- Make investments to gain talent, build top notch research enterprises and compete for federal dollars in those focused areas where the state can be world-class;
- Encourage, even mandate, collaboration among universities, the private sector and other institutions;
- Put world-class professionals, not political pals, in key positions;
- Create an organization and consistent funding source that facilitates a continuity in R&D partnering and spending; and
- Hold the recipients of public investments accountable for delivering on promised benefits.

Public and private sector leaders, however, struggle to manage what they can not very well measure. Measuring innovation inputs and outputs and making causal linkages is still a nascent science. In fact, there are few tools to measure and map where innovation is flourishing in what fields. For the United States to maintain its competitive advantage and to avoid technological surprises in the national security arena, it must do a better job to map innovation globally and continually.

When the United States was the undisputed global leader across the spectrum of frontier research and technologies, metrics were not so important. Today, the frontiers of technology are truly global, but the tools to assess technology leadership are only beginning to be applied. Researchers are only beginning to turn the tools of science on itself—to examine the problem of scientific and technological leadership more scientifically, using America's leadership in high performance computing and visualization. The TLSI could help accelerate that process by developing a framework to benchmark the elements of technological advantage, including the role that collaboration plays in innovation leadership around the world.

Review of Recent Studies and Metrics

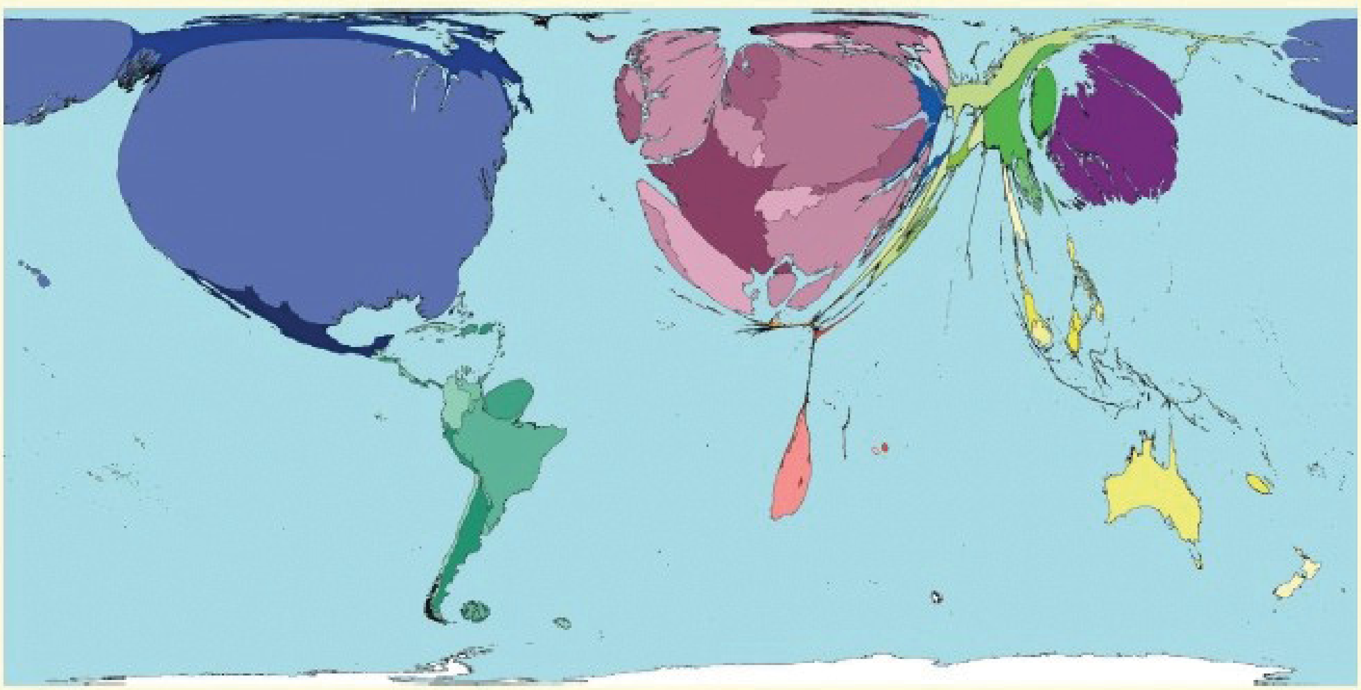
A number of online tools have been established that break down various indices on a global map, including indices relevant to innovation. One of the earlier efforts was Worldmapper, constructed by the Social and Spatial Inequalities Group at the University of Sheffield and Mark Newman at the University of Michigan. Worldmapper resizes nations based on their rank on a particular metric, including R&D per

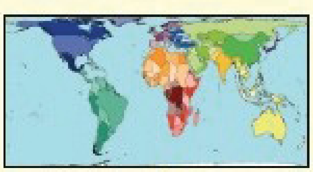
31 National Governors Association and the Pew Center on the States. *Innovation America: Investing in Innovation*. 2007.

capita, R&D expenditure or even female managers (figure 26)—a potential indicator for how well a nation benefits from all of its talent.

The management and consulting firm McKinsey and Company has been involved in two graphic presentations of global innovation. McKinsey produced an interactive scatter plot of innovation clusters based on U.S. patents earned, patent growth and the diversity of patents (figure 27). The analysis covers data from 1997–2006, but is limited by its reliance on patent data to measure innovation.

Figure 26. Worldmapper





Land area

Technical notes

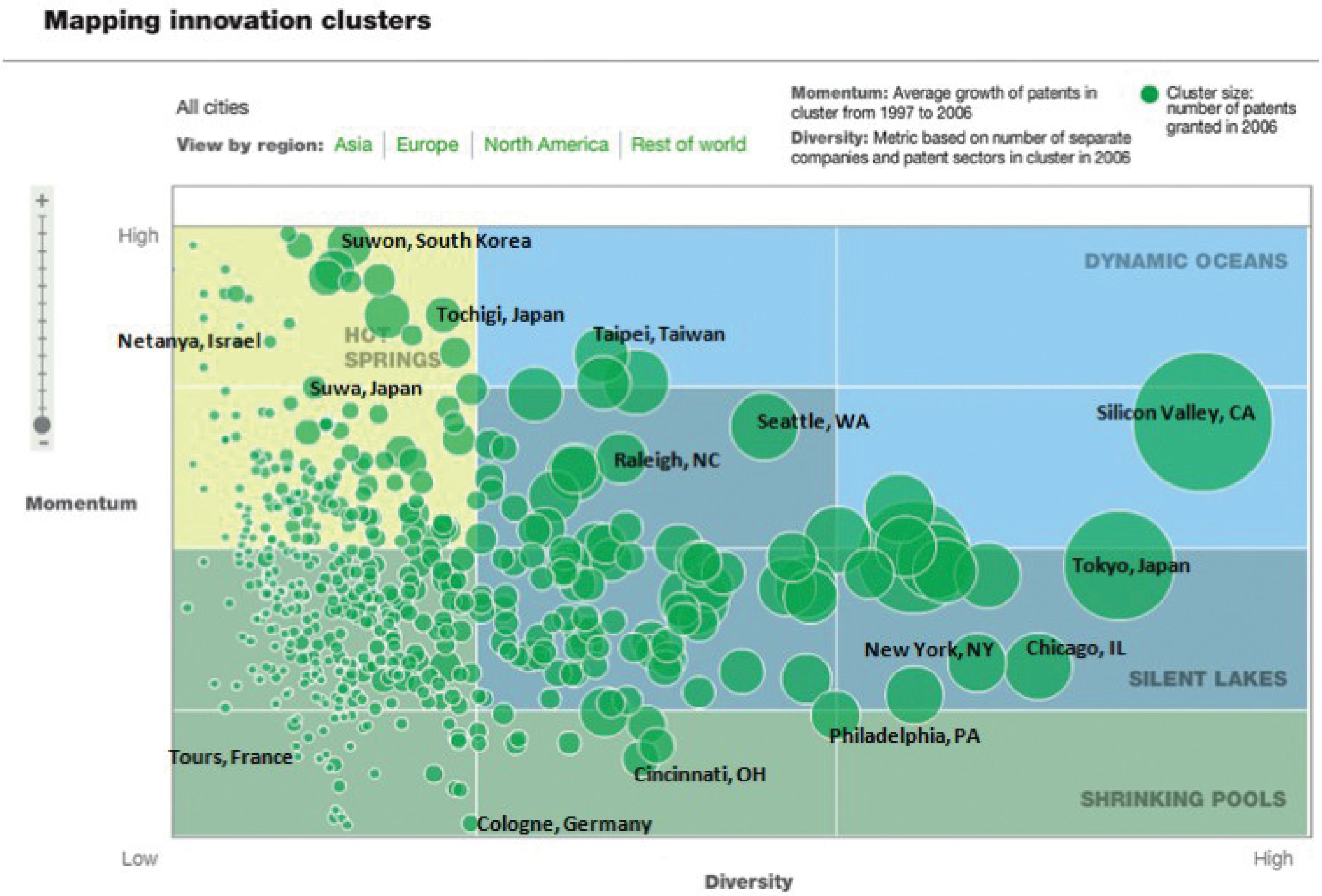
- Data are from the United Nations Development Programme's Human Development Report, 2004.
- *There were almost no female managers in 44 territories.
- See website for further information.

MOST AND FEWEST FEMALE MANAGERS AND PROFESSIONALS

Rank	Territory	Value	Rank	Territory	Value
1	Luxembourg	32	147	Egypt	0.00235
2	Norway	20	148	Indonesia	0.00222
3	United States	20	149	Georgia	0.00203
4	Ireland	17	150	Sierra Leone	0.00193
5	Greenland	15	151	Bosnia Herzegovina	0.00158
6	Canada	14	152	Albania	0.00134
7	Australia	14	153	Cote d'Ivoire	0.00133
8	Denmark	13	154	Mauritania	0.00127
9	Iceland	12	155	Gambia	0.00123
10	Switzerland	12	156	Sudan	0.00108

*female managers as a percentage of population**

Figure 27. Cluster Analysis—Selected Locations Indicated



In 2008, the World Economic Forum (WEF) unveiled the Innovation Heat Map, a much more ambitious project on which the Forum partnered with McKinsey to create a tool that maps innovation at the country and city level based on many variables (more than 700 metrics at the country level). Figure 28, for example, compares the amount of venture capital invested in biotechnology. The variables fall under categories such as business environment, demand, government, human capital, infrastructure and output. The heat map is publicly available at http://www.weforumihm.org and represents some of the most detailed mapping information on innovation to date.

In 2009, the OECD rolled out the latest version of a new tool, OECD eXplorer, which produces maps and scatter plots based on regional data. Data sets include metrics on education, research and development, patents and labor productivity. The OECD partnered with National Centre for Visual Analytics at Linköping University, Sweden, to produce the tool which also offers options to add your own data, view trend lines and insert narrative information.

Figures 29 and 30 illustrate the mapping function of OECD eXplorer, displaying state rankings on U.S. students enrolled in higher education and European rankings at the provincial level for patent applications per million people. OECD eXplorer is available at http://stats.oecd.org/OECDregionalstatistics.

A final tool that has been developed recently is an intranet mapping capability to help World Bank employees discover innovations around the world and discuss them. The tool is for internal purposes but suggests what might be possible for other organizations or a public web-based version. It was developed on open source collaboration software known as Open Atrium and a few web shots are available that give a glimpse of the interface (figure 31).

Collectively, the innovation mapping tools to date seem more limited by the data available for input than the tools themselves. Even with very sophisticated tools like the WEF Heat Map and the OECD eXplorer, one could not submit an inquiry on where the hottest clusters are for laser technology and get a graphic representation, list of locations and comparative data.

Figure 28. World Economic Forum Innovation Heat Map

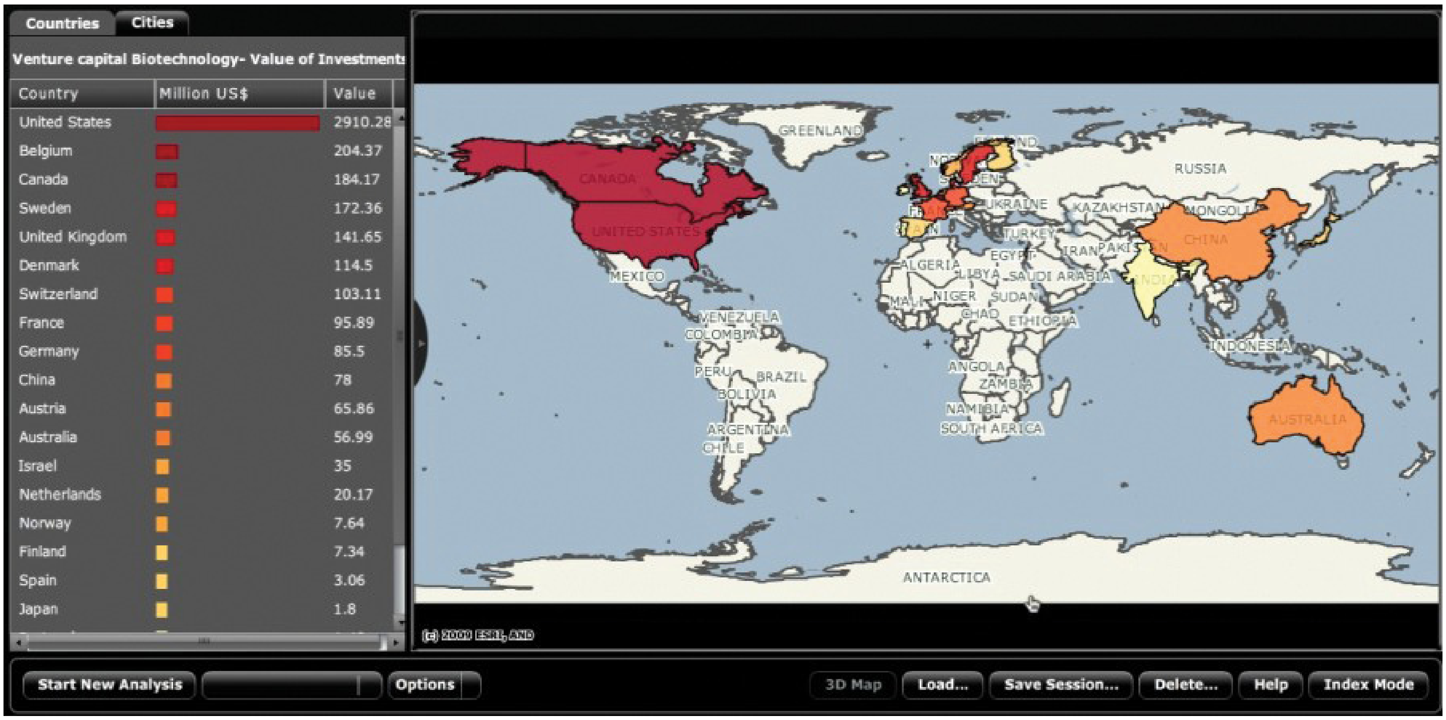


Figure 29. OECD eXplorer, Student Tertiary Level—United States and Canada

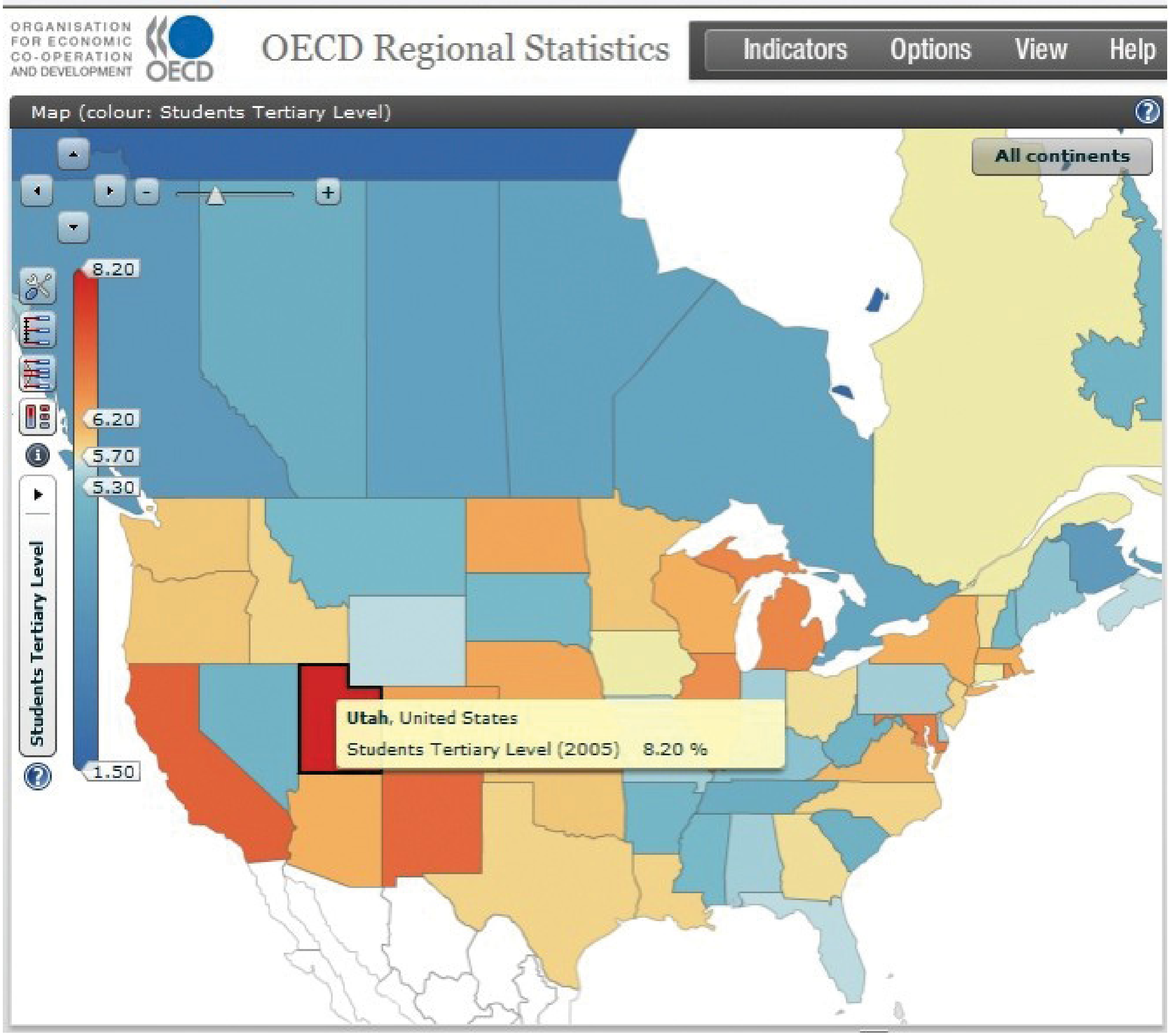


Figure 30. OECD eXplorer, Patent Applications—Europe

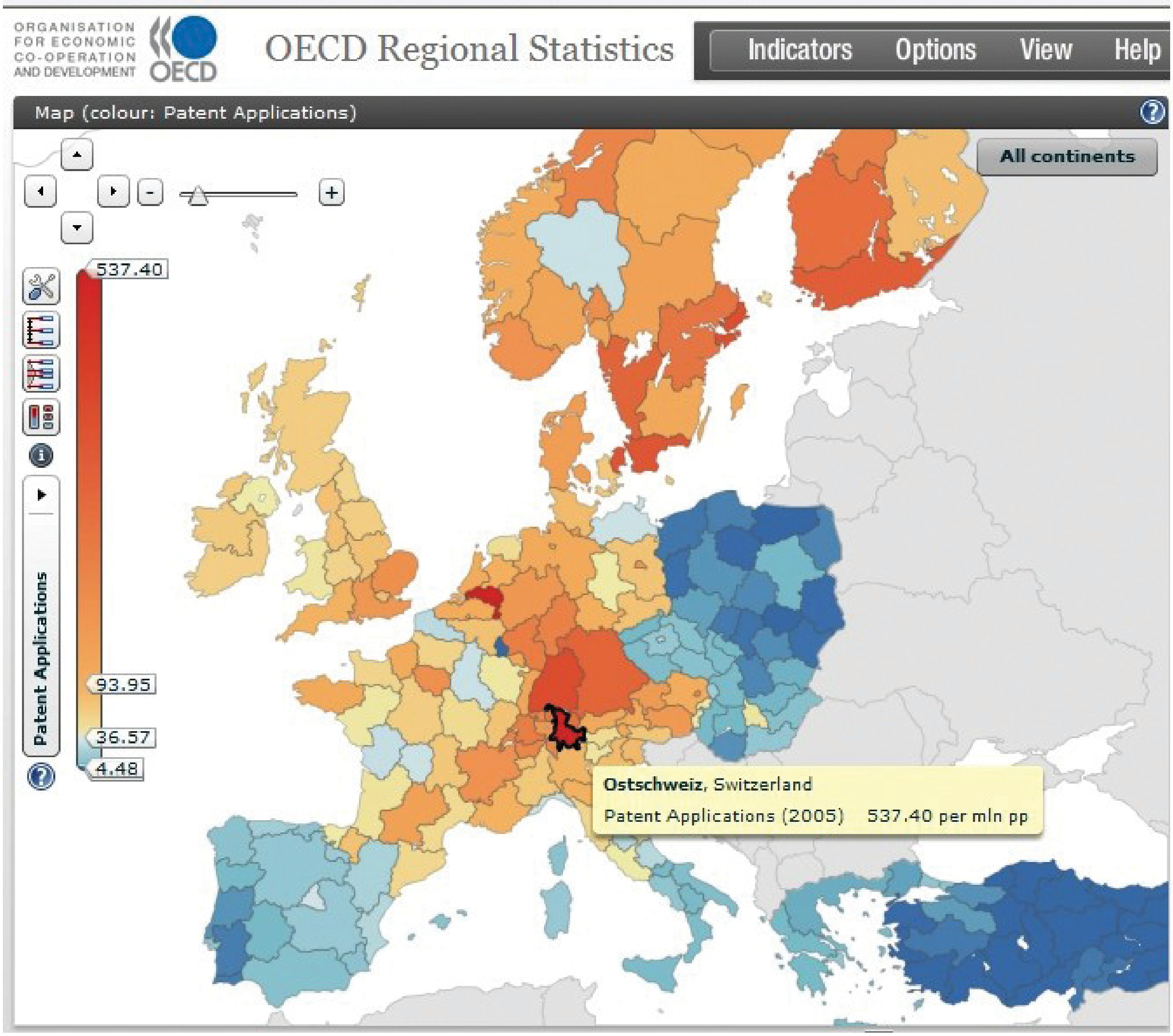
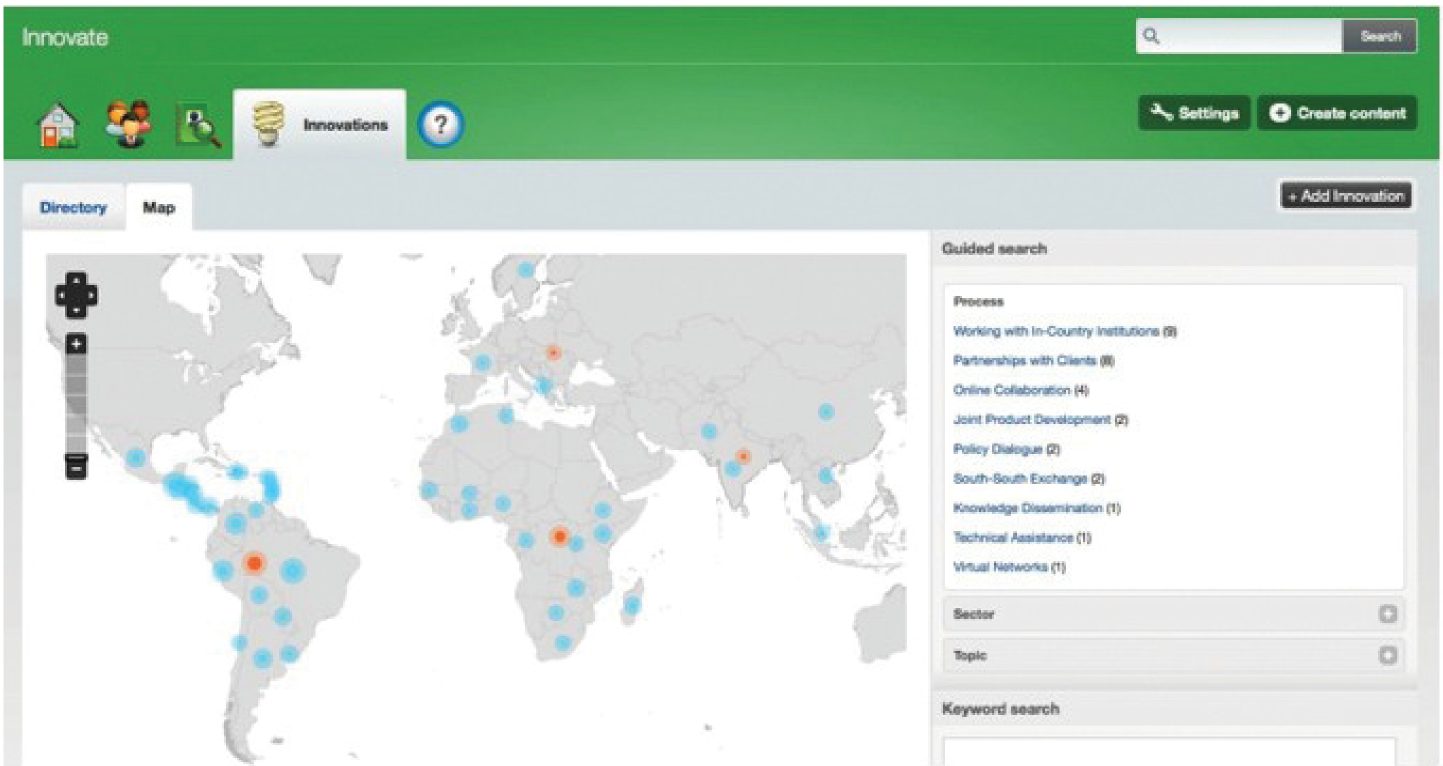


Figure 31. World Bank Open Atrium Innovate Intranet



PART 1: SETTING THE STAGE FOR TLSI DIALOGUE 2

Conclusion

The purpose of this report is to offer TLSI participants a more robust empirical background on the issues of the dialogue, so that those issues can be accurately framed and their proposed solutions aligned with current conditions. The number and complexity of the issues, however, are such that many reports have been devoted to virtually every issue, requiring that the TLSI cull out the most salient points that are relevant to its objectives.

TLSI Dialogue 1 was a successful exchange between many of America's leading technologists who produced a wealth of ideas on how the United States can address its shortcomings and become more adept at productive innovation in a changing global landscape. As the TLSI enters its second Dialogue, the Council anticipates that these ideas will be gradually honed into priority recommendations with a strategy to implement them.

Part 2:
Findings from
TLSI Dialogue 2

PART 2: FINDINGS FROM TLSI DIALOGUE 2

Opening Remarks

Deborah L. Wince Smith, president of the Council on Competitiveness, welcomed participants to TLSI Dialogue 2 and thanked co-chairs, Ray Johnson of Lockheed Martin and Mark Little of General Electric.

Wince-Smith framed the initiative in historical context, noting the Council's leadership since the early 1990s on technology and innovation issues and highlighting key Council reports and initiatives that paved the way for the TLSI. She expressed pleasure that the TLSI is a public-private partnership, noting support from the Department of Defense and the Department of Homeland Security, as well as participation in the second dialogue by Chris Scolese, NASA associate administrator.

"We're trying to create a new paradigm for collaboration between the public and private sectors to optimize our investments in research, talent and technology," Smith said.

Wince-Smith also linked the work of the TLSI to recent and current Council initiatives, including the September 2009 National Summit on Energy Security, Innovation and Sustainability. "We released a comprehensive agenda for energy transformation and sustainability," Smith stated. "Innovation will drive that agenda and is at the heart of our competitiveness agenda."

The Council's longstanding work in high performance computing (HPC) also compliments the TLSI, as will a new initiative to be launched on 21st century manufacturing. Finally, Wince-Smith and then Council Chairman Charles O. Holliday, Jr., chairman and CEO of DuPont, have been working to create a network of competitiveness councils worldwide to understand best practices and stay abreast of government policies and private sector actions across the globe. A first meeting in September brought together the leaders from these councils.

Little, senior vice president and director of global research for the General Electric Company, opened the dialogue for the co-chairs. He thanked the participants and noted the importance of the subjects before the TLSI. "Even as we go through the ups and downs of the business cycle, the need for innovation and technology leadership has never changed, and our role is to think together how our country and our world can become more competitive and to drive innovation faster."

Johnson, senior vice president and chief technology officer for the Lockheed Martin Corporation, praised the progress made by the TLSI and the job done by the Council to capture and advance the substance and sentiment of the dialogue. Johnson asserted that the competitive environment faced by the United States today is unique historically. As an example, he noted China's strategic engagement with Africa, which includes a recent offer of $10 billion in development loans.

Johnson discussed the importance of innovation to increase efficiency and affordability so that resources devoted by companies, governments or individuals result in greater productivity—or in an environment of constrained resources, societies can still generate high levels of production.

Chad Evans, Council on Competitiveness; Mark Little, General Electric Company; Chris Scolese, NASA; Ray Johnson, Lockheed Martin Corporation; Deborah L. Wince-Smith, Council on Competitiveness.

Innovation for affordability also is important to compete globally, Johnson said. He relayed how competing in emerging markets like India (or competing globally with firms from emerging markets) requires innovation that makes products and services affordable and of equal value to those available in developed countries. He voiced concern that U.S. engineers are being taught to think about performance without adequate regard for affordability, whereas U.S. competitors consider affordability aggressively out of necessity. Johnson also set the stage for a discussion on commercialization by noting the importance of innovation that makes incremental changes to a product or innovation in operations, tactics, techniques and procedures.

PART 2: FINDINGS FROM TLSI DIALOGUE 2

New Directions: Picking Up the Pace of Commercialization and Value Creation

Discussion Leaders
Steven Ashby, Thomas Cellucci, Andrew Garman, and John Langford

Steven Ashby, deputy director for science and technology at the Pacific Northwest National Laboratory, shared his thoughts about accelerating the pace of innovation and commercialization. He recalled how TLSI Dialogue 1 asserted that better public-private partnerships are needed to both accelerate innovation and to address national and global challenges.

Ashby reviewed how Secretary of Energy Steven Chu introduced the notion of energy innovation hubs as a mechanism to bring together national labs, industry and academia in one place to focus on some of the most pressing problems. Department of Energy (DOE) chief research officers from 17 national labs are working on such a model to offer the labs as collaborative test beds for making progress on major challenges.

Ashby reviewed three essential elements to building a 21st century collaboratory:

- Ensure a shared sense of purpose with clear, expected outcomes;
- Enhance tech transfer mechanisms to facilitate interactions between the public and private sectors; and
- Share intellectual capital and property across institutional boundaries.

Steven Ashby, Pacific Northwest National Laboratory; Mark Peters, Argonne National Laboratory; Harold Morgan, Sandia National Laboratories.

"I want to put forward a model for commercialization and technology deployment that combines the first two elements. I endorse the TLSI assertion that we need to do a better job of involving intellectual property (IP) capture and technology transfer team members as integral members of the overall research enterprise and as key members of any successful collaboratory," Ashby said.

The pace of innovation lags the pace of invention significantly, Ashby said. He cited a study by the World Intellectual Property Organization in the dialogue pre-report that shows an accelerating rate of invention as measured by the number of patents granted globally. He contrasted the rising patent trend with a recent National Academies' report estimating that only 0.1 percent of all funded basic research results in a commercial venture.

One reason for the disconnect, Ashby stated, is outdated and inherently unscalable tech transfer operations at research universities. "The failure of tech transfer extends to the national laboratories. One of the problems we have that is an artificial separation between our research teams and our technology transfer offices. Today, including in our laboratory, many tech transfer offices rely more on serendipity than strategy for success in commercialization.

"In most laboratories, an R&D agenda is carefully formulated. We identify problems to tackle, get our researchers together, and develop an agenda. We engage the tech transfer people downstream rather than up front, so they typically work independently and sequentially. Somewhere along the line, the tech transfer folks find out about a research invention, usually through in-house review processes, and often after the invention's been made."

Ashby would like to do a better job of aligning and integrating research and tech teams from the beginning. He described an experiment in which the Pacific Northwest Lab is trying to focus the tech transfer team from the beginning on the shared outcome goal noted as a key collaboratory element. "We not only need to do this in-house," Ashby asserted. "We also must engage external actors across various sectors."

Ashby illustrated the benefits of involving the tech transfer function up front through a pilot research initiative around carbon capture and sequestration. "We had our tech transfer people involved early on and formed an IP capture team that helped survey the landscape to make sure we invest our research dollars in areas that wouldn't lead to intellectual property already owned by others. We made an effort to figure out the right commercialization partners up front so we could engage them in the research. Although still a pilot program, the results are encouraging."

Ashby also talked about the need for seamless execution, describing user facilities at DOE where people can access lab resources. To do that, one has to sign a user agreement. "The nice thing about these user agreements, unlike tech transfer at the labs, is that typically something is negotiated up front that is common across all institutions. Users generally have a clear idea of what they need to do to access those resources. We need to apply these user agreements to tech transfer across the country, within the DOE national laboratories and federal laboratories more broadly."

TLSI Dialogue 1, Ashby noted, described the labs as having a lot to offer but also as difficult with which to interact. Participants talked about clumsy mechanisms that were slow and did not allow the labs to interact with industry on their terms.

Thomas Cellucci
Chief Commercialization Officer
Department of Homeland Security

I'd like to share what we're doing at the Department of Homeland Security (DHS). When I joined the Department a little less than two years ago, it quickly became clear that the Department was not articulating its requirements or needs very well. Although I didn't set out to write books, we just finished publishing our sixth to address that problem. I'm sharing with you today what we call the product realization chart. It is the end product of a conversation I had with then Secretary Chertoff, asking why the Department spends so much time and money developing technologies that probably exist in the private sector.

We are creating public private partnerships based on a simple hypothesis. I believed that the private sector, the national labs, and the universities would be ready, willing and able to work with us if we gave them two things: (1) detailed operational requirements that articulate exactly what we need and (2) a conservative estimate of the potential market value. I am both proud and a little embarrassed to say that within the next year the commercialization office will have produced over forty three products and services. That's more than the whole Science and Technology Directorate since its inception in 2001.

Consistent with Ray's comments about innovating for affordability, performance price ratios are very important. We buy products from China, Israel, and many other countries. Competition has never been tougher in terms of people trying to get business

Harold Morgan, Sandia National Laboratories; Thomas Cellucci, Department of Homeland Security; Caroline Greenwood, Department of Homeland Security; and Thomas Halbouty, Pioneer Natural Resources Company.

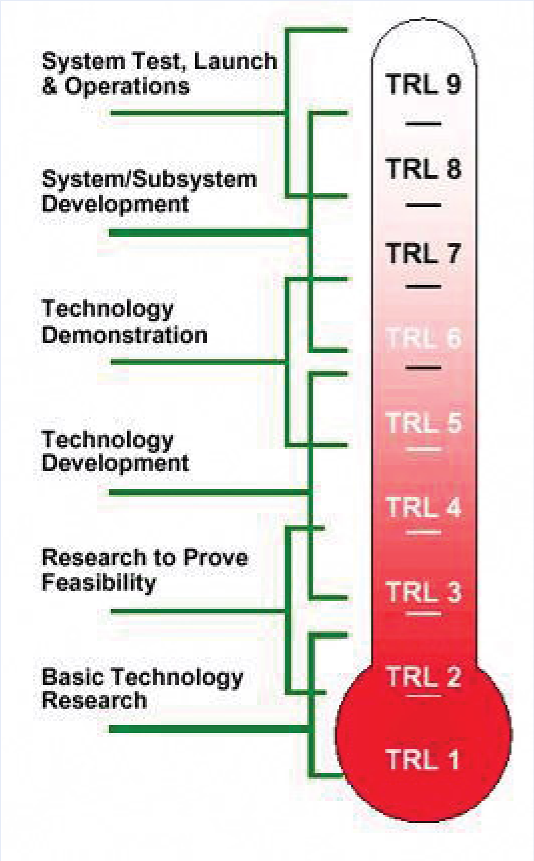
with the department. Yet working with universities and national labs, we've found that many people have never been trained in commercialization. The University of Texas has one of the few programs related to commercialization, a Masters of Technology Commercialization. I know of no other school doing that. Most of the students already have MBA's or MD's, but they had never been taught about commercialization.

The product realization chart that we've developed shouldn't be new to many of you, particular those in government. We took the technology readiness levels (TRLs) that were developed in the eighties by NASA and tweaked in the nineties by DOD, but we added language on deliverables that the private sector could understand. This has been very, very helpful.

Next month, private firms will release two products that are analogous to black boxes for subways, buses, and trains. The price point is two hundred dollars or less. It's pretty rare to see a product come out at two hundred dollars or less that the government would have designed and made. When the university community, the national labs, and people in aerospace and defense with independent research and development (IRAD) money saw this, they said, "what about us?" DHS is not in the business to commercialize technology so we introduced the Future Tech program.

In Future Tech, the objective is to certify a TRL 6 technology that can then be used in either an acquisition or commercialization program. We are inundated in a good way with companies doing this and it saves tax payers a tremendous amount of money. Aneesh Chopra and the President are now challenging us to spread these programs across the government.

Anything we can do in terms of efficiency in the federal government is well received these days. We are working with partners to release products, services, and now technologies. It's a certification program. So even if we didn't have these large available markets, many companies and groups would work with us just to get that certification seal. It's worth something. In many ways it's like the good housekeeping seal of approval. If you look on DHS.gov, look up commercialization. You'll see the articles, books and other tools we have developed that are working very well.



Source: U.S. Department of Homeland Security, 2009.

"The new administration is open to changing the game, and since the first dialogue, there has been a white paper at a fairly high level circulated to Daniel B. Poneman, DOE deputy secretary, at his request. The laboratories have been engaged with the national laboratory contractors working group on a variety of problems at a detailed level. Tech transfer is an element of one four major recommendations. There's a detailed proposal that sought input from industry, and I think has an opportunity to change how we do tech transfer, moving toward seamless execution."

Ashby completed his remarks by requesting that the TLSI examine the mechanisms for collaborating with the national labs and offer feedback on these ideas. Participants agreed to form a working group for this purpose.

Brendan Godfrey, Department of Defense; Melvin Bernstein, University of Maryland; and Andrew Garman, New Venture Partners LLC.

Andrew Garman, founder and managing partner of New Venture Partners LLC, noted that he and Thomas Cellucci, chief commercialization officer of the Department of Homeland Security, have worked together to launch 60 or 70 ventures during the last few decades. Most of those ventures spun out from corporations, Garman said, but his comments on commercialization apply broadly across corporations, national labs, nonprofits and universities.

"We were asked to discuss how to increase the pace of commercialization, and I think that's exactly the right question. We've observed over and over again that invention does not necessarily equal success. The winners are the ones who are able to commercialize at the right time."

Garman noted how Westinghouse invented the liquid crystal display in the late 1950s, but did not commercialize it, resulting in no U.S. industry in the fundamental display business that drives the world's TVs and computers. He also offered the example of Xerox inventing most of network personalized computing in the late 1970s, yet few benefits accrued to Xerox shareholders.

"How do you capture value once having made an invention?" Garman asked. "We're familiar with a variety of commercialization models in a corporation, such as technology transfer into a business unit. That happens less frequently than one would like, but there are other models worth looking at. The list includes the licensing model, the joint venture model, the internal business unit model and our favorite of spinning out a new entrepreneurial venture that has the flexibility and the freedom from the parent institution to drive disruptive technologies."

Creating a new venture and bringing in the right entrepreneurial talent, capital and market expertise has been a big driver of job formation in the United States and for commercialization of new technology. At issue, Garman noted, is what many people refer to as the commercialization gap. "There's a gap between what most institutions create and what most capital markets or businesses want. On the one hand, we see the output of labs as a set of bright Ph.D.s, patent applications and some exciting proof of concept. What the venture capital community, corporate investors or strategic investors want is a developed product, customers in tow and a credible management team."

The business of New Venture Partners is to bridge the gap, Garman said, noting that the gap is growing as capital market performance has weakened. "We typically fund between a half million and five million dollars to create a company around a team of technologists, or in certain cases a single technologist, which other people would recognize as an investible entity. That means pushing product development focused on key technical risk items. It means bringing in seasoned entrepreneurs, bringing in trial customers to define applications for the technology, solving the parent's IP issues, and carving out appropriate economics so that the parent institution can benefit and reuse that capital. Where appropriate, we bring in the parent institution as a true commercial partner, but an arm's length partner, to help accelerate the new entity. These steps create a company that mainstream investors can invest in."

Garman described a project at Bell Labs in the late 1990s as an example of a success story. A brilliant inventor there, a Ph.D. of Indian origin, was working to reinvent the design and protocols of mobile networks. At the time, U.S. networks were second generation, but he was already thinking ahead to a fourth generation that would exploit the maximum available bandwidth possible.

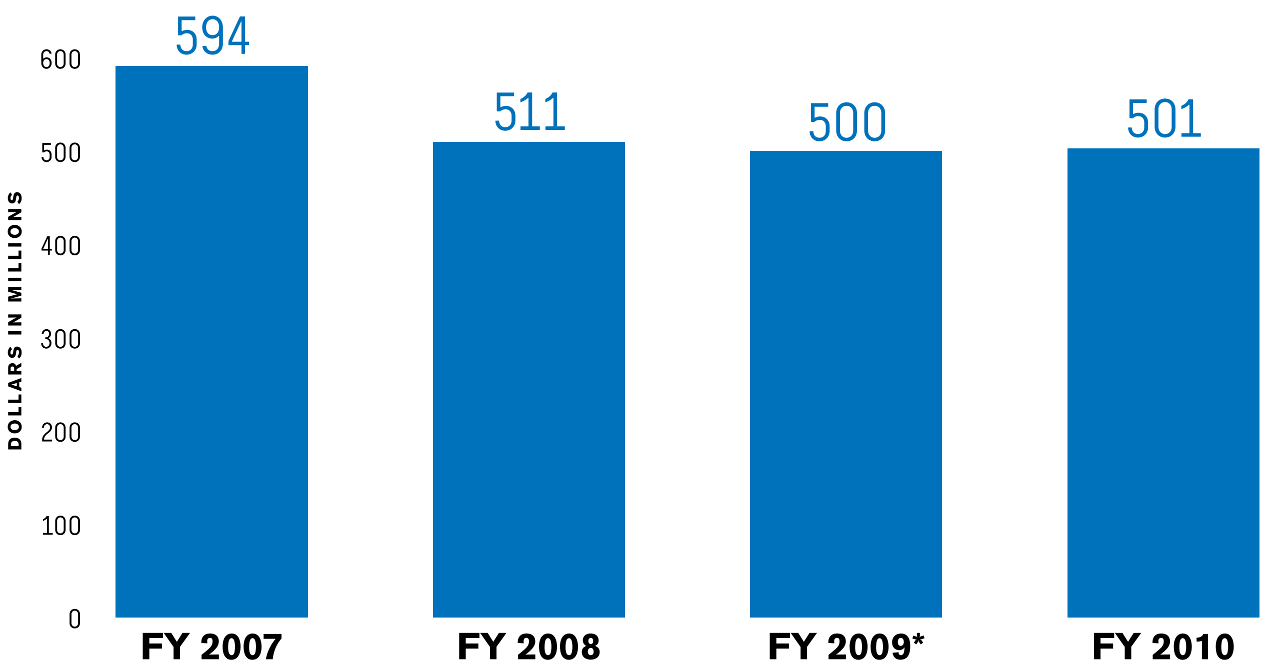
He had a patent application, Garman said, but no interest from the business units of his parent institution. New Venture Partners funded the project and brought in veteran entrepreneurs from the telecom industry to help. A lead customer, one of the major carriers, was willing to co-design the first network with him and ultimately $150 million dollars followed the original investment, both from venture capitalists as well as major corporations. In 2006, the company was sold to QUALCOMM—the second largest venture backed exit deal of the year, and the basis of the fourth generation networks that are just starting to be rolled out in 2010.

Garman concluded by noting that his work is a subset of the larger theme of open innovation raised by Ashby. "We see an accelerating trend toward openness and sharing between corporations, across corporations, across corporations and universities, and within the departments of the universities and labs. Given the complexity of multiple technologies and multiple disciplines required to succeed at the commercialization game, it's absolutely necessary to play this open collaborative game."

John Langford, chairman and president of Aurora Flight Sciences, raised global competitiveness issues in aerospace and robotic aircraft. "Many people might not think that the United States would be in trouble in this field, but I think we are," he stated.

"If you look back to the last century, the United States played a leading role in the development of aviation as we know it. The Wright Brothers, as a private venture, invented the first airplane, but their

Figure 32. NASA Aeronautics Budget



* American Recovery and Reinvestment Act adds an additional $150 million to FY 2009 Aeronautics FY 2010

first paying customer was the U.S. government. Ever since that time, aerospace has been a prime example of a public-private partnership. The government has played many different roles, but the promotion of fundamental research is one of the key areas, starting with the formation of the National Advisory Committee for Aeronautics in 1915."

The United States gained and lost its leadership position several times in the 20th century, Langford noted. International competition emerged, and America responded through leaders who established the programs and the agencies that led to a fairly dominant position in the aeronautics market in the last part of the 20th century.

Langford noted, however, that America's leadership position during the last 25 years has eroded steadily. Part of the decline is due to less support for fundamental research, particularly at NASA.

Historically adjusted, appropriations for NASA's aeronautics budget remain at some of their lowest levels. "This is at a time of emerging competition from foreign entities that have adopted a very long-term perspective relative to our approach in the United States," Langford explained. "Airbus is the obvious example in commercial airliners, but the Brazilians and Canadians have achieved a dominant position in some of the smaller transports. Countries like Italy and Spain are dominant in some of

U.S. Department of Homeland Security: Commercialization Office

Product Realization Chart

DHS S&T Portfolio	**N/A**	**Basic Research**			
Technology Phase	**Needs Assessment**	**Science**			
Technology Readiness Level (TRL)	**N/A**	**TRL 1 – TRL 3**			
Key Objectives	❑Identify S&T capability gaps (mission needs) requiring material solutions. ❑Preliminary operational requirements are developed. ❑Market survey. ❑Technology scan. ❑Assess technology-based solutions to address gaps. ❑Develop rough order-of-magnitude (ROM) estimates of project cost and schedule. ❑Investigate the value proposition of a product idea. ❑Establish technical objectives and milestones. ❑Conduct preliminary IP review. ❑Ensure the qualifications of tools, materials, processes, and suppliers as required. ❑Provide a preliminary production plan. ❑Develop preliminary marketing objectives and milestones. ❑Initiation of Congressional Appropriations Memo, Technology Transition Agreements (TTA), Program Descriptions (Research and Innovations), and Feasibility Studies lead to Program and Budget Execution. ❑List other objectives when defined.	TRL 1 ❑A program sponsor and end-users / customers have been identified. ❑Mission Needs Statement has been developed. ❑Communication with end-users and customers has been initiated. ❑Preliminary operations requirements have been defined. ❑Program Management Vision has been developed. ❑A Feasibility Study White Paper has been developed and accepted. (TRL 1 and 2) ❑A threat, vulnerability, or gap has been identified. ❑Initial risks have been identified. ❑Develop and update the preliminary product plan. ❑List other objectives when defined.	TRL 2 ❑End-user is involved in concept and requirements development. ❑An empirical or theoretical design solution has been identified. ❑Analytical studies to confirm the basic principles of the technology have been developed. ❑Operational requirements analysis has been conducted; Operations requirements are applied to Functional Requirements. (TRL 2 and 3) ❑System concept(s) / architecture have been assessed. ❑Program Risk Assessment has been conducted; Risk Management Plan has been developed. (TRL 2 and 3) ❑Program Cost Analysis has been completed and updated. (TRL 2 and 3) ❑Preliminary Security Assessment has been conducted. ❑Develop a Technology Roadmap. ❑Refine the market assessment and technology scan. ❑List other objectives when defined.	TRL 3 ❑Supplemental and alternate technologies throughout DHS S&T have been surveyed. ❑Technology's physical validity has been proven in laboratory experiments. ❑Program Management Plan (PMP) has been developed. ❑Systems Engineering Management Plan (SEMP) draft. ❑Proof of Concept Plan has been developed. ❑Manufacturing / production strategy has been developed. ❑Develop Quality Control Plan to include standards conformance, reliability testing, etc. ❑Develop Marketing Plan to include market size and research. ❑List other objectives when defined.	TRL 4 ❑All required technology components are integrated for Proof of Concept. ❑Proof of Concept is conducted. ❑IPT has been briefed on progress of the technology's development. ❑The customer has been briefed on the Proof of Concept results. ❑Functional Requirements Document has been finalized. ❑SEMP has been finalized and updated. (TRL 4, 5, and 6) ❑TEMP has been completed and updated. (TRL 4, 5, and 6) ❑Configuration Management Plan exists. ❑PMP has been updated. (TRL 4, 5, and 6) ❑Risk Management Plan is updated. (TRL 4, 5, and 6) ❑Program Cost Analysis is updated. (TRL 4, 5, and 6) ❑Quality Assurance Plan exists. ❑Program Transition Manager is engaged in transition planning. ❑List other objectives when defined.
Key Deliverables	❑Preliminary market assessment and technology scan. ❑Congressional Appropriations Memo, Technology Transition Agreements (TTA), Program Descriptions (Research and Innovations), and Feasibility Studies lead to Program and Budget Execution. ❑Preliminary product plan that assesses features, benefits, and risk. ❑Initial plan for marketing, production, and quality control. ❑List other deliverables when defined.	❑Mission Needs Statement. ❑Feasibility Study. ❑Program Management Vision, or ❑Description of Leap-ahead Capability. ❑Written report of findings and recommendations (preliminary product plan). ❑Feasibility Review meeting. ❑List other deliverables when defined.	❑Preliminary Operations Requirements Document (end-user / customer validation). ❑Program Cost Analysis (updated). (TRL 2 and 3) ❑Program Risk Assessment (technology, schedule, etc.); Risk Management Plan (TRL 2 and 3) ❑Preliminary Security Assessment. ❑Functional Requirements (draft). (TRL 3) ❑Preliminary product plans (approved and ongoing). ❑New Technology roadmaps (approved for further development and implementation). ❑Updated market assessment and technology scan. ❑List other deliverables when defined.	❑Systems Engineering Management Plan (SEMP) draft. ❑Proof of Concept Plan. ❑Program Management Plan (PMP) draft. ❑End-user / Customer Status Review. ❑Detailed product and marketing plan. ❑Quality control plan. ❑Optimization Review meeting. ❑List other deliverables when defined.	❑Proof of Concept Report. ❑Functional Requirements Document. ❑SEMP (TRL 4, 5, and 6) ❑TEMP (TRL 4, 5, and 6) ❑Quality Assurance Plan. ❑PMP (updated). (TRL 4, 5, and 6) ❑Risk Management Plan (updated). (TRL 4, 5, and 6) ❑Program Cost Analysis (updated). (TRL 4, 5, and 6) ❑End–user / Customer Status Review. ❑List other deliverables when defined.
		FutureTECH Program			
Management Review	❑Corporate review meeting of value proposition and product overview. ❑Results and follow up actions.	❑Corporate review meeting of the preliminary product plan. ❑Feasibility Review meeting. ❑Results and follow up actions.	❑Corporate review meeting to approve preliminary product plan and technology roadmap. ❑Results and follow up actions.	❑Optimization Review meeting. ❑Results and follow up actions.	❑Analysis of the engineering and manufacturing plan. ❑Results and follow up actions.

Definition: Commercialization – the process of developing

Innovation and Transition				
Technology Development		**Product Development**		
TRL 4 – TRL 6		**TRL 7 – TRL 9**		
TRL 5 ❑ORD and CONOPS are developed. ❑Security Assessment is updated. ❑OMB 300 and Acquisition Plan have been completed (if required). ❑IPT has certified readiness for the transition of the Technology. ❑Program Transition Manager has assisted in transition documentation development. ❑Technology scan and market survey. (ongoing) ❑Analysis of Alternatives is developed and updated. (TRL 5 and 6) ❑Entry Criteria Checklist is completed and delivered to the TM. ❑PDD has been created, approved, and signed. (TRL 5 and 6) ❑Director has approved the transition. ❑List other objectives when defined.	TRL 6 ❑Germane to both Acquisition and Commercialization ❑ ❑Execute a preliminary Technology Transition Agreement (TTA), or Technology Commercialization Agreement (TCA) as applicable. ❑Program Manager has been identified. ❑Successful T&E in a simulated operational environment has been conducted. ❑End-user / customer has been briefed on the results of T&E. ❑Initial Security Guidelines have been developed. ❑Draft Program Assessment Rating Tool (PART) plan exists, if required. ❑National Environmental Policy Act (NEPA) plan / assessment, if required. ❑Interoperability Assessment. ❑List other objectives when defined.	TRL 7 ❑Germaine to both Acquisition and Commercialization ❑ ❑S&T and the end-user / customer have begun to develop final transition planning document; Transition Plan has been developed. (TRL 7 and 8) ❑Technology has been successfully demonstrated in an operational environment. (TRL 7 and 8) ❑Updates (if required) have been made to the Operation and/or Functional Requirements Document. ❑Risk Management Plan, Program Cost Analysis and PMP have been updated (as needed). ❑Strategic Program Planning (e.g., Balanced Scorecard) has been conducted. ❑Operations and Maintenance Manual has been completed / updated. ❑Security Manual has been developed. ❑Interoperability has been demonstrated. ❑Management Directives (MD) have been reviewed to assure compliance. ❑List other objectives when defined.	TRL 8 ❑Germaine to both Acquisition and Commercialization ❑ ❑Technology components are form, fit, and function compatible with an operational system. ❑Technology production has been addressed and planned by DHS and the end-user / customer. ❑Training Plan has been developed and implemented. (TRL 8 and 9) ❑Operational Test Report has been completed. ❑Limited User Test (LUT) Plan has been developed. ❑List other objectives when defined.	TRL 9 ❑Germaine to both Acquisition and Commercialization ❑ ❑All critical program documentation has been completed. ❑Planning is underway for the integration of the next generation technology into the existing program components. ❑End-user fully demonstrates the technology in CONOPS. ❑Lessons Learned completed. ❑Sustainment Plan is completed. ❑List other objectives when defined.
	Specific to Commercialization ❑Finalize Manufacturing Plan. ❑Finalize engineering documentation. ❑Update Marketing Plan. ❑Develop and implement at test plan for quality control. ❑List other objectives when defined.	Specific to Commercialization ❑IP Protection and Licensing. ❑Prepare sales release package. ❑Verify and update quality control requirements. ❑List other objectives when defined.		Specific to Commercialization ❑Finalize quality plan. ❑Finalize marketing plan. ❑Finalize manufacturing and assembly routines. ❑List other objectives when defined.
❑ORD and CONOPS. ❑Security Assessment (updated). ❑Program Definition Document (PDD). ❑OMB 300 Capital Asset Plan. ❑Acquisition Plan. ❑Entry Criteria Checklist. ❑Analysis of Alternatives. (TRL 5 and 6) ❑List other deliverables when defined.	Germane to both Acquisition and Commercialization ❑Technology Transition Agreement (TTA), or Technology Commercialization Agreement (TCA) as applicable. ❑Initial Security Guidelines. ❑Draft Program Assessment Ration Tool (PART) plan, if required. ❑National Environmental Policy Act (NEPA) initial assessment, if required. ❑Interoperability Assessment. ❑List other objectives when defined.	Germane to both Acquisition and Commercialization ❑Transition Plan (draft). ❑Operational and Functional Requirements Documentation (updated). ❑Risk Management Plan (updated). ❑Program Cost Analysis (updated). ❑PMP (updated). ❑Strategic Program Planning Documentation (if conducted). ❑Operations and Maintenance Manual. ❑Security Manual. ❑Finalized Interoperability Assurance Report. (TRL 7 and 8) ❑Applicable Management Directive (MD), if required. (TRL 7) ❑List other deliverables when defined.	Germane to both Acquisition and Commercialization ❑Limited User Test (LUT) Plan. ❑Deployment or Transition Plan. ❑Training Plan. ❑Operational Test Report. ❑Customer Acceptance Document. ❑Initial Systems-level Metrics Assessment. ❑List other deliverables when defined.	Germane to both Acquisition and Commercialization ❑Customer Feedback. ❑Lessons learned. ❑After-action Review. ❑Sustainment Plan is completed (a. Spiral Development Assessment, b. Preplanned Product Improvement, c. Emerging Threat(s) Assessment, d. Technology Refresh Insertion, e. Quality Assurance / Metrics Report, f. Risk Management Reassessment). ❑List other deliverables when defined.
	Specific to Commercialization ❑Engineering documentation package release and manufacturing plan. ❑Updated marketing plan. ❑Test plan for quality control. ❑Development Phase Review meeting. ❑List other deliverables when defined.	Specific to Commercialization ❑IP Protection and Licensing. ❑Manufacturing and sales plan release package is to be distributed. ❑Pilot Phase Review meeting. ❑List other deliverables when defined.	Specific to Commercialization ❑Demonstrate that a defect–free product can be manufactured on schedule and at a cost consistent with the target price points. ❑List other deliverables when defined.	Specific to Commercialization ❑Finalized product plan sales release package is to be distributed. ❑Sales Release Phase Review meeting. ❑Execution of the acceptance, shipment, and after–sales support of the new product. ❑List other deliverables when defined.
❑Analysis of the engineering and manufacturing plan. ❑Results and follow up actions.	❑Development Phase review meeting. ❑Comprehensive analysis of the engineering and manufacturing plan. ❑Results and follow up actions.	❑Corporate review of the manufacturing release package. ❑Pilot Phase review meeting. ❑Results and follow up actions.	❑Analysis and review of the manufacturing plan. ❑Results and follow up actions.	❑Corporate review of the finalized product plan and sales release package. ❑Sales Release Phase Review meeting.

SECURE Program

DT&E Designation (SAFTEY Act)

Designation (SAFTEY Act)

Certification (SAFTEY Act)

markets and producing and delivering products or services for sale.

Legend: Black Type – Primary Public Sector Blue Type – Primary Private Sector

Brett Lambert, Department of Defense, and John Langford, Aurora Flight Sciences.

the smaller military transports. China is beginning to make its presence known in every sector, including the commercial area, where they've begun work on a 150-seat commercial transport."

In addition to the decline in the fundamental research base for aeronautics, Langford noted the Department of Defense, the largest buyer in the United States, appears to be moving toward inviting foreign competition into U.S. procurement markets as a means of promoting competition in an over consolidated domestic market. "This is an issue with a lot of ramifications, requiring that we determine the responsibilities of different sectors of the U.S. government. In this case, how should the government balance job promotion with fostering competition that serves taxpayers?"

Langford urged U.S. leaders to recognize and focus on the problem. Revitalizing the aeronautics R&D base, particularly at NASA, is on the agenda of many groups. The question is how far beyond basic research should government efforts extend. He praised the DHS chart (see pages 124-125) for summarizing the issue well using the technology readiness level (TRL) scale. There is broad consensus that government should support fundamental research, but less so as it moves into the higher TRL levels. Langford wondered whether the economic events of the last year impact that consensus, and whether the United States should change its approach to technology leadership in aerospace and defense.

"My organization is probably the only small business represented in this discussion today. I believe there are examples of programs in the U.S. government that do a very good job of promoting U.S. technology development down the TRL scale without violating the norms of where the government should go," he said. He cited the Small Business Innovation Research (SBIR) program, NASA's Discovery program, the Air Force Research Laboratory's Advance Composite Cargo Aircraft program, and various programs at DARPA as examples.

Langford concluded by noting that although many small programs are highly competitive, they often struggle to build a constituency large enough to sustain them. The NASA Discovery program may serve as a model to overcome this challenge, linking a series of small programs into a larger omnibus program that many organizations can get behind. Competitors recognize that they may not win one particular project, but that there will be others coming up soon thereafter on which they can bid.

Discussion

Chad Evans, senior vice president at the Council on Competitiveness, identified broad ideas that emerged from conversation under which many issues could be tackled, including closing the commercialization gap, and identifying models used by organizations or regions that are scalable nationally, such as affordability management and open innovation models.

Brendan Godfrey, director of the Air Force Office of Scientific Research, noted that the Air Force is not particularly successful at tech transfer and explained part of the problem as a cultural issue. In an environment of scarce resources, key personnel are rewarded for meeting the milestones of various programs rather than devoting time to developing patents and working with the private sector.

Mark Peters, deputy laboratory director for programs at Argonne National Laboratory, agreed that cultural issues hinder tech transfer at the national laboratories and added the role played by resources. Tech transfer, he noted, is primarily an overhead function that is woefully underfunded.

Cellucci also confirmed differences in culture, stating that government often measures itself in terms of budget and personnel rather than through outcome-based performance metrics. He also commented on the difficulty of working out licensing agreements with universities—a hurdle rarely faced in countries like China—and noted that universities frequently struggle to commercialize because they do not have the resources to patent a technology worldwide.

Johnson raised a larger cultural issue of distrust between key actors. "When it works well," he said, "the public-private-academic relationship is fantastic—in fact, it's almost a specialization of labor between high-risk organizations like DARPA and perhaps a bit lower-risk organizations like the service labs. We have many programs and actors that fulfill different roles. Taken together, the diversity of the system in the United States can be a huge competitive advantage that we need to strengthen."

Pradeep Khosla, dean of Carnegie Mellon University's College of Engineering, urged that TLSI examine U.S. laws that impact the commercialization gap. He noted that technologies coming from universities are made possible by billions of U.S. investment dollars managed under several federal laws. Khosla acknowledged the difficulty of resolving issues of commercialization and technology transfer, but also put forward fundamental questions about whether taxpayers are receiving an adequate return on their investment and whether the fruits of that public investment should be awarded as intellectual property if it hinders commercialization.

Participants put forward many ideas that expanded on the themes raised by the discussion leaders, including:

(a) How the university model of licensing patents slows the pace of commercialization. Many participants confirmed that industry-university collaboration falters most often over IP differences. Some expressed concern that the licensing model is expanding beyond universities, citing venture companies in alternative energy fields seeking to license technology rather than produce it.

Melvin Bernstein, vice president for research at the University of Maryland, and Rick Shangraw, vice president of research and economic affairs at Arizona State University (ASU), offered a different perspective. They asserted that many universities are moving away from strict licensing models. Shangraw described an approach at ASU where in talks with an industry partner, the university does not ask for a short-term payment for the transfer of intellectual property. Instead, the company is asked to estimate what would be fair compensation for the university if the firm enjoyed a large financial gain based on the university property. Shangraw stated that the industry value proposition is usually acceptable to ASU and that negotiations on most such transactions have been shortened from 18 to two months.

(b) Whether patent terms should vary by whether a holder declares their intent to license or produce. An idea was floated that patent applicants would decide whether their intent is to license or produce. Producers would receive the existing 17-year protection and license awardees would receive a shorter term.

(c) Whether more frequent use of government march-in rights would be an appropriate tactic to spur commercialization. Cellucci responded to this question by noting that the government can only march in for government, not commercial, purposes. He explained that agencies prefer not to use this power so as to not scare off partner firms, but retain the right to ensure that missions move forward.

(d) The risk of U.S. leaders forgoing innovation for productivity in favor of maximizing job creation. Tony Tether, distinguished fellow with the Council on Competitiveness and former director of DARPA, shared a concern that U.S. policy might follow a model he encountered in India whereby officials embraced few technologies that drove productivity in favor of those that produced more jobs. His concern is that such an approach could produce a short-term employment gain at the cost of longer-term American competitiveness and a larger number of sustainable jobs.

(e) Whether SBIR awards are adequate to start a company. Cellucci raised a concern that a $100,000 SBIR award is often inadequate to start a company. He described a DHS program under which awards can range between $100,000 and $20 million.

(f) The problem of aging infrastructure. In sectors like energy, there is little capital turnover for U.S. infrastructure that is fully depreciated but still operating—encouraging the use of older, less efficient technology. Participants suggested looking at the tax code or other incentives to create more turnover, which would spur jobs and speed adoption of more efficient and higher capacity infrastructure.

(g) Preventing open innovation from lowering investment levels. Harold Schmitz, the chief science officer of Mars, Incorporated, cautioned that open innovation must not become code for relying on the resources of other partners. "We don't want a scenario where everyone is at the table, but nobody has a budget," he stated.

(h) Defensive patenting by corporations. Many participants supported Khosla's suggestion to examine the Bayh-Dole Act and the larger patent system. One problem noted is that a great deal of patenting by industry is defensive in nature, designed to ward off competition on existing products rather than create pathways to commercialization.

Merle McKenzie, senior advisor to the associate administrator at NASA, closed the discussion by stating that her experience in a university tech transfer office and with a federal agency confirms the differences discussed about cultures, motives and practices.

McKenzie suggested that the Council prepare a document describing various commercialization models, the players and the motivation systems. "It would be particularly useful if TLSI developed accompanying recommendations—a tool kit that spells out each model, explains how it works, lists its benefits and offers examples."

Sandy Baruah, Council on Competitiveness, and Merle McKenzie, NASA.

PART 2: FINDINGS FROM TLSI DIALOGUE 2

Creating the Talent Pool for 21st Century, Tech-Driven Innovation

Discussion Leaders
Melvin Bernstein and Pradeep Khosla

Melvin Bernstein, vice president for research at the University of Maryland, kicked off the conversation by noting that to succeed in today's economy, an educated workforce is necessary but not sufficient. The workforce also has to be tuned in to the challenges of the future.

Bernstein reviewed traditional attempts by universities to adapt to workplace needs from as early a stage as possible. "The University of Maryland, like most universities, works at this problem by engaging in K-12 education. We run summer camps for students and reach out to as diverse a population as possible. We try to popularize the exploits of great scientists and technologists, but I think it's fair to say that the results are mixed. Scientific disciplines often suffer in comparison to competing disciplines."

The University of Maryland is focused on offering an entrepreneurial education whereby undergraduate and graduate students get involved in business plans and investment opportunities. "We're creating degrees in these areas which are of great interest to many students," Bernstein explained.

Bernstein also shared some of the non-traditional efforts that universities undertake to instill a Sputnik-like sense of urgency or national pride that could drive more students into studying science and technology. "At Maryland, we've been in discussions with museums, with the Discovery Channel, with others, trying to reinforce how exciting this field can be. We're also working hard to change our internal

Merle McKenzie, NASA; Brendan Godfrey, Department of Defense; and Melvin Bernstein, University of Maryland.

> What universities do best is prepare the next generation of talent. We want to ensure that we continue to do that in the most effective and progressive way.
>
> **Melvin Bernstein**
> University of Maryland

culture from one that is solely focused on the quality of scholarship to one that also offers opportunity to people interested in taking science results and translating that into technology and commercialization."

Bernstein described a nationwide trend of more faculty hires, known as "professors of the practice," which are non-tenure track positions that enable universities to bring in experienced professionals from industry, government or nonprofits. "In fact, I'm a professor of the practice at Maryland," Bernstein stated. The idea is to introduce new ideas, new talent, new activities and new approaches to benefit students. Many universities also have reformed their tenure and promotion committees to be able to reward individuals coming up through the traditional system.

Universities are challenged to ensure as best they can that there will be job opportunities for the kind of graduates they produce. Universities must anticipate and confer the skills sought by the outside world, be it industry or government, Bernstein noted. Often there is a lag between recognizing a new skill set in demand, developing curriculum and faculty to teach those skills, and producing graduates.

Bernstein also conveyed the challenge and opportunity posed by globalization, noting his institution's relations with China. "As a university and as a state, we've invested in China. We are the home of one of the first research parks that China created outside of China to send their company representatives and students to be educated and trained. China and the Emirates also want to invest in our technology, raising questions of whether this is a good thing for our university and for our country."

"We're now talking about joint education programs that go far beyond the satellite campuses that have existed for a long time," Bernstein continued. "I'm talking about true global education where we merge our educational models. We have, for example, students in Abu Dhabi studying with the Petroleum Institute. They have students coming to our country, sharing this kind of knowledge. It could only be a matter of time before we create shared degrees."

The TLSI has discussed the tensions between innovation and commercialization partners, yet all share the same goals, Bernstein asserted. "We have different cultures, and that's not going to change, but how do we adapt to the needs of the world and to this country to create a talented workforce that meets the expectations of the world outside universities? How do we do it without compromising quality and the core mission of universities? What universities do best is prepare the next generation of talent. We want to ensure that we continue to do that in the most effective and progressive way."

Pradeep Khosla
Dean
Carnegie Mellon University, College of Engineering

"Let me take a different tack to address these issues. If you look at the history of this country, post-World War II until today, we have seen the largest creation of wealth that mankind has ever seen in a sixty year period. That wealth generation has been driven and absorbed mainly by the United States.

If that's the case, why did India and China wake up? Basically what happened is that, starting like 1990's when the IT industry became hot and the barrier to entry was literally zero, we saw unprecedented foreign investment and creation of wealth in India and China. I'm taking these two giants as examples.

Wealth was created not because those countries made investments, not because they were ready or because they had a reasonable skill level in their workforce. The primary reason was that the barrier to entry was exactly zero in the IT industry and they were able to create companies. If you look at India and China, the companies that have been created are predominantly IT-based companies reliant on technology developed in the U.S. at one point or the other, customized to the local region. That wealth is now helping these countries enter other pursuits like energy, nanotechnology, and biotechnology. We have enabled them to generate this wealth and they are using this wealth very effectively to compete with us.

This doesn't means that the United States is going to lay down as if dead. We still have greater resources than any other nation in the world. Although by many measures the percentage of wealth held by the United States is going down, in absolute dollars or on a per capita basis we are still a very powerful, very rich nation. We cannot forget that fact and we have to ask ourselves how we can maintain that

Thomas Cellucci, Department of Homeland Security; Caroline Greenwood, Department of Homeland Security; Thomas Halbouty, Pioneer Natural Resources Company; and Pradeep Khosla, Carnegie Mellon University.

level of wealth while giving something up, because the rest of the world cannot be panhandlers while we are eating steak. There is a flattening of wealth going on which is good.

The point I'm trying to make is that if you observe this generation of wealth in various regions of the globe, local entrepreneurship is part of the equation, but I think the fundamental driver was U.S. investment in research and development. Much of it was motivated by the Cold War, but it was also used very effectively for commercial enterprises. We have done a spectacular job of that and most of the investment in research was at universities. That's what created the great American research university.

We have to ask ourselves what we're going to do now. I think the first thing we need to do is to keep investing in R&D at universities and at companies and flatten the IP regime to create a frictionless flow of technology and wealth generation.

Second, we have to rethink education. The cost is increasing much faster than inflation. We should address a grand challenge in the delivery of education. We need to maintain the quality and contain costs so as to open up that money for investment and other endeavors.

Third, we need to consider a new class of education. We should continue graduating electrical and mechanical engineers, but they should be graduating with the ability to enable, manage and deploy innovation in multi-cultural, multi-lingual distributive environments. In real markets (e.g. 2.6 billion people in India and China), we cannot sell them ten thousand dollar orthopedics. We need to sell them hundred dollar orthopedics, so I agree with Ray Johnson's point about our stake in innovation for affordability. If we create innovations that are affordable, we not only can sell them in India and China but also sell and deploy them in the U.S., opening up a lot of capital for other priorities.

Fourth, we are all concerned about STEM education. There's nothing wrong in getting our kids excited about STEM. Don't get me wrong, I'm a big fan of it but there is a fever we have caught without thinking through the details. The capacity in this country to graduate engineers is roughly 75 thousand. Even if the whole K-12 population got interested in engineering, capacity doesn't go up over night. My university might get a slightly better student, but not always the best of the best because people have different interests. Just getting kids excited doesn't mean fundamentally that the capacity changes. I think our paradigm should be more about how our 75 thousand engineers are going to enable and manage the much larger combined number educated in India and China.

Fifth, we need to consider graduate education. Mel talked about how people post-Sputnik were excited, but even if you go back to that time, the percentage of students getting Ph.D.'s in America who were foreign was still very high. Throughout the history of this country the percentage has been high and now what we are seeing is that because of various security concerns, we are limiting not so much the number of immigrants, but limiting our ability to leverage their skills through international traffic in arms regulations (ITAR) and other rules. I recently walked away from a five million dollar inter-intelligent agency contract because they would not let foreigners work on the project. They wanted me to segregate my campus so that only U.S. citizens could participate, but that's not the way universities in this country operate. We need to rethink such policies.

We also have to think about an investment strategy where DARPA and AFOSR can fund highly aggressive, high risk research, while SBIR and others take on commercialization and transfer risk rather than the development and the discovery type of risk. I don't see a coordinated strategy there. Most agencies use SBIR's to fund faculty research because fifty percent of the money can go back to the university.

One last point—we should double the number of graduate fellowships. It would be great for the country. Once we reach a point where there are no more qualified U.S. citizens, we should open them up to the most qualified foreign citizens, perhaps starting with countries deemed as "friendly" to the United States.

Discussion

Khosla began the discussion by responding to questions about his proposal to increase the number and expand the eligibility of graduate fellowships. Brendan Godfrey, director of the Air Force Office of Scientific Research, probed further on the scope of the proposal. Although Khosla did not have exact figures, he estimated the engineering Ph.D. pool that would benefit from graduate fellowships to be approximately 15,000 to 20,000, roughly half of which are foreign students.

Godfrey, Khosla and Tether exchanged views on what level of U.S. support is preferable for non-U.S. students. Khosla agreed that federal agencies fund most Ph.D. projects, but that foreign students are necessary "to create technology and solve our problems. We don't have enough manpower and need these people for our own sake; this country's sake, and we should help them stay."

Godfrey stated that the Department of Defense funds 500 to 600 fellowships per year that are limited to U.S. citizens. However, Godfrey said, "If you add up the money that flows to graduate students through grants to universities, it probably supports about 5,000 grad students per year. We make no particular effort to restrict those resources to U.S. citizens." So although U.S. policy aims to support U.S. grad students, the government supports students from all countries through research projects at U.S. universities. The fellowships are only a tiny portion of the total support for grad students, Godfrey continued, noting that the Defense fellowship to research grant numbers are consistent with those at NSF and other agencies that offer both forms of support.

Tony Tether, Council on Competitiveness, and Wolf von Maltzahn, Rensselaer Polytechnic Institute.

"I'm greatly troubled by the suggestion that we can't find enough qualified U.S. students. We need to address the K-12 and undergraduate issues that limit the supply of U.S. students," Godfrey said.

Tether questioned whether the U.S. government should fund both the research project and the foreign student through a graduate fellowship, but strongly agreed with Khosla and others that U.S. policy should incentivize foreign Ph.D. earners to stay. "A reason it takes foreign students so long to earn their Ph.D.'s is because once they graduate, they often have to leave. That's part of the rules and it's crazy. It ought to be the reverse," Tether said. He, Khosla and Godfrey endorsed a proposal suggested by former Intel chairman Craig Barrett to automatically award green cards to foreign Ph.D. earners in strategic fields. Others added that such a policy should extend to master's and bachelor's degree earners in such fields.

Participants also noted the findings of the Venture Capital Association report that measured the tremendous wealth, jobs and new companies created by immigrants in the United States. There was a broad consensus about the importance of preserving this diversity and entrepreneurship in the American workforce.

Khosla suggested easing certain hiring restrictions on defense contractors and the defense labs to enable them to employ more foreign Ph.D. earners. Acknowledging that some restrictions would remain appropriate, he asserted that "there is a class of work on which these talented foreign students could be engaged that would not compromise national security."

Khosla also emphasized that the United States fails to produce more engineering students not out of weakness, but because of the country's strength. "Kids make choices about how much an engineer will earn versus other professions. It speaks to the strength of this country that there are so many opportunities to do well in life besides being an engineer. When we think about getting more people into engineering, we have to consider the market for engineers."

Tether agreed, but returned to a theme raised by Bernstein that students also are motivated by being inspired or challenged. "There are jobs that are not just jobs, but a chance to do exciting things," he said. Tether offered as an example the Obama administration's investment in advanced energy. "We have to create challenges that kids embrace, knowing that they have to learn engineering to tackle them."

Other concepts put forward by participants include:
(a) The growing importance of global partnerships. Johnson observed that for a long time, U.S. institutions were substantially better than their global counterparts. That is changing rapidly, he asserted, and Americans will have to extend their boundaries by relying more on partnerships as top talent and knowledge becomes more distributed globally.

Wince-Smith agreed and suggested that universities require more students to spend at least a semester in emerging markets like China, India or Brazil. "If we're going to succeed in a more integrated world, our children need to go overseas. It's not just that we want to keep foreign students here; we also need to consider how Americans will be skilled at collaborating globally."

(b) The value of STEM literacy. Participants agreed on the value of greater STEM literacy. The general population needs at least a basic understanding of science and innovation in order to mobilize the public and private sectors to achieve the goals of the TLSI. STEM literacy also serves individuals well in many professions. "Not everyone's going to be an engineer or a scientist," Wince-Smith stated. "But individuals can't function without quantitative skills in our society, whatever their career. STEM literacy conveys those baseline skills."

(c) The need to develop more STEM professionals suited for today's challenges. Many participants expressed a desire to encourage and enable more Americans to become STEM professionals. The discussion touched upon reforms at the K-12, undergraduate and graduate levels.

Wince-Smith addressed structural issues related to K-12. “America spends more per student than any country in the world but Switzerland, yet we have persistent teacher issues and a system characterized by virtually no productivity, huge costs and tremendous resistance to reform. Unless we realize the need for fundamental reform, the population on which our future relies will continue to fall short of their potential, and far too few will attend our universities.”

Wince-Smith also emphasized that engineering is an integrated discipline, yet too few institutions fuse the arts, humanities and social sciences with engineering. Schmitz built on this theme advocating that an engineer’s university experience be more entrepreneurial to include case study work that conveys the importance of having the relevant players (e.g. marketing, regulatory) at the table in order to innovate successfully, and knowledge about business models to understand the importance of cost, profit and loss.

Little closed the discussion on talent by describing GE’s global centers—one in India with 4,000 technologists and one in China with 1,200. “It’s obvious to me that brains are evenly spread globally,” Little said. “In these centers, we have passionate people who are growing rapidly in their ability to innovate. Having said that, it’s very clear to me that the United States still holds tremendous competitive advantages. As Mel articulated, we have world leading universities and people who come here because they want to participate and stay. Anything that the Council can do to encourage our country to enable these people to stay is very important for our country. Companies like my own will hire this talent anywhere in the world. Companies won’t be hurt, but their economic activity will be centered in those places where they have access to the best talent.”

Mark Little, General Electric Company, and Deborah L. Wince-Smith, Council on Competitiveness.

PART 2: FINDINGS FROM TLSI DIALOGUE 2

A Conversation with Larry Bock

Johnson introduced Larry Bock, a highly successful entrepreneur and venture capitalist who has founded at least nine firms listed on the NASDAQ, mainly in the life sciences. Bock organized the San Diego Science Festival discussed at TLSI Dialogue 1. He joined the second dialogue to share information about a National Science Festival to be held in Washington.

Bock opened his remarks by thanking the Council for the opportunity to speak about the festival and Johnson for suggesting the event in Washington.

This is going to be the biggest celebration of science and engineering in the United States.

First, what is a festival? The notion is that society gets what it celebrates. We often celebrate entertainers and pop stars. Why don't we celebrate science and engineering? That was the idea behind the San Diego Science Festival that consisted of about 500 events over the course of a month and culminated in a large expo. We engaged roughly 200,000 people over the month and about a 100,000 people on the final day.

The festivals are more analogous to an arts, music or literary festival than to a science fair. They're not a competition; they're a celebration of science and engineering. The festival that we're organizing for Washington will last two to three weeks. We'll begin October 10, 2010, culminating in a two-day expo on October 23-24 on the National Mall. At the expo, we will have over 500 organizations doing hands-on, interactive science outreach to the general public.

Our goal is to have half a million people at the final event on the National Mall. We already have about 225 organizations participating—just eight weeks after starting the effort. We have about 75 professional science and engineering organizations like the National Academy of Engineering, the National Academy of Sciences, the American Chemical Society and the American Physical Society. We have 45 universities, colleges and research institutes like Harvard, MIT, Yale, Cal Tech, Duke, Georgetown, UC Santa Barbara and the University of Washington. We have all the major museums and aquariums in the Washington area, plus about 50 science centers from around the country. Roughly 25 government agencies have signed on to participate, including the National Science Foundation, the National Aeronautics and Space Administration, the National Institutes of Health, and the Department of Agriculture. We also have about 25 high tech and life science companies like Lockheed Martin, Genentech, Amgen, Hitachi and 3M.

Looking at the list of TLSI participants, I'm happy to report that the University of Maryland is participating, as is Georgetown. Many defense-related departments also have signed up, including the National Defense Education Program. NASA has about 20 exhibits at the festival. We have multiple national labs such as the Jefferson Lab, Lawrence Livermore, Lawrence Berkeley and others. I'm hoping that I can excite TLSI participants to contact me and join us. We are confident that we will fill up the mall completely very soon. There will be a thousand exhibit spaces on the mall, from right in front of the capital all the way down to about Tenth Street.

So I'm happy to open it up for a few questions and I'm hoping that I will get a call from everyone in the room saying how can they get involved in this event.

Discussion

Evans opened the conversation by exploring how the TLSI could participate in the festival. "We have a great group of chief technology officers, heads of university research, heads of research at national laboratories and leaders in our defense and energy agencies," Evans said. "I note that the expo is scheduled near the dates that we are considering for a fourth TLSI dialogue. Our leaders are committed to creating and leveraging talent to drive our future standard of living. How might we best get this group engaged?"

Bock replied that the expo was the top priority at the time, but that in the weeks prior to the expo, his team plans to replicate three other major activities from the San Diego festival and welcomed TLSI participants to work with them to develop programs along the following lines:

(1) "We recruited a hundred leading scientists and engineers to go into the schools and give assemblies at the local middle and high schools," Bock explained. "We engaged about 50,000 students with that program. The scientists were very high caliber, such as genomics pioneer Craig Venter. We recruited ten Nobel laureates to have brown bag lunches with students."

(2) "We also did the reverse, bringing students to the major science venues in the area. We recruited 50 high tech and life science companies to open their doors for students to do hands-on experiments in state of the art facilities. Lockheed Martin, for example, hosted 15 hands-on demonstrations for three nights for about 600 or 700 students. In another example, a company brought 150 students into their auditorium. They purposely exposed them to boring scientists. Just as the students' eyes started glazing over, the alarms went off and people entered the room in containment suits. The students were told that they had been exposed to a pathogen and had the next two hours to learn how to sequence that pathogen and develop a vaccine. This offered lots of hands-on activities and even a little theater and comedy mixed into the act."

(3) Finally, "We had a series of events geared to the general public with an informal hook that snuck science in the back door. For example, we had an event on the science of wine. Come and learn about the aging properties of red wine and have a tasting. We also had events on the science of beer, the science of chocolates, the physics of burping, the science of golf, and the intersection of politics and science. We had about 75 such events—fun, interesting evening activities with lectures or paneled discussions."

Little asked whether the organizers were engaging key politicians and their staffs. Bock replied that evening sessions are planned with various politicians. "We're still in the process of putting those together, talking about things like the politics of science and how the political world can help spur interest in science. We have asked the president to give the keynote address opening the festival and hope that the president's children will attend."

Bernstein asked whether any continuing activities are planned after the festivals. “We consider the festivals as a once a year opportunity for everyone to come together and showcase what they do in science,” Bock replied. “Although we don’t strive to be a year-round program, we ask all of the organizations that participate to alert the attendees of their year-round programming, whether it’s scholarships, internships, or other opportunities. But we don’t want to replace those programs.”

Evans, Johnson and Wince-Smith suggested that Bock coordinate in some fashion with the Council to promote TLSI recommendations through the science festival events. “We can jointly support STEM and convey its importance to the nation’s competitiveness,” Johnson noted. Wince-Smith suggested that Chuck Vest at the National Academy of Engineering might be interested in joining such a partnership and that the Council and TLSI could hold a reception that would bring together political leaders and festival participants. Bock supported these ideas and confirmed his intent to work with the Council.

PART 2: FINDINGS FROM TLSI DIALOGUE 2

Examining Technology Frontiers

Evans opened this conversation by recalling how TLSI Dialogue 1 expressed interest in ways to push technology frontiers and in identifying technology game changers. He introduced Rick Shangraw and Harold Schmitz to provide opening remarks.

Rick Shangraw, vice president for research and economic affairs at Arizona State University, focused on how to push technology frontiers by collaborating more effectively. He put forward seven habits of global collaboration "that I have found useful over my career, leading both public and private sector organizations in the research arena."

Harold Schmitz, chief science officer of Mars, Incorporated, discussed some of the larger technology challenges he sees from the vantage point of one of the world's largest food companies.

"No. 1 is securing global supply chains. As many of my industrial partners have experienced," Schmitz noted, "global supply chains have fragmented in the last few decades. In the world of food and agriculture, it is a science unto itself as to how that chain diversified globally. The technology base that provides security for those supply chains is important because there is a real threat of contamination for economic or terrorist purposes."

Schmitz also discussed health care. As a food company, Mars' interest centers on prevention more than treatment. "There's a complexity challenge that scientists, technologists and engineers must deal with in the food industry—complexity in natural products requires really sophisticated chemistry or material science, and in food and agriculture you almost never have the benefit of working in pure systems as one might at a pharmaceutical company."

C. William Booher, Council on Competitiveness; Paul Hallacher, Pennsylvania State University; and Rick Shangraw, Arizona State University.

Schmitz noted his partnership with IBM to tackle such issues. "We're thinking about how high performance computing could allow us to make, for the first time in the history of food and agriculture, a dent in understanding the complexity of natural products, whether for preventative health care or global supply chain security."

Another challenge Schmitz returned to was innovation management, such as graduating students with an understanding of the need to work across business functions from the onset of a project to innovate effectively. A related challenge, Schmitz continued, is managing innovation processes globally. "Each culture brings a different lens on what it means to innovate, so that's a topic I think about a lot within my company."

Seven Habits of Highly Effective Global Research Collaboration
Source: Rick Shangraw, Arizona State University

1. **Adequate Funding.** Although this one is obvious, Shangraw said, many people think that funding is all you need to make such collaborations work. “I’ve thrown tons of money at global collaborations, but without having the other six attributes, almost every one of them failed.”
2. **Motivation.** Researchers must be driven by the grand challenge and truly engaged in the topical area, not just the allure of international travel.
3. **Language Fluency.** “Years ago to earn a Ph.D. in the sciences or engineering in the United States, you had a language requirement. You had to learn German, for example, because the German journals included a lot of great science. We should revive that requirement. There are good journals now in Mandarin, and we must understand that material.”
4. **Outcome Orientation.** Collaborations must narrow their focus from a grand challenge to an outcome-oriented piece of that challenge. Shangraw illustrated the point through his broad collaboration with the Chinese Academy of Sciences on sustainability. “We narrowed further by thinking about renewable energy—still too broad. Then we considered biofuels—still too broad. We’re having success, however, in sinew bacterial strains for biofuels. With that kind of focus I attract the right kind of people and we make progress.”
5. **Core Locations.** “Counter to prevailing theories that we can have distributed research conducted around the world, I believe you need to have a core set of facilities where people physically interact,” Shangraw said. “U.S. organizations will have to make decisions about where to invest money in those core facilities. The national labs are great places, but often they’re not optimal for global collaboration. Foreign nationals are not usually accepted at the labs in a way that allows for long-term research and our universities often need better facilities to become the core location.”
6. **IP Flexibility.** Shangraw advocated tremendous flexibility with intellectual property. “This is an area where we often get caught up in a long debate about who owns a property and who’s going to patent, and who will license—particularly in global collaborations.
7. **Strong Leadership.** Almost every successful collaboration observed by Shangraw had great leadership. “I think leadership has two dimensions. There’s a scientific dimension and a managerial dimension. I’ve found that it’s hard to find that in one person, so we often have a scientific leader and a managerial leader.”

We're thinking about how high performance computing could allow us to make, for the first time in the history of food and agriculture, a dent in understanding the complexity of natural products, whether for preventative healthcare or global supply chain security.

Harold Schmitz
Mars, Inc.

Participants also learned of the value placed by Mars on economics, as Schmitz shared the company's principle of mutuality. "Forest Mars, Sr., offered a definition of mutuality in the mid-forties, that a successful business meant satisfying consumers, regulators, competitors, suppliers, as well as the shareholders, which at that time was only him." Mars continues to look at the role of economic metrics in stimulating innovation by enabling the company and others to manage it more effectively.

Schmitz emphasized the importance of the larger concept of intellectual capital that surrounds intellectual property, particularly for the food and agriculture sector. In many industries, there are paths for creating intellectual property that also leads to value creation. "In my industry," Schmitz said, "intellectual property usually won't be a driver in the end value creation of my product. It will more often be speed, trademarking or other areas of output. Being able to understand and quantify intellectual capital, the whole picture, would illuminate a different, possibly better way to comprehend how to compete beyond intellectual property, even though it will remain a core interest."

Finally, Schmitz echoed Shangraw's comment on leadership, noting the time spent by Mars on leadership development and training in its S&T organization. "I believe that leadership is a very important challenge to address if we are to seize opportunities successfully," Schmitz concluded.

Discussion

Participants entered into a wide-ranging conversation that covered three broad topics: high performance computing (HPC), telling the research and innovation story to policymakers, and regulatory reform.

High Performance Computing

Cynthia McIntyre, the Council's senior president for strategic operations and high performance computing, elaborated on Schmitz's statement about using HPC to understand natural products. She noted that the Council's HPC Initiative examines the use of the technology by industry and government—highlighting through case studies how HPC is used. The Council recently explored HPC for manufacturing, producing two white papers to advise the Obama administration and Congress.

"We will have a meeting in 2010 on the use of HPC in health care and how the technology can be used to support clinical decision making," McIntyre announced. The effort will include the analysis of natural products, computational chemistry for pharmaceuticals and a possible visualization of real-time biological environments. "We'd like to bring together medical device companies, independent software vendors (ISVs), hardware manufacturers and designers. We also want to include the end users and medical research community because I see them as first adopters who would be critical to help implement a more robust HPC environment."

Participants seized on the HPC theme, discussing various applications and its role in competitiveness. One participant supported Schmitz's assertion about the importance of HPC to secure and manage global supply chains, noting recent research on the presence of heavy metals in the food chain from China and the growth of autism in the United States. "There is growing evidence that the lack of due diligence in inspections—FDA only inspects 1 percent of the shipments coming into the country—has real health impacts," she said.

Harold Morgan, senior manager of industrial partnerships at Sandia National Laboratories, acknowledged the drawbacks raised by Shangraw of working with the labs, but also noted the labs' success in HPC collaboration. "In some cases, we've changed cultures in major companies in terms of how they innovate for affordability. HPC is a very high powered tool."

Morgan illustrated his point through the lab's 16-year partnership with Goodyear. "There were many times along the way when we could have stopped and would have fallen well short of their goals and ours, but because there were commitments and patience on both sides, we were able to make a large difference in their business." Morgan suggested adding patience and commitment to Shangraw's habits of highly effective global collaboration.

Participants noted that the licensing of software for HPC can pose a formidable cost issue for a mid-sized company. Sometimes a license is based on the number of cores running. McIntyre agreed,

Harold Morgan, Sandia National Laboratories; Cynthia McIntyre, Council on Competitiveness; Debra van Opstal, Council on Competitiveness; and Thomas Halbouty, Pioneer Natural Resources Company.

noting that one of the Council's recommendations is to look at the federal government's body of codes. "These are sometimes research codes. They aren't necessarily industrial strength codes, but they could potentially be brought out in an open source way for end users or ISV's to apply them. Perhaps that's an approach that could get more useable software available without necessarily pushing the ISV's aside," she said.

Wince-Smith emphasized that the Council promotes HPC because if organizations have more computing power, it will strengthen their competitive advantage. The Council hopes that the TLSI will integrate HPC into its agenda. "It is one of our most strategic competitive advantages for manufacturing, job creation and making the entire product cycle more efficient," Wince-Smith asserted.

Johnson stated that HPC will open avenues to derive exact solutions on things that were estimated in the past. "Two paths will help us get there," he said. "One is the type of computing system able to tackle more complex problems. The other is the ubiquity of extremely fast computers, putting this tool in more hands and changing how it's used. People will consider how they can utilize really fast computers at every workstation in a laboratory. In addition, if you link computers together and get software that's smart enough to make use of that power in a distributed way, it will expand the science horizons of the world."

Shangraw sought to clarify the role of academia in HPC. "On one hand, we have centers around the country that have big computers—Texas, Illinois, Pittsburgh and San Diego. They seem to be focused on more cores, bigger size and doing high-scale research computing. We have other programs that have medium-scale machines, and they appear to want to obtain bigger ones and work on software issues. It seems to me that the big challenge facing universities is how we train the next generation work force that can provide solutions. That's the part on which we need to spend more time. At ASU, our job should be to partner with industry and help them solve problems—working with code, paralleling code and doing the things necessary to make them successful. We haven't broken that barrier yet. There are still issues related to the proprietary nature of data, where the systems are stored, software issues and paying for cores. Such issues prevent ASU from playing a deep role that plays to our strength, which is training and education for these purposes."

Bernstein added that enrollment in computer science as a major is going down, but the use of computers is becoming ubiquitous across almost all disciplines. "We view that broader usage as a very positive thing. The hope is that HPC can help address some of these major problems, but you also need skilled people and the right models."

A number of participants stressed that software development is more important to HPC than building better computers. One speaker noted that the Departments of Defense and Energy sponsor enormous computers, "yet the typical program running on these computers uses only a few hundred processors, not the thousands that are available. Nothing scales," he lamented. The point also was made that it usually takes a substantial amount of labor to keep a code functioning over time due to changes in operating systems or other reasons.

Another concern raised was that HPC supporters focus on the technology as a competitive advantage rather than a rigorous documentation of the results achieved by applying the technology. "If we want to accelerate exascale computing by 10 years as a multi-billion dollar investment, we must justify the worth of the technology." Part of that challenge might be the idea of complexity raised by Schmitz. Participants observed that often when HPC is used to solve a problem, it enables researchers to start tackling potentially far more complex ones—making it more difficult to perceive the HPC's value.

Participants also saw value in Shangraw's suggestion for a new type of degree called computational scientists—people who not only develop programming code, but also apply and process software models. As he observes declining enrollments in computer science and computer engineering, Shangraw noted that social scientists, humanists and life scientists are crafting their own HPC code out of necessity. "It's usually not very elegant and incredibly inefficient because they don't have the fundamental skills. We're seeing some emerging programs and majors, but I don't believe that they convey the skill set that's necessary to do what is needed for the next generation of HPC."

Telling the Research and Innovation Story and Regulatory Reform

Bernstein asked TLSI participants how the group should help ensure long-term, bipartisan support of major research to push the frontiers of technology. "The real question is whether a group like this—with government, industry, university and other groups represented—can help us think about models that bring together the critical people to innovate. The models would have to be in specific topical areas to be effective. I think of SEMATECH as one example that worked very well for the country."

Wince-Smith responded, "Given what's going on in the economy and the issue of job creation, it's critical that we link innovation models to national missions. It's not enough to say we need more R&D just for basic research in this environment. Innovation policy has to be coupled with solving the complex national missions that also create economic value. When I was assistant secretary of commerce, I did a great deal of work on flat panel displays. All the research, every technology path, was done in the United States, but we didn't create economic value at home. The work was done in Japan.

"There's a lot of talk on the policy front that the same thing could happen in clean energy. We hear CEOs say that they are not going to manufacture these new technologies in the United States. The issue is whether we are going to be the R&D supplier to the world. How do we capture the value? That is a question for this group to consider and on which we should produce some very powerful recommendations."

Khosla expanded on that theme, describing his efforts to establish a new engineering research center with support from the National Science Foundation. "We have problems with the complexity of conflicting federal regulations, whether from the NSF, INS, IRS, patent law or Bayh-Dole, that keeps us from really having good practices." Khosla noted that NSF and other agencies impose general requirements that aim to create value and economic impact, but have not established clear guidance on how to achieve them or how they'll be evaluated for compliance.

"The University Industry Demonstration Partnership that is part of the National Academies has been struggling for six years to establish best practices on how companies and universities can interact more effectively," Khosla said. "Members of Congress want to fund research through the various agencies so that voters in their districts will benefit from it. Between that desire and the funding, there is a huge gap, and that we need to address. We need to establish best practices; we need to clean up the federal regulatory environment; and we need to look at how competing countries are doing—how they're bridging the gap, and how we might have to change our culture."

Wince-Smith agreed. "It's important for the university research community to make the case for maintaining our R&D investment levels. We shouldn't, however, neglect other systemic issues that impact the development, deployment and creation of the value. I'm talking about everything from tax policy to regulatory policy. The liability costs borne by this country (more than 2 percent of GDP) are tremendous. We know from the data and studies that there are whole fields of research that aren't even performed in the United States and companies don't do certain work because of our product liability laws. It's important that this group look at innovation policy as a broad integrated system and not just consider the front end on the research piece."

Bill Bates, vice president for government affairs at the Council, added that it is difficult to convey the value of research to some members of Congress because the return on research investment is poorly measured. Most of the evidence is anecdotal. "It's rare to find a good study that says if you invest X you will get Y, whether Y is jobs, GDP, new companies or new products."

Johnson believes that the technical community does not generally do a good job of telling the innovation story. "We know that there is a history in this nation and around the world of research and development supporting solutions to big problems and growing economies. Maybe we don't do a good job of quantifying the data to support the telling of that story. We also have a political system where few members of Congress have any kind of technology educa-

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>
> **Deborah L. Wince-Smith**
> Council on Competitiveness

tion, and who often seek answers for today without adequate long-term thinking."

Shangraw relayed how the research and innovation story was told to policymakers in Arizona. "We were fortunate to be asked by our state legislators to imagine not having any research. As opposed to asking what research buys us, we were asked to imagine that we didn't have any research. The first thing we talked about was the deep integration between research and education. If we pulled research out of the university, we wouldn't be using state of the art tools, equipment, processes. We'd be teaching from a basis that is less than state of the art, and we don't want our children to have less than a great education when they go to the university.

"Second, we demonstrated how much it would cost if we pulled research out of the universities in terms of buildings and facilities. Federal research investment provides a share of overhead and other things at a university for which the state would otherwise have to pay. When we present that argument to state officials and lawmakers, they realize that they would have to write more checks. Universities alone can't pay for the necessary equipment, buildings and faculty salaries. We made additional points, but once we made the case for research that way, we were able to talk about the benefits in a way that was much more compelling."

Bernstein suggested that TLSI form a working group on how to "tell the story," and that participants take into account efforts underway for that purpose at the Association of American Universities and the Association of Public and Land-Grant Universities.

Participants also advocated a working group to examine reforms to key laws and regulations, including Bayh-Dole; state, federal and local laws that impose conflicting requirements; liability issues; and ITAR restrictions.

PART 2: FINDINGS FROM TLSI DIALOGUE 2

Keynote Address: NASA Technology and Innovation

Chris Scolese
Associate Administrator
National Aeronautics and Space Administration

I'd first like to address the TLSI's interest in public-private partnership, because in many ways NASA lives at the intersection of government, international partners, industry and academia. For example, NASA builds satellites for the National Oceanic and Atmospheric Administration (NOAA) that enable you to see weather patterns on television. We do research in cooperation with NOAA to explore what we need. We engage industry and academia to develop those capabilities, first through research and ultimately as operational satellites. Through this collaboration, we also improve the aviation industry, from aerospace system management with our colleagues in the Federal Aviation Administration to the performance of aircraft in concert with companies and universities.

In these engagements there are typically a myriad of international activities. Probably the most visible is our space station that 15 nations built over the last two decades—almost a million pounds worth and about the size of a football field. The station was both a management challenge and a technical challenge when you think about the 25 to 30 shuttle flights that it took to get the components up there to start outfitting it. It took an almost equal number of flights to build it. We partner with our European and Japanese allies launching missions to the station, but we often struggle in managing that partnership.

Ray Johnson, Lockheed Martin Corporation; Deborah L. Wince-Smith, Council on Competitiveness; and Chris Scolese, NASA.

I think the Council on Competitiveness can help us. We, too, struggle with ITAR. In our recent history, the United States has developed incredible capabilities that once were one of a kind. Because of the restrictions, however, we couldn't export our capabilities or even discuss them. Other nations developed those capabilities, and we lost markets as a result.

The relationship between government and industry is always complex. NASA is by and large a research organization. What we build, we typically build once. It's rare when NASA has a production line like the Department of Defense because our needs are different. Perhaps we'll launch two crafts for the exploration of Mars because of the risk of losing one, or for a mission like the Hubble Space Telescope, we would launch one unit and gradually improve its capabilities. You can't really look at NASA, however, from a high-volume production standpoint.

The question is how to build a partnership in such a way that we help industry develop capabilities and technologies, and yet not leave those technologies limited through proprietary relationships with just one industry or one company. We would benefit from your guidance on this question.

We also could collaborate on encouraging people to pursue careers in science, technology, engineering and math. NASA doesn't actually have a hard time hiring people because we have an interesting mission. Yet we don't have the money of Wall Street, and we don't have the excitement of being a football player, so we need organizations like yours to encourage people that there is a great future in improving life on Earth or in making a grand discovery. Success in that endeavor will ultimately drive America's economic engine and improve the STEM talent situation in which we find ourselves in today.

I'd also like to share with you a little more about what NASA does. NASA is fundamentally a mission and research agency. As I noted, a big production line for us is two. We buy most of our rockets commercially and the shuttle is the only real NASA vehicle. Although we fly shuttles multiple times, and we do have three orbiters that we fly regularly, the external tank is brand new every time, and the engines are rebuilt every time.

Our real challenges are the missions we undertake and the research that goes into those missions. They're extremely challenging. Think about going to Mars. When we first did it, we just flew past. Then we had to figure out how to get into orbit around another planet. There is a big gravity well around planets, and if you don't approach them the right way and spend the right amount of energy, you either have a rendezvous with the surface of the planet or you go whizzing by it—neither option is good.

Next, we had to find a way to land on planets both with and without atmospheres. The reason I selected Mars as an example is because it presents unique challenges. It's got an atmosphere, so you think you might come down with a large parachute like you did with Apollo. Unfortunately, the atmosphere isn't dense enough for us to do that. On Mars we have no terminal velocity, so we use a parachute only to slow us down from supersonic speeds to subsonic speeds, at which point we can employ a rocket or a balloon to safely land on the surface. We do all that remotely, without any people.

In fact, once we launch most of our satellites, no human will ever touch them again. That challenge helps NASA drive advances in things like communication. How do you get the data back from so far away? Sometimes the sun or the moon is in the way. Regardless, the distances are great, and there are time delays to deal with. The rovers on Mars are very sophisticated. We give them a place to go and they get there autonomically. We don't tell them anymore to rotate their wheels 47 times on the right side and 46 times on the left side to get up to this rock.

We also are challenged by extreme radiation environments. We're sending a mission to Jupiter called Juno without using radioisotope thermoelectric generators. We chose instead to use solar rays to power the spacecraft because it was feasible. Juno will live in one of the highest radiation environments that human objects have ever entered.

We also want to peer deeper into the universe, so we're building a six meter diameter telescope. It's got to live in space, get energy from the sun and operate at 35 Kelvin. That's 35 degrees above absolute zero. Think about controlling such a device. At one end, you've got the telescope with all of its instruments operating at about 35 Kelvin, while on the other side the temperature rests between 200 and 250 Kelvin. You can only allow nanowatts to go across the interface that has to exist between them. This kind of challenge helps us drive technologies and gets people's creative juices flowing.

Looking at the Earth is another example. How do you answer a question about climate change that asks you to predict something 50 years in the future, and you have to pull that signal out of everything that humans and nature do on the planet? You can understand why there is a debate about some of the data. Yet we're extracting that data and striving to make it sensible and useful.

So what does it all mean? NASA does these cool things that drive multiple technologies. NASA can't take credit for cell phones, but NASA certainly helped people think about cell phones and helped drive the miniaturization, lower power requirements and satellites to operate such devices. Many people left the space program and went to work in the communications industry.

Some NASA contributions aren't as obvious. The image processing and detectors that we developed for the Hubble space telescope, for example, ended up in machines for mammography.

If you visit our website, you can see a really neat image that we produced with our partners in industry and academia showing how almost every aspect of aviation has been touched by NASA in some way. Again, NASA didn't build a 787 jet. We didn't build a GE turbo fan engine, but like the BASF commercial, we helped make them better or helped people think of ways to make them better.

In sum, NASA's mission is to do some really hard things that challenge and excite people. We may not produce an object more than once, but the missions are so difficult, and we hope so compelling, that people conceive and apply new insights that benefit industry and government. We hope that innovation and technology spins off our missions, whether it's through the intellectual capital of the people who work on them or the actual capabilities that offer greater societal benefits by improving the economy, health care or aviation. Thank you.

Discussion

Evans opened the discussion by noting that Apollo was a major stimulus that encouraged people to enter science, engineering and math disciplines. He asked Scolese what topics might draw young people into these disciplines today that would convey the thrill of solving difficult problems. Scolese replied that in addition to space exploration, students continue to be drawn by sea exploration and the frontiers of medicine. "People want to engage in something that they perceive as having a real benefit, so it's very important to have grand challenges put forward in many fields," Scolese said.

Scolese also was asked about public-private partnerships and whether NASA has an explicit mission to transfer technology to the private sector. "Absolutely," Scolese answered. "The 1958 Space Act tells us to do that exactly—to share information with the public and to develop technologies and capabilities that can be used broadly. It wasn't as explicit as saying, 'give information and technology to industry,' but that is clearly part of our requirements, and we have programs that do that, such as our innovative partnerships program. Many of our programs in aeronautics also are related directly to technology transfer, so we have it in our charter.

"The difficulties that we have relate to intellectual property rights. Does the government own the intellectual property, and therefore everybody owns it and can use it? Does the company, companies or universities with whom we're working own it? Sometimes the final decision is made in a courtroom, but most questions get resolved without going to court because it's made pretty clear in the partnering agreement. It's an area that is getting more interest as international corporations play a greater role in what we do, so intellectual property rights really need to be examined and understood."

Participants also asked Scolese to discuss the balance between NASA's space science and Earth science missions. Scolese noted that NASA has many missions, including aeronautics, human space flight, and a science mission with Earth and space components that balance fairly well. "Space science is less politically charged and generally enjoys broad support," he commented. "It is for the most part pure exploration that expands human knowledge and human presence."

Earth science also explores new frontiers and expands knowledge, he noted. "But it has a more direct impact on actions we take, so it receives more attention and its budget tends to sawtooth up and down depending on the views of the administration in power." Earth science helps make practical decisions, Scolese stated. "If we would like to know where to place a dam, it's helpful to have data on what the climate might look like in 50 years so we get maximum utilization out of it. Perhaps we want to know where to grow crops and what kind of crops to invest in—Earth science has those practical applications and therefore has a certain vicissitude associated with that."

From a technology standpoint, Scolese continued, "there is an incredible connection between Earth and space science. Most of our space science missions and most of our Earth science missions are in Earth's orbit. In the simplest sense, you're either looking down at the Earth or you're looking up away from Earth. The spacecraft are largely the same, which is why we can buy many of them off the shelf rather than relying on NASA-developed spacecraft. The instruments have started to become more similar. We actually have a better map at higher resolution of a higher percentage of the surface of Mars than we do of the Earth. A large part of the reason is that we've been flying Earth science instruments around Mars. In two years, we may have a better map of the moon than we do of the Earth, including where the minerals are. So there's a tight connection between Earth and space science.

"Even in aeronautics and human space flight, there's a connection to Earth and space science. Many of our Earth science instruments first flew on human missions. The first good images of the Earth were taken by Tyros in infrared in 1961, and improved upon by subsequent Mercury and Gemini missions. Apollo 8 orbited the moon and gave us the first image of the whole Earth (see image) that really captured people's imagination." NASA science instruments also flew on Skylab, the shuttle, and on the space station, Scolese explained.

Aeronautics is also very much involved in space and Earth science, Scolese noted. "We're building an aircraft to conduct infrared astronomy and to check data from satellites to make sure that they're operating properly."

Shangraw stated that NASA has become a core funding element for many universities, particularly at the basic science level, and asked Scolese, "As you continue to have pressure on your budget, how are you thinking about the way that NASA will support the basic science mission versus the applied or space missions?"

Scolese replied that NASA's basic research and analysis programs make up a smaller portion of the budget than missions, so those programs tend to be the last place the agency looks when it has a funding issue. "We would like very much to increase our investment in basic science at universities," he said. "We've actually had a contraction in our capabilities. In the 60s and the 70s, there were probably a dozen universities that were capable of competing and developing instruments and maybe even spacecraft. Now we're down to three or four."

Participants returned to Scolese's comment about NASA mapping mineral deposits on the moon, asking why the agency was not mapping them on Earth, given that some strategic minerals for national security purposes are at risk of being cornered by China. Scolese confirmed that NASA is mapping minerals on Earth. "In the late 80s through the late 90s, we devoted a lot of funding to develop the instruments for that task. One of the reasons it's hard on Earth is that we have a much more dynamic environment. On Mars, there are clouds but they're infrequent because of very low moisture. On the moon there are no clouds. You can map the whole surface of Mars in a year or two and the same is true with the moon. You can't do that on the Earth because we have storms and clouds that limit our ability to collect the data and get a complete map."

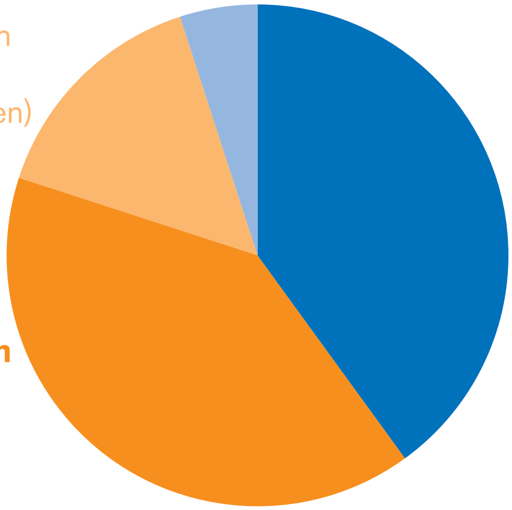
NASA image of the Earth taken from Apollo 8, December 22, 1968.

Scolese also was asked about how NASA is using money received under the American Recovery and Reinvestment Act (ARRA). He explained that NASA programs and facilities received $1 billion, with an additional $2 million going to NASA's Office of Inspector General. Of the billion dollars, $400 million is devoted to science, $400 million is for exploration, and $200 million is for aeronautics and cross-agency support. The $400 million in science largely went to Earth science missions. Because ARRA funding must be obligated by the end of fiscal year 2010, it did not allow NASA to advance some of the decadal survey missions exactly as the agency might have liked—such missions would replace aging Earth science satellites.

"We had to be somewhat creative to spend the money over eighteen months," Scolese explained. "We advanced missions that were already in progress, such as the global precipitation mission and the landsat data continuity mission. That frees up resources in later years so we can advance the decadal survey missions, including through new research."

"We used the $400 million in exploration to advance certain capabilities that we know we're going to need," Scolese continued, "like a new restartable upper stage engine called J2X. We had to do that to get long lead materials for the Orion spacecraft that will carry people. We also set aside a $150 million in exploration to encourage commercial investment in space for transporting crew. This was complicated because we had to manage expectations at both ends of Pennsylvania Avenue, as well as manage the expectations of industry as to what could be done with limited resources."

Figure 33. NASA Recovery Act Funding: $1 Billion



The remaining $200 million dollars will go to aviation ($150 million) and to restore NASA facilities damaged by Hurricane Ike in Houston ($50 million). The aviation funds will be devoted mainly to the Environmentally Responsible Aviation Project, which is under NASA's Integrated System Research Program. The program looks at the entire airspace system, seeking ways to improve its efficiencies, including fuels, engines, aircraft and the traffic control system.

Godfrey thanked Scolese for NASA's cooperation with the Air Force on hypersonics and other research areas. He also asked Scolese to share his thoughts on how best to sustain bipartisan support for science and research in Congress and with national leaders.

Echoing Johnson's point, Scolese noted that it would be better if there were more scientists and engineers in our political establishment. "I read an editorial last year that compared some of the world's largest countries by the percent of their political leadership with technical degrees. If I remember correctly, China India, and Germany had greater than 50 percent. Less than 10 percent of U.S. leaders held technical degrees."

On the other hand, Scolese perceives stronger bipartisan support for science and engineering today than 10 years ago. Back then he said the question commonly posed was, "why should I spend money on research?" Today, the question is more likely to be, "you guys do good work. What should we spend our money on?"

Scolese noted that individual lawmakers and officials have their differences. "Some people want NASA to work in hypersonics and some want us to work aeronautics in general. Some people want us to do more in exploration to improve knowledge and others want us to maintain U.S. prestige through human space flight. Even so, the discussion is generally positive and supportive. That was not the case 10 years ago." To preserve that support, Scolese returned to Wince-Smith's suggestion that research must be linked in a sustained and bipartisan way to growing the economy.

"Another way to sustain support," Scolese said, "is to issue reasonable challenges and demonstrate real capabilities and progress. As an example, who remembers what was probably the second most important thing done by Abraham Lincoln? He challenged the country in the middle of the Civil War to build the transcontinental railway. The railway worked over time to reunite the country, and it generated economic benefits almost immediately. The Apollo challenge did something similar. It captured people's imagination and produced economic and technology benefits that we still enjoy today.

"I don't think people fully understand what space exploration is all about, and we have to explain the value more effectively. People are aware of the accidents and the grand events like landing a person on the moon. Many also follow the rovers and their discoveries. Too many, however, don't realize that communication satellites execute bank transactions and transmit television.

"There are existing and potential advantages. Connecting the people on Earth for more efficient transportation is a potential advantage. The hypersonics on which we're working with our partners could change transportation dramatically. Supersonic aircraft may end up like the canal system advocated by George Washington, while hypersonics could prove to be more like the transcontinental railway that revolutionized transport and changed society.

"Our work on living in space is relevant to life on Earth. Through our efforts to learn about the impact of living in space on astronauts' immune systems, we believe a vaccine for salmonella will be developed. We didn't develop the vaccine in space nor was a vaccine manufactured in space. However, by observing salmonella on the space station, scientists noticed different things about it that they wouldn't have seen in a 1G environment. I'm not a biologist, but this gave scientists insights on how to control the bacteria on Earth and to develop a vaccine.

"Fundamentally, we must tell people that their lives depend on space. They get their weather from our satellites and severe storm prediction is better. Responses to natural disasters are much improved as we now get information in real time. Our planning for evacuations is better because we can see areas more clearly and determine optimal routes. Our aircraft fly better and more safely. We re-route aircraft for volcanic activity, for example, by sending data to the Federal Aviation Administration and partner agencies in other countries. Fighting fires is done more effectively. If you wonder why forest rangers don't rely on towers anymore, it's because satellites are constantly watching the forests. If a fire starts approaching a populated area, they can address it much more quickly. We need the public and our leaders to understand these benefits."

PART 2: FINDINGS FROM TLSI DIALOGUE 2

The Path Forward

Evans reviewed the ideas and some of the volunteers that would form the basis of working groups on:

- Accelerating the pace of commercialization;
- Telling the story / making the value proposition; and
- Regulatory policy.

Evans pledged to reach out to participants and set a 2010 calendar with the co-chairs.

It was noted that the President's Council of Advisors on Science and Technology (PCAST) issued a report in 2008 on university-private sector partnerships for innovation. Wince-Smith confirmed that the Council will examine the PCAST report for common themes and coordinate its findings as appropriate with TLSI activities. She also agreed with a suggestion that the TLSI leverage Council members serving on PCAST to present the initiatives findings to the president.

On behalf of the co-chairs, Little thanked the participants for attending and concluded, "We hope to continue making the time you spend on TLSI meaningful. We don't just want to have a nice dialogue; we really want to turn TLSI into something unique that gives voice and influence to our concerns and recommendations. We'll work with the Council to make that happen."

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About the Council on Competitiveness

WHO WE ARE

The Council's mission is to set an action agenda to drive U.S. competitiveness, productivity and leadership in world markets to raise the standard of living of all Americans.

The Council on Competitiveness is the only group of corporate CEOs, university presidents and labor leaders committed to ensuring the future prosperity of all Americans and enhanced U.S. competitiveness in the global economy through the creation of high-value economic activity in the United States.

Council on Competitiveness

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HOW WE OPERATE

The key to U.S. prosperity in a global economy is to develop the most innovative workforce, educational system and businesses that will maintain the United States' position as the global economic leader.

The Council achieves its mission by:

- Identifying and understanding emerging challenges to competitiveness
- Generating new policy ideas and concepts to shape the competitiveness debate
- Forging public and private partnerships to drive consensus
- Galvanizing stakeholders to translate policy into action and change

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