Testimony of

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"Espionage Threats at Federal Laboratories: Balancing Scientific Cooperation while Protecting Critical Information"

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Chairman Broun, Ranking Member Maffei, I am Charles Vest, president of the National Academy of Engineering (NAE) and president emeritus of the Massachusetts Institute of Technology (MIT). I have spent my career in higher education and research, and have served on the boards of major corporations. I am a proponent of openness in education and research, and I hope to explain the value of such openness.

I also understand the importance of security, having served on the independent Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction appointed by President George W. Bush, and I am a trustee of In-Q-Tel, that identifies, adapts, and delivers innovative technologies to support the missions of the CIA and the broader intelligence community.

I believe in openness of education and research to accelerate discovery, contribute to the worldwide advancement of knowledge and technology, and to enhance America's leadership, economy, diversity, and values.

My views support what is called in the vernacular "the Leaky Bucket Theorem," that when it comes to research and technology, it is far more important to keep filling our bucket than it is to obsessively plug leaks. I also believe in high fences around the small area of scientific results and technology that truly must be denied to others, i.e. critically important secrets should be classified, and we should minimize security mission creep and the bureaucracy that wastes time on over-classification and grey areas such as so-called Sensitive but Unclassified Research.

Openness is highly valued throughout the science and technology communities; it has three major dimensions:

1. Open flow of ideas, i.e. scientific and engineering knowledge;
2. Open flow of people, i.e. international students, faculty, and employees; and
3. Open flow of technology products and devices.

These three flows are frequently stemmed by counterproductive or unduly applied policies that many believe will harm our national security, technological leadership, and our economic competitiveness in the long run.

HISTORICAL POLICY CONTEXT

The basic point is this: Our policies regarding export controls and visas are rooted in the Cold War when two superpowers faced off against each other. The dominant security asset of the U.S. was our technological superiority; that of the Soviet Union was a huge military. It was more or less possible to maintain secrets from each other, and military technologies were more or less separate from consumer products.

The Cold War ended in 1989. Today, a quarter century later, we face very different diffuse threats such as terrorism; we no longer singularly dominate the world's science and technology; we are subject to the instant and open communications of the Internet and World Wide Web; our military and intelligence agencies are very dependent on commercial products; and our companies have global supply chains, open innovation, manufacturing facilities, customers, suppliers, and research laboratories all over the world.

Three world-changing events have driven the development or reexamination of U.S. policies regarding the flow of scientific and technical knowledge, non-U.S. citizens, and commerce:

1. The Cold War,
2. The advance of Japanese consumer manufacturing, and
3. Post 9/11 terrorism.

The Cold War Era

Cold War policy regarding the balance between openness and security began soon after the end of World War II. Even in that early context, in 1947, President Truman's Scientific Research Board stated:

> *Strict military security in the narrow sense is not entirely consistent with the broader requirements of national security. To be secure as a Nation we must maintain a climate conducive to the full flowering of free inquiry. However important secrecy about military weapons may be, the fundamental discoveries of researchers must circulate freely to have full beneficial effect. Security regulations therefore should be applied only when strictly necessary and then limited to specific instruments, machines or processes. They should not attempt to cover basic principles of fundamental knowledge.*

In 1982 Executive Order 12356 broadened the authority of the government to classify defense-relevant information, but the order stated that *Basic scientific research information not clearly related to national security may not be classified.* There was much debate about the interpretation of this sentence, and great uncertainty about how it would be applied. An answer soon came. As an optics researcher, I attended a meeting of the Society of Photo-Optical Instrumentation Engineers, in San Diego in August 1982. Under government pressure, and with less than ten days notice, scientists and engineers withdrew presentation of more than 150 technical papers on the subject of cryptography.

The vigorous debate that was launched by the quashing of basic cryptography papers was more or less settled in September 1985 when President Ronald Reagan issued National Security Decision Directive 189 (NSDD 189) that stated:

> *It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. ... that where the national security requires control, the mechanism for control of information generated*

during federally funded fundamental research in science, technology, and engineering at colleges, universities and laboratories is classification.

Each federal government agency is responsible for: a) determining whether classification is appropriate prior to the award of a research grant, contract, or cooperative agreement and, if so, controlling the research results through standard classification procedures; b) periodically reviewing all research grants, contracts, or cooperative agreements for potential classification.

No restrictions may be placed upon the conduct or reporting of federally funded fundamental research that has not received national security classification, except as provided in applicable U.S. Statutes."

Japanese Competition

The issues of export controls and visa policy gained currency again in the very late 1980s and the 1990s. This time around, the issues were even more complicated because they were driven as much by industrial competitiveness as they were by traditional military security issues. The rise of Japan in particular as a major economic power was driven by their sudden dominance in high-quality, high-throughput manufacturing of consumer products such as electronics and automobiles.

There were strong pushes to bar international students from university research programs because it was believed by many that foreign countries, especially Japan, would send students and visitors to our universities and laboratories to master our technology in order to return home and use it against us economically. It certainly is true that during this period the Japanese created a playing field that was unfairly tilted by their import restrictions. But they also completely outpaced us through their quality movement and through their advantage of building new "greenfield" manufacturing facilities. However, the fundamental problem was that much of American industry had become fat and lazy through the days in which we totally dominated. Eventually, they woke up and did the terribly hard but effective work to become competitive again. This coupled with a huge thrust forward of American entrepreneurship in new fields like information technology and biotechnology got our economy moving again. I conjecture that our manufacturing sector gained more value from learning about high-quality production from the Japanese than they gained from learning about our technology. I also am confident that U.S. openness to foreign citizens and the open flow of information were, and are, dominant forces in our success as high tech entrepreneurs.

Post 9/11 Terrorism

The horrific attacks on our nation on 9/11 quite naturally raised many new questions and perspectives about our traditional openness to those from other nations and about the open flow of scientific and technological knowledge. This was compounded by the rising realities of the Internet and World Wide Web, and by the globalization of modern industries and their supply chains. It accelerated after the dot-com economic bubble burst, and a national paranoia about leaking technological knowledge and mild xenophobia recurred. This played out particularly in the blocking of visas to foreign students, visitors, and participants in conferences held in the U.S. Since 9/11, this has been a complicated mixture of legitimate concerns, overreaction, bureaucratic foibles, risk aversion, antiquated systems, good intentions, bad policies, heart-rending personal experiences, and, finally slow but steady improvement. During this period, in November 2001, then National Security Advisor Condoleezza Rice, acting on behalf of the President, stated that pending further review and updating of export control policies, "… the policy on the transfer of scientific, technical, and information set forth in NSDD-189 shall remain in effect, and we will ensure that this policy is followed." Unfortunately, at the working level, this statement frequently did not appear to be implemented.

Starting in the late 1990s, universities began to be told that the conduct of basic scientific research that utilized satellite systems, and in some cases computer systems, were off-limits to foreign students and to collaborative efforts with other countries, even close friends like Japan. If non-U.S. citizens worked on projects and came into contact with certain specialized equipment, the knowledge they gained was considered a *deemed export* of sensitive technology and they were either barred from the contact, or required to pass certain security reviews. Quiet, but essentially fruitless, discussions between university leaders and federal officials ensued, and in several instances universities turned down such contracts rather than accept restrictions on their students.

In my view, the application at the working level of policies regarding visas and deemed exports were and are, cases of policy schizophrenia. Both before and after 9/11, the dominant reason for rejecting students applying for visas to study in the U.S. appears to have been *immigrant intent*, i.e. the government was afraid that these prospective students would stay in the U.S. after they completed their studies. On the other hand, many policy makers simultaneously decried the fact that increasing numbers of international students who had studied here were returning to their countries of origin to contribute to the development of their economies and universities rather than to ours.

The traditional American welcome mat was withdrawn after 9/11. Although the situation has slowly improved, damage has been done and continues. The matters discussed here, together with larger geopolitical considerations, have created a far less favorable opinion of the United States in much of the world than that to which we are accustomed. For example, in 2005, the Pew Research Center asked 17,000 people from 16 countries "Suppose a young person who wanted to leave this country asked you to recommend where to go to lead a good life – what country would you recommend?" In only one of the 16 countries (India) was the U.S. the most frequently recommended country.

WHY OPENNESS IS OF GREAT NATIONAL VALUE

My views on the critically important value to U.S. national interests of maximizing the flow of scientific and technological knowledge and people are driven by five considerations:

1. America's traditional values and strengths,

2. The nature of basic science and technology,
3. U.S. science and engineering workforce,
4. The value of a well-educated world, and
5. National Security writ large.

It is my belief that America's modern economic and military strength and leadership have been made possible by our unique combination of democracy, market economy, investment in research and advanced education, and diversity. As fundamental as these factors are, they are threatened or damaged by bureaucratic restrictions on openness beyond those classified areas that truly must be maintained as national secrets. Simultaneously, we are disinvesting in the research universities and scientific infrastructures that make our success possible, even as many other countries have learned from us and are implementing the policies and making the investments in which we used to lead. As I noted at the beginning of this testimony, it is more important to keep filling our scientific and technological bucket than to obsessively plug the leaks.

Here is an example of what our openness has brought to America: At MIT we are very proud of the Nobel Laureates who teach and work on our campus. Those who received their Nobel Prizes in recent decades were born in the United States, India, Germany, Italy, Mexico, and Japan. Similarly, the recent Laureates from the University of California were born in the United States, Taiwan, Poland, France, Hungary, Germany, Austria, and Norway.

These scientists, as well as countless others, came to the U.S. because of our openness and investments, and because American colleagues understand that science thrives in unfettered communication among scientists everywhere. Indeed, the conduct of science requires criticism and testing of the repeatability of experiments by other scientists. Scholarly pursuits more broadly require access to knowledge and artifacts, and are strengthened by criticism and exploration from different vantage points. One need only look back to the history of the Soviet Union to understand that science, even science practiced by brilliant and well-educated scholars, cannot flourish in isolation. In a similar vein, advancing and improving commercial technology benefits by open discussion and pre-competitive cooperation.

Let me turn to my deep concern about the future of the U.S. engineering workforce. This is the Knowledge Age, and to be able to compete and lead in the global marketplace, we need people with knowledge – especially engineering knowledge. But here is the reality: Across Asia, more than 21 percent of university graduates today are engineers. Across Europe, about 12.5 percent of university graduates are engineers. In the United States, only 4.5 percent of our university graduates are engineers. The primary reason that we haven't already been economically steamrollered is obvious: we import engineering talent. Talented immigrants now comprise a large percentage of our engineering and scientific faculties, and just over 50 percent of our engineering PhD students are non-U.S. citizens. And in 1998, Chinese and Indian CEOs alone were running around one quarter of the companies in Silicon Valley, accounting for $16.8 billion in sales and more than 58,000 jobs. In 2005, immigrants founded 25 percent of U.S. startups and the fraction of immigrant-founded Silicon Valley startups was 52.4 percent. These figures are now declining as individuals find improving opportunities in other countries and as we squeeze our institutions. From 2009 through 2012, the number of applications to U.S. graduate schools from overseas increased about 10 percent annually; for 2012-13, these applications grew by less than 2 percent. And from 2009 through 2012, the number of applications to U.S. graduate schools from China increased about 20 percent annually; for 2012-13, these applications declined by about 5 percent.

These warning signs about our future engineering and technical workforce must be taken seriously. They reflect many things, particularly the deep problems of STEM education in our K-12 system and a popular culture that broadly does not value science and engineering. But they also reflect the impact of policy and negative perception about declining openness and opportunity at a time when opportunity is rising elsewhere in the world. In the long run, if these trends continue, it is likely that loss of scientific leadership and decline in the talent base available to us will cause serious economic and security damage.

Another important topic regarding openness is education, not only on our campuses, but also through the Internet and World Wide Web. As I have indicated, damaging restrictions on access to our universities and research institutions were threatened or implemented in the 1990s. Post 9/11, pressures for restriction on foreign students and scholars intensified, and discussions in Washington considered barring non-U.S. citizens from even studying certain subjects in our universities. Fortunately, many of these pressures and considerations subsided. Today, initiatives such as MIT's OpenCourseWare and MOOCS (Massively Open Online Courses) offered by both non-profit and for-profit university consortia like edX and Coursera represent another form of openness valued by the academic community.

In many ways, these movements were initiated by MIT's OpenCourseWare program that makes the basic course materials such as detailed lecture notes, course syllabi, reading lists, problems sets, examinations, etc. available on the web at no cost for anyone who wishes to use them. They have been used by millions of teachers and self-learners all over both the developed and developing worlds. The materials can be used in whole or in part, added to or modified, and tuned to local needs and contexts. This and other open courseware programs have brought value to students and teachers around the world and have created very positive images of the United States as a generous nation.

MOOCs and other advanced on-line learning tools are in their infancy. But already it is clear that they reach very large numbers of students throughout the world and directly provide actual education to them, often with mechanisms for feedback on homework assignments and exams. While these initiatives and organizations deliver aspects of what is best in American higher education to massive numbers of students who might or might not be able to come to the U.S., most of us believe that a well-educated world is a better world in the long run. They reflect U.S. leadership despite the fact that they contribute knowledge, learning, and opportunity to those who will compete with us in the future.

Our national security is no longer a straightforward matter of dominance in weapons technology over a well-defined threat such as the Soviet Union during the Cold War. Our national security now and in the future is primarily a matter of science- and technology-driven economic strength in a highly competitive and thoroughly integrated world economy. While recognizing that a narrow segment of truly critical technologies needs to be protected by well-enforced classification, I believe our national security generally is best served by maximizing openness of scientific discourse and knowledge, pre-competitive technologies, and education.

COMPETING AND COOPERATING: THE 21ST CENTURY REALITY

Finding the right balance between openness and security of our citizens and institutions is not always easy. And it plays out as much, or perhaps even more, in the industrial and economic domains than in traditional national security domains. Just as there no longer is a singular military threat from the Soviet Union, there also is not a singular economic threat such as a surging Japan. The world and its institutions are now connected and integrated by instant digital communication, readily shared knowledge, an expanding talent base, and the accelerating emergence of new markets in every corner of the world.

Just as there is a modest slice of technology secrets that must be classified, so too must industry expect effective patent systems to protect truly valuable intellectual property. But in general, the response of our companies to this new age has been to become far more open. First, in recognition of growing markets and capabilities, they have moved many of their operations to countries where the new consumer bases and talent are. No matter where they produce goods or deliver services, their supply chains are now global networks. For example, it is reported that the new Boeing 787 is assembled from 132,000 engineered parts manufactured in 545 locations around the globe. Furthermore, companies have moved dramatically to Open Innovation, i.e. they no longer do everything themselves; rather, they acquire technology from wherever it is found in the world, including sometimes from their own competitors. These interactions have also led to situations in which some intellectual property (IP) is not held as closely as in the past.

Some elements of IP are readily shared and frequently even given away. In other words, the world of business and industry is becoming more open, and what have emerged are new balances in which companies, and indeed nations both compete and cooperate.

A powerful example of global openness by businesses is found with Apple's development of the iPad. By openly sharing the necessary information about its computational codes and promulgating standards, Apple created a worldwide industry of "App" developers, most of them creative young individual entrepreneurs.

So in many ways, competition and cooperation are the yin and yang of the 21st century. We must do both, and federal policy surely affects our ability to do so

Let me give a specific example: In 2011, the U.S. National Academy of Engineering (NAE) and the Chinese Academy of Engineering (CAE) held a joint meeting of experts in Shanghai to discuss the future of Global Navigational Satellite Systems (GNSS). This is the system of satellites and ground-based facilities that make possible the GPS systems on which we are very dependent today. The Chinese are building a navigational satellite system called *Compass* that will be their equivalent to the U.S. GPS system. The NAE brought a delegation of our top experts from universities, business, DOD, and the State Department, including the individual who led our original project to deploy the GPS system. The Chinese delegation was equivalent in stature and included the government official in charge of *Compass*. Unfortunately, experts from NASA had to withdraw from our meeting at the last minute because of Congressionally imposed restrictions on NASA interactions with the Chinese.

In our meetings, we discussed applications to consumer products, transportation, agriculture, and science. It was noted in particular that the codes that enable civilians to access and use the non-defense U.S. GPS signals are openly published and available to anyone, whereas the Chinese codes that would make possible similar uses of COMPASS were closed and unavailable. If we could make commercial and scientific use of both the U.S. and Chinese systems, the redundancy would improve accuracy, coverage, reliability, and safety for all. A highlight of the meeting was when the founder and CEO of one of our largest GPS companies explained that in the U.S. the role of the government is to launch and maintain the satellite system and provide open codes for its use. Entrepreneurs and others in the private sector then find useful applications and bring them to market. I believe that such open discussion and cooperation, as well as market-based competition, should characterize interactions in the 21st century.

Although I have no basis to claim direct cause and effect, soon after this joint meeting, the Chinese made the codes for *Compass* openly available. This is what I mean by both competing and cooperating.

CLOSING COMMENTS

It has been my intent to present a case for maximizing openness in science, technology, and education, as well as to present both historical and current policies that sometimes get in the way. How should universities and other research institutions respond to outdated or misapplied federal policies? I believe the answer has three simple parts, and my colleagues and I tried in my years as MIT's president to follow them:

1. Obey the law.
2. Reject grants or contracts incompatible with institutional values.
3. Analyze and give voice to needed reforms in federal policy or its implementation.

The views I have expressed here are mine, but they are very consistent with recent work by the National Academies. In particular, I commend to you our 2009 report, *Beyond Fortress America: National Security Controls on Science and Technology in a Globalized World.* The highly experienced committee that drafted that report was co-chaired by Gen. (ret) Brent Scowcroft and Stanford president John Hennessy. Its opening passage makes its general findings clear:

> *The export controls and visa regulations that were crafted to meet conditions the United States faced over five decades ago now quietly undermine our national security and our national economic well-being. The entire system of export controls needs to be restructured and the visa controls on credentialed foreign scientists and engineers should be further streamlined to serve the nation's current economic and security challenges.*

Beyond Fortress America, presents four specific findings and three recommendations, each with several specific action items that would be required for its implementation. The recommendations themselves are:

> **Recommendation 1**. *The President should restructure the export control process within the federal government so that the balancing of interests can be achieved more efficiently and harm can be prevented to the nation's security and technology base, in addition to promoting U.S. economic competitiveness.*

> **Recommendation 2**. *The President should direct that executive authorities under the Arms Export Control Act and the Export Administration Act be administered to assure the scientific and technological competitiveness of the United States, which is a prerequisite for both national security and economic prosperity.*

> **Recommendation 3**. *The President should maintain and enhance access to the reservoir of human talent from foreign sources to strengthen the U.S. science and technology base.*

As I noted, the Scowcroft-Hennessy report contains details of many specific actions to implement these broad recommendations.

Mr. Chairman, thank you for the opportunity to present this testimony. I would be pleased to entertain questions.