



IMPACT STUDY and REPORT
RESTRICTIVE TRAVEL POLICY
PROJECTED IMPACTS to MISSION-CRITICAL GOALS

December, 2015

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Executive Summary

PMIC Incorporated (PMIC) is honored to have been selected by the United States Government to conduct this Impact Study and Report. PMIC conducted this work to fulfill the actions recommended in the United States General Accountability Report to Congress, “***Defense Science and Technology: Further DOD and DOE Actions Needed to Provide Timely Conference Decisions and Analyze Risks from Changes in Participation***” (GAO-15-278).

The objective of this Impact Study and Report is to comply fully with U.S. Government recommendations in GAO-15-278 to “establish time frames for providing conference request decisions” and “develop a plan to analyze and periodically reevaluate risks from conference participation changes.”

This Impact Study responds to the key research requested by the GAO: To what extent does government S&T compliance with OMB 12-12 restrictive travel policy impact mission-critical outcomes in health, safety and national security and defense; and what are the broader consequences over time to U.S. national economy, workforce and global technology leadership if the government S&T community remains subject to the restrictive travel policy?

This Impact Study and Report examines the role of governmental Science, Engineering and Technology (S&T); the evolution of the restrictive travel policy; and the costs associated with the policy. PMIC obtained primary data from government S&T, government non-S&T, technical experts, private industry leaders, academic professional society, and private industry subject matter experts (SMEs); secondary sources included government, technical and professional publications, including findings from GAO-conducted research identified in GAO-15-278.

PMIC’s findings indicate that the restrictive conference and travel policy threatens to undermine the nation’s international scientific, technical and economic leadership status. The absence of U.S. government scientists creates a void in global innovation and collaboration that will likely be filled by our competitors unless we act swiftly and decisively to remediate damage and mitigate inevitable further risks to government S&T force mission-critical goals attributable to restrictive travel policy.

PMIC Recommendation: Government S&T be exempt from the OMB 12-12 restrictive travel policy predicated on two key facts:

- **First and foremost: PMIC finds the Scientific Method *necessitates* collaborative procedures through a robust, personal exchange of knowledge among S&T members from different fields; technical and professional society conferences provide mission-critical venues for face to face interaction that cannot be replicated by telecom, web-based sessions or other remote methods.**
- **Second, the risk of malfeasance on the part of governmental S&T members is extremely low, and the return on investment of their collaboration is extraordinarily high.**

Foreword

There is nothing which can better deserve your patronage than the promotion of Science and Literature. Knowledge is in every country the surest basis of public happiness.

- ***President George Washington, Inaugural Address***

As U.S. grade school children learn, the key to United States Independence was the innovation of Revolutionary War heroes who refused to follow British rules of engagement by lining up in formation to be slaughtered. Today, the United States of America continues to lead the globe in innovation because the inventive, entrepreneurial and patriotic spirit that drove our founding fathers continues to this day. Of the duties ascribed to the federal government by the United States Constitution, perhaps none is more central to the preservation of the union than the duty to provide for the national defense. Our national ascent to superpower status can be largely traced to a series of policy decisions before, during and after the Second World War that led to advances in vaccine development and the eradication of polio, the Manhattan Project's development of the nuclear industry, aviation and space programs, and, more recently, advanced communications networks like GPS and technologies that undergird the Internet.

From equipping heroes who risk life and limb to defend cherished national freedoms and rights, to funding research that led to global leadership in health care, drugs, technology, entrepreneurship, higher education, prosperity and longevity, federally-funded Research and Development (R&D), conducted by the world's finest scientists, engineers and technologists, paved the way for unprecedented U.S. advancements.

The Return on Investment (ROI) to United States citizens on our investment in science and knowledge is incalculable. ***The Human Genome Project alone had a 140,000% ROI.*** The Internet paved the way for Google, Facebook, and countless commercial applications of a government invention. Americans are safer, healthier, better-educated, more prosperous and more advanced scientifically and technologically than any other nation on earth because in doing its job to protect and defend the citizens of country, U.S. S&T also gave the nation the Radar, GPS, the world's safest food supply, cures for once-fatal illnesses, disease prevention, safe workplaces, better schools, safer air travel and global acknowledgment as the world's greatest economic and military superpower.

It is equally important to consider the potential damage to our nation if we fail to heed the advice of our Founding Fathers and renege on our commitment to invest in knowledge. What would the ripple effect to U.S. be had China invented the Internet? Of greater concern, what could the impact to U.S. interests be if China or another nation were to invent the NEXT ground-breaking innovation? The U.S. is starting to feel the impact of other nations' increased investment in scientific collaboration. The likelihood of falling behind in mission-critical thought leadership is projected to be quite high. The negative impact to the U.S. is projected to increase dramatically the longer U.S. S&T is absent from the collaborative world stage, upon which the process of scientific advancement is carried forth.¹

¹ Please see "Innovation Gap" Tables in Appendix

Methodology

PMIC obtained primary data from government S&T, government non-S&T, academia, professional society, and private industry subject matter experts (SMEs); secondary sources included government, technical and professional publications; PMIC reviewed secondary data sources including findings from GAO-conducted research identified in GAO-15-278.

To arrive at the projected impacts detailed in the Impact Study and Report, PMIC reviewed and analyzed 272 primary sources of data which included: surveys of more than 10,500 members of the Governmental and Non-Governmental S&T Community; 88 secondary source documents such as government reports, national and trade print media, and technical journals; and U.S. Government and Non-Governmental Organizations (NGOs) statistics; and scientific publications.

Appendices include Comments, Data Sources, and acknowledgements of the many individuals who contributed their first-hand subject matter knowledge and experience, which enabled PMIC to correlate data findings to insights from independent experts.

The Study and Report includes an analysis of the Return on Investment in government S&T for the United States and projects the impact to S&T ROI if current policies remain unchanged. The Impact Study and Report projects impacts to the United States health, safety and national security, as well as broader implications for United States global standing in the areas of technology, national security and the economy. The Impact Study and Report concludes with PMIC recommendations.

Subject Matter Expert Interviews

PMIC conducted independent research and interviews of Subject Matter Experts (SMEs) across a number of categories and fields. PMIC weighted the projections of the most senior Government S&T SMEs heavily, because their personal experience enabled them to provide counter-factual projections based on actual prior events and inventions specific to their area of expertise. PMIC also took into account these experts' first-hand assessments of current mission-critical impacts and unintended outcomes of the restrictive travel policy.

PMIC separated SME sources into the following categories:

- **Core Impact Study Group:** Consisting of Government S&T experts, Professional Society members, and Academics who have been identified by the DOD and whose credentials reveal them as highly reliable and reputable sources of information.
- **Government S&T:** Consisting of members of governmental S&T community across agencies, primarily those related to Health, Safety and National Defense.
- **Government Non-S&T:** Consisting of knowledgeable non-S&T government employees, primarily with agencies related to Health, Safety and National Defense.
- **Academia:** A survey group of academics well as PhDs within the STEM fields including those who opined through an online repository. Also, responses were gathered from a deeper dive within select non-STEM as well as top ranked STEM universities.
- **Professional Societies:** Professional societies whose conferences bring together significant diverse S&T SMEs, particularly those related to Health, Safety and National Defense in the United States.

- **Private Industry:** Consisting of highly skilled leaders within privately owned companies who work and contribute to S&T in the United States within the Health, Safety and National Defense.

PMIC Sources

- Interviews with S&T community members within in Government, Academia, Private Industry and Professional Societies
- American Association for the Advancement of Science (AAAS) data URL: <http://www.aaas.org/yourstory/submissions>
- Government S&T community attendance records at key professional conferences (data provided by Government S&T entities, and separately by Professional Societies)
- Interviews of S&T Subject Matter Experts
- FDA Data (10,000+ survey) Research and Findings
- ARL Budget; Comparison of Budget to Presentations, and Research
- NIH Conference Attendance Data
- Academic and Professional Journal Publications
- R&D Budget Analysis
- Research Presentation, Paper Authorship and Patent Analysis
- Journalistic Reports
- Government Statistics
- Interviews with non-S&T health, safety and national defense sector SMEs
- Public data sources and knowledge repositories

**Please see Appendix I for a comprehensive list of sources.*

AAAS Professional Societies Surveys

The American Association for the Advancement of Science (AAAS), an international non-profit organization “dedicated to advancing science for the benefit of all people” gathered primary source data by requesting submissions on a dedicated URL, www.aaas.org/yourstory.

AAAS provided PMIC with the raw data collected through the URL, which contained 162 entries. To quantify the findings and separate them by sector and risk area, PMIC conducted six reviews of the data which counted keyword specific to the sector under review. Coupled with an independent analytical review of the narrative, the keywords revealed patterns and trends relevant to the sector under study (health, safety, and national defense and security); and broader risk area (U.S. economy, workplace, and technology leadership).

Of that total, PMIC deemed three as non-responsive or unreliable because the source was missing or because the information provided was unrelated to the query. PMIC separately coded each entry to identify source (academic, government, media, private industry, S&T) and applicable sector (health, safety, and nation defense). PMIC also noted possible attendant impacts on broader risk areas of technology, workforce and U.S. economy.

Projections and Counterfactual Analyses: S&T Community Survey

PMIC conducted interviews with Subject Matter Experts through telephone interviews followed by a one-question survey: “Assuming restrictive travel policies continue, what are your predictions related to

the efficacy of governmental S&T work in your field (health, safety, national security, and/or global technology innovation) and why?"

The quantitative data obtained was linked to the qualitative data obtained through the SME interviews to confirm or corroborate the projections via triangulation, to provide detail and elaboration to the analysis, and to provide a strategic comparison across data sets to identify deviant cases.

PMIC conducted SME interviews with individuals in Government (DOD and non-DOD), academic institutions, private industry and professional societies.

Professional Society Surveys

PMIC requested information related to government S&T attendance at "Influential Conferences" from 33 professional society representatives. PMIC aggregated the data and applied the average decline to inform the baseline assumption of overall Government S&T decline since the inception of the restrictive travel policy.

PMIC also conducted telephone interviews with six (6) professional society points of contact to obtain context or clarification regarding data provided. Several professional society leaders provided additional relevant commentary as included in the comments section of this report.

PMIC used the average decline to project the future state based on the number of mentions by Government S&T community members who no longer take the time to request conference approval, the average decline is likely to be a conservative estimate.

Academic Data Analysis

PMIC reviewed information from eighty one (81) members of academia from sixty-eight (68) separate colleges and universities in the U.S. and overseas. These included respondents to the AAAS URL, interviews of a team of Georgetown Medical School residents who rotate through the VA hospitals and conduct data mining research using VA records. PMIC conducted a survey of professors and academics who were asked two questions: "Do you think it is important for government S&T to attend technical and professional conferences? Why or why not?"

Science, Technology and the Constitution

A thorough analysis of the impact of limiting United States Government S&T access to technical and professional conferences required two preliminary steps: 1) examination of the nature of the Scientific Method itself; and 2) an analysis of the “mission-critical” function of Government S&T, particularly in relation to the Constitutional mandate that the federal government defend the American people from harm.

The Scientific Method: Collaboration is Procedure

The Scientific Method is a human invention that has saved countless lives, bought cultures together, and underlies the greatest achievements of humankind. Webster’s dictionary defines “Scientific Method” as: “*principles and procedures for the systematic pursuit of knowledge*”

Scientific Method *procedures* include experimentation, replication of results, scrupulous adherence to evidence, and a willingness to have others prove hypotheses true or false. Face to face collaboration among scientists from different disciplines and backgrounds is an essential procedural component embedded within the scientific process that leads to discovery and invention. **99.7% of the 262 discrete data points PMIC analyzed cited "collaboration" as essential to their work, and 75% mentioned "chance encounters" at conferences as catalysts for discovery and invention.** More than **97% of the diverse SME survey group concur that the loss of technical and professional conference collaboration opportunities poses a serious threat to the United States.**

The preponderance and unanimity of data led PMIC to conclude that collaboration among scientists from different fields is a vital *procedure* embedded within the Scientific Method. Preventing scientists from attending technical and professional conferences to connect with other brilliant minds is equivalent to banishing a cardiologist from the hospital. Sooner or later, patients will die. When scientists cannot meet to exchange ideas, the Scientific Method itself may die, too.

Government S&T: Mission Critical Defending the Nation

According to the GAO, “The United States depends on science, technology, and engineering to help protect the American people, advance national interests, and prepare to meet the challenges of an uncertain future.”² Members of the nation's S&T community reject higher wages and more freedom in the private sector for two key reasons: 1) the opportunity to conduct ground-breaking basic research underlying myriad innovations that fuel the nation’s economy and defense; and 2) they are *patriots* who believe in and are willing to make personal sacrifices to protect and defend the principles of respect for life, liberty and the pursuit of happiness that represent the U.S. citizenry’s shared values as a people.

In 1979 Manhattan Project mentors encouraged now-Secretary of Defense Ashton Carter to take a year off from academia to join a team of scientists at the Congressional Office of Technology Assessment. According to Secretary Carter, “**They had it in their blood that there was a public responsibility that went with being a technologist, and that was bred into my generation.**”² Source: *Wired*.

² U.S. Government Accountability Office Memo *Defense Science and Technology: Further DOD and DOE Actions Needed to Provide Timely Conference Decisions and Analyze Risks from Changes in Participation* (GAO-15-278), page 1

As Secretary Carter demonstrates through his service, the U.S. has protected our warfighters and citizens thanks in large part to the collaboration that occurs among government, technical, academic and private sector members of the S&T community. The United States of America also has a moral and Constitutional obligation to provide our military with the very best weapons and equipment available. There is consensus among DOD and other nation's defense entities that developments in science and technology will play an increasingly important role in military affairs.³³ **Members of the Government S&T Community attend technical and professional conferences with the sole motive of collaborating with peers to fulfill their mission-critical goals.**

The outputs of U.S. government S&T collaboration is knowledge, discovery and invention that not only strengthens our defense, but also fuels much of the United States economic prosperity and global leadership by investing in basic research upon which military and commercial applications are based. For example, the Internet is ubiquitous. Many Americans do not know that the Internet was borne of the 1969 invention of ARPANET, a United States Government S&T innovation. The likelihood of private industry investing in basic research needed to create the next Internet – or future innovations like secure networks to protect vital United States defense intelligence – is virtually nil because private companies must satisfy short-term shareholder expectations, not investments that might yield tremendous Return on Investment over time.

The Return on Investment in Science, Technology and Engineering to the United States cannot be measured in its totality; however, several studies have indicated the potential impact. **The \$3.6B public investment in the Human Genome Project yielded a 140,000% ROI between 1988 and 2003** in terms of economic output and new industry creation. **Each dollar of federal investment leads to a 32-cent increase in private medical research investment as discoveries diffuse out of academia and filter into the market.** A Science Press study found that NIH-sponsored research was more likely to be considered “advanced,” “novel,” or be related to “orphan diseases” than entirely privately funded drug research. This means that the NIH not only supports an ecosystem of business and innovative companies, but the innovation that comes out of this research is more likely to be novel and substantial.⁴ Additional examples below illustrate the ROI of U.S. cutting-edge R&D⁵:

Defense Advanced Research Projects Agency, or DARPA: 1958–present

- Founded in response to the launch of Sputnik to ensure the United States had cutting-edge military technology, the Defense Advanced Research Projects Agency now operates as a small R&D team within the Department of Defense, delivering world-leading technology both on the battlefield (stealth fighter jets) and off (the Internet). Describing itself today as “**one hundred geniuses connected by a travel agent**,” DARPA works with universities and teams across the country to push scientific boundaries, on projects like human exoskeletons and mobile robots capable of performing medical operations.

³ ***Chance Favors Only the Prepared Mind: The Proper Role for U.S. Department of Defense Science and Engineering Workforce***, Coffey, 2013, Center for Technology and National Security Policy, National Defense University

⁴ <http://scienceprogress.org/2011/05/investing-in-innovation-pays-off/>

⁵ “***INNOVATION: The High Return on Investment for Publicly Funded Research***,” by Erickson, Pool, 12/10/12, ***Science Progress***

- **What we invested:** \$246 million in the first appropriation in 1962. Investment has continued, reaching nearly \$3 billion, or 0.02 percent of GDP, in 2012.
- **What we got:** Pioneer technologies that brought us the Internet, the Global Positioning System, and Siri.

Department of Energy labs: 1943–present

- Founded in 1943 to address the need to mobilize our nation’s scientific assets to support the war effort—including the Manhattan Project and development of radar—and then afterward to consolidate and repurpose our national investments in military research.
- **What we invested:** A few million dollars in the early 1940s, growing to about \$5 billion, or 0.03 percent of GDP, in 2012.
- **What we got:** The optical digital recording technology behind all music, video, and data storage; fluorescent lights; communications and observation satellites; advanced batteries now used in electric cars; modern water-purification techniques that make drinking water safe for millions; supercomputers used by government, industry, and consumers every day; more resilient passenger jets; better cancer therapies; and the confirmation that it was an asteroid that killed the dinosaurs 65 million years ago.

National Science Foundation: 1950–present

- The National Science Foundation was founded “to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense.”
- **What we invested:** \$3.5 million for its first full year of operation in 1952 (roughly \$29 million in 2012 dollars), growing to \$7 billion, or 0.05 percent of GDP, in 2012.
- **What we got:** Google, which was started by a couple of students working on a research project supported by the National Science Foundation, is today worth an estimated \$517 billion. Apple is worth more than \$650 billion, and together these companies employ more than 120,000 people. These alone would pay for nearly all the program’s costs reaching back to its inception, but funding has also been instrumental in the development of new technologies and companies in nearly every major industry, including advanced electronics, computing, digital communications, environmental resource management, lasers, advanced manufacturing, clean energy, nanotechnology, biotechnology, and higher education.

Human Genome Project: 1988–2003

- Started as a joint project between the Department of Energy and the National Institutes of Health, the Human Genome Project ultimately helped coordinate the work of scientists in countries around the world to map the human genome.
- **What we invested:** \$3.6 billion, or approximately 0.005 percent of GDP over 15 years.
- **What we got:** Critical tools to help identify, treat, and prevent causes of disease—and huge opportunities for the high-growth American biotechnology industry, which accounted for more than three-quarters of \$1 trillion in economic output, or 5.4 percent of 2010 GDP, and now depends heavily on these advances in genetics.

Planned Serendipity: Collaboration in Science

Innovations can effectively achieve the outcomes that citizens want and deserve, including technology solutions, such as ‘smart’ asthma inhalers that pinpoint hotspots for improved air quality, or digital government platforms that put state services in the palm of every citizen’s hand.

- A New Paradigm for Government: Adopting an Outcomes Mindset, 11/6/15, Cecilia Muñoz, DJ Patil

Since pre-Revolutionary War days, American patriots have contributed to our national security and defense, often making quiet sacrifices to ensure the protection of life, liberty and pursuit of happiness of their fellow citizens and the nation as a whole. The most brilliant minds in the country forgo wealth and unfettered access to peers to protect our nation’s warfighters. Without the process of collaboration among peers, many of the advances that have made their way into American’s daily lives – from advanced prosthetic limbs to lasers to GPS navigating systems to iPhones – would not exist.

Subject Matter Experts from the highest levels to junior scientists and technologists across **100% of surveyed groups** – *private industry, academia, GOV S&T, GOV non-S&T, and professional societies* – **cited the loss of a “problem rich environment” as a grave consequence of the loss of U.S. government S&T participation resulting from the restrictions placed on U.S. Scientific Collaboration.** Of 159 submissions to the AAAS request for information, 157 cite restricted access to technical and professional conferences and collaborative venues as a serious issue. The most often-cited risk was ***loss of opportunities for “chance” encounters that could yield what one scientist described as “a mission-critical nugget of discovery.”***

Science has always been intrinsically and intensely collaborative. Virtually every major advancement requires coordinated teams of scientists working to solve problems arising in different fields in service of the larger project. Scientists often quote Louis Pasteur’s observation, “Chance favors the prepared mind,” to describe the phenomena of “planned serendipity” that occurs when cross-disciplinary scientists gather face-to-face to share ideas, think out loud and create new insights that increase our knowledge of the world. Such chance encounters have real-world impacts, as evidenced by the many comments included in the Appendix and the following example:

Max Planck Florida Institute for Neuroscience: With knowledge of how enrichment protects the aging brain we can work toward preventing dementia. It took getting outside my lab, my circle, my institution, to see this amazing finding for what it was. It took talking to people outside of what I was buried in, to understand what I was buried in. At the Max Planck Florida Institute for Neuroscience, we have a saying: “Neurons never function in isolation and neither do we.” Science is one huge collaborative effort, a conversation that needs conferences and meetings to thrive.

The public sector, academia and the private sector – independently and apolitically – agree that ***face to face collaboration is an essential component of the scientific process*** and that members of the Government S&T community are vital to national interests. The following examples represent a fraction of the benefits federal S&T conference collaboration contributes to U.S. national security, safety, technology, public health and global standing.

Benefits of U.S. Government S&T Conference Participation

- Every source group surveyed mentioned the benefits of a “problem rich environment” that exists only when S&T members from different fields collaborate at conferences. Information exchange through collaboration at scientific and technical conferences happens significantly faster than through published journals, leading to more rapid innovation.
- Federal researchers who participate in formal presentations associated with conferences are exposed to thought-provoking questions and comments from fellow researchers and are engaged in informal conversations that often develop into collaborations.
- Many science and technology conferences provide undergraduate and graduate students with an opportunity to present their research through poster sessions, allowing federal researchers and program managers an opportunity to recruit prospective researchers.
- Conference paper authors present and publish their work to gain credibility in their respective field, increase industry exposure, foster collaboration, and to advance research. For many, conference participation and leadership are required for career advancement, peer recognition, awards and programs.

In the words of a decorated veteran (Lt. Col, U.S. Army, Ret), ***“To reduce funding that enables government scientific collaboration is to renege on our promise to our warfighters and their families, and to ignore our obligation to secure our homeland.”***



THE TIME TO ACT IS NOW

The United States needs strong and sustained investments in Government S&T R&D



Policy: Roots, Evolution, Costs

The OMB May 2012 Memo M-12-12 conference and travel policy has had a profound impact from 2012 through 2015 on government, academia, and private industry S&T professionals. An outgrowth of public spending scandals that garnered widespread national attention, the intent of the Memo was to ensure that American tax dollars were spent judiciously.

A review of the root cause of the policy, the misuse of taxpayer dollars by several non-S&T agencies, led PMIC to conclude that OMB acted swiftly and decisively to curtail government waste by issuing Memo 12-12, which was itself a response to a 2011 Executive Order requiring “Efficient Spending.” PMIC further notes that OMB issued additional instructions in January giving agencies more flexibility to reduce burdens and streamline the process. As detailed in GAO-15-278, the U.S. Government recognized the potential risks of the loss of U.S. government S&T community’s contribution to U.S. health, safety and national security as an unintended consequence of OMB Memo 12-12. On September 23, 2015, the DOD issued a 14-page Conference Guideline 3.0 to “balance the continuing requirement to exercise responsible stewardship of taxpayer money with the ability of commanders/directors to manage professional development.”

Although DOD guidelines and revised DOE conference approval guidelines are intended to mitigate risk while streamlining conference approval, PMIC believes government S&T should be exempted because collaboration is a **mission-critical training procedure** that is essential to the Scientific Method, as opposed to non-essential retreats or optional off-site meetings. The government and many agencies have made important progress in establishing the appropriate balance between fiscal responsibility and vigilance in national security. PMIC believes the government demonstrated both responsiveness and innovation in soliciting a data-driven impact study to provide independent analysis of unintended risks resulting from the policy.

PMIC evaluated the costs, risks, and benefits of U.S. government S&T participation at technical and professional conferences. PMIC’s analysis finds the U.S S&T brain trust is at risk because compliance with the well-intentioned OMB Memo 12-12 **already obstructs** DOD S&T’s ability to accomplish mission-critical goals **today**.

PMIC’s recommendation is that government S&T be exempt from the policy predicated on two key facts. First and foremost is that the Scientific Method *necessitates* the collaborative procedure through a robust, personal exchange of knowledge among S&T members from different fields. This finding was true among every group surveyed and more than 95% of data analyzed. In short, government S&T cannot do their jobs if they do not participate fully in conferences, including those hosted by Professional Societies who were formed to create venues to foster such innovative collaboration.

Second, the risk of malfeasance on the part of governmental S&T members is extremely low, as was evidenced after a pre-policy conference in Las Vegas attended by a large group of scientists. As reported in the media, at the conclusion of the conference, the hotel owner contacted the conference host with a request that the scientists never return. The reason for the request was because the scientists spent every waking hour during the conference in the collaborative procedure, “they didn’t spend enough in the casino.”

Unless U.S. Government S&T community is exempted, the restrictive travel policy is likely to have increasingly dire consequences to U.S. mission-critical interests in the areas of health, safety and security and national defense. The projected likely consequences to the U.S. national economy, workforce and global technology leadership are equally perilous to the United States.

U.S. Government S&T Costs

The costs of U.S. Government S&T Travel comprise an astonishingly small percentage of the total budget; conversely, the Return on Investment is extraordinarily high to United States interests.

Using the NIH data and the federal R&D budgets by agency, PMIC estimates the total costs of S&T outside conference registration, travel and other costs and compare those to the total government spend.

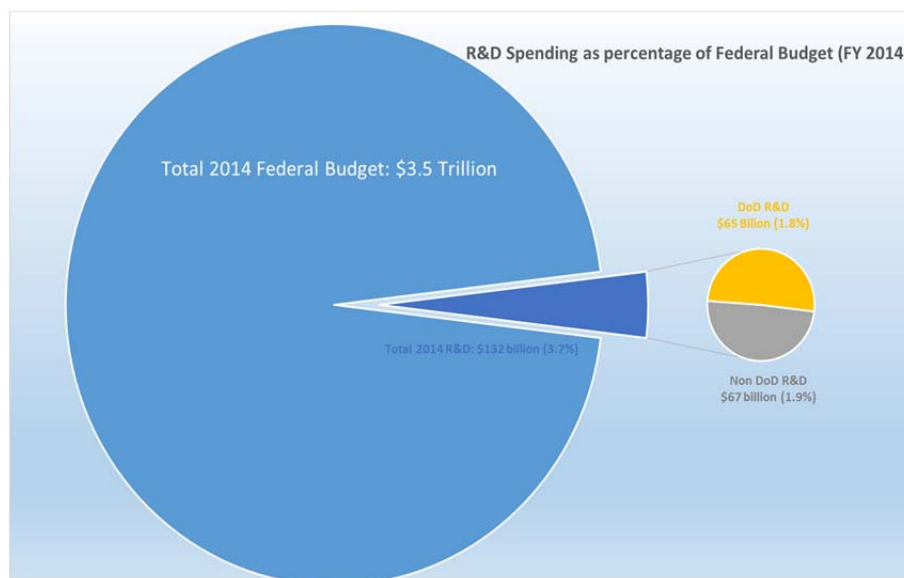
- NIH conference travel and associated costs: \$89.4M
- NIH total R&D budget:\$29.6B
- NIH conference travel and associated costs represent 0.3% of the total NIH \$29.6B R&D budget

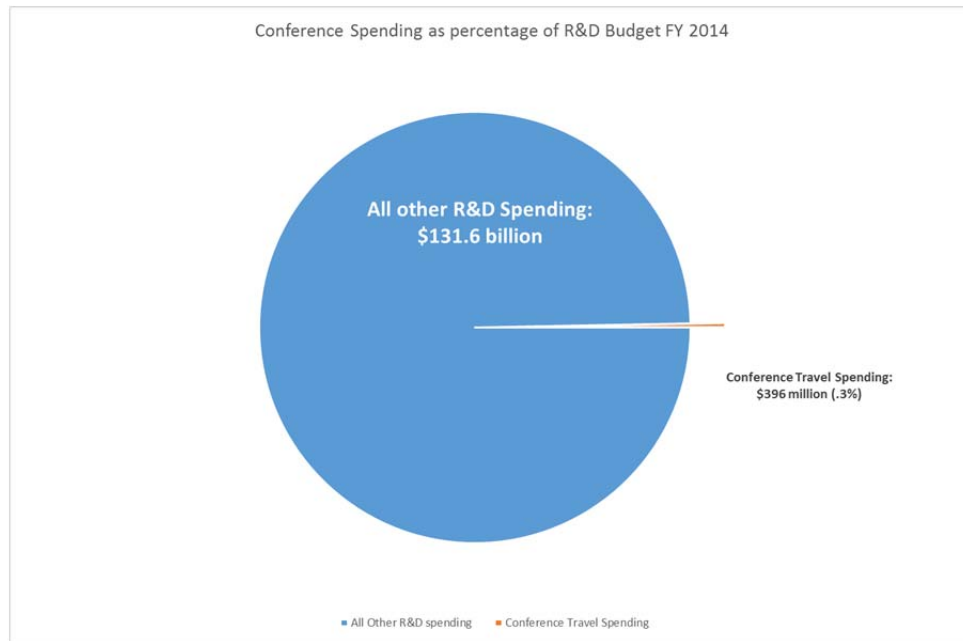
Total S&T outside conference costs (including registration, travel and other costs):~ \$396M.

- \$396M is 0.3% of \$132B All GOV R&D budget
- ***\$396M is .01% of the \$3.5T total Federal Budget (1/10,000)***

Baseline Numbers:

- | | |
|---|---|
| - 2014 Federal Budget (total): \$3.5T | - DoD R&D as % of DoD total Budget: 11.25% |
| - 2014 DoD Budget: \$578B | - DoD R&D % of All Gov R&D: 49% |
| - 2014 DoD R&D: \$65B | - All Gov R&D % of total Federal Budget: 3.7% |
| - 2014 All Gov R&D: \$132B | |
| - DoD R&D % of total Federal Budget: 1.8% | |





Decline in Conference Attendance

PMIC aggregated government conference attendance data provided by Professional Societies and calculated the overall average year over year decline pre- and post-policy implementation. PMIC reviewed data pertaining to attendance records from a sample of “Influential Conferences” as identified by the Core Group of Government and Professional Society Subject Matter Experts.

To assess the impact of the conference policy, PMIC first assessed the actual decline in government S&T participation in technical and professional conferences. PMIC evaluated quantitative data relating to number of government S&T attendees at “Influential Conferences” (sample S&T conferences as identified by the Governmental S&T Core Group) to determine the decline in Government S&T attendees.

An aggregate of Government S&T conference attendees at **eight (8)** Influential Conferences in 2012 vs. 2015 showed an average decline of **28.4%**:

- In 2012, there were 2,549 registrants with .gov and .mil email addresses
- In 2015, there were 1,824 registrants with .gov and .mil email addresses.

PMIC believes the actual reduction is greater than the conservative estimate because the number of individuals no longer requesting conference approval, the number of conferences no longer being held in the United States, and the number of conferences cancelled as a result of the policy cannot be determined with absolute accuracy.

PMIC’s analysis of the data revealed a negative cost-benefit of the policy as applied to the U.S. Government S&T Community. The negative impacts include increased overhead, higher per-person costs, and of grave concern, a loss of morale that is projected to have mission-critical consequences to the US Federal Agencies unless U.S. Government S&T is exempted from the policy. PMIC did not analyze the impact of the policy to non-S&T government agencies, which is out of the scope of this Study.

U.S. Government R&D: Preserving America's Edge

Competitors in the global arms market are increasing R&D funding as the United States is cutting R&D spending. The United States already lags other nations. A major share of R&D research in the U.S. is funded by the federal government. Government R&D spending is seen as particularly important because, unlike the private sector, it funds basic research. ***This is research that often takes years or decades to yield results, but it can also lead to new industries and jobs.***

China is a highly prolific source of research output. In the decade from 2004 to 2014 China's research output has grown more than 400 percent. By comparison, global output during the same period grew 70 percent and in the US, the output increased a little over 30 percent. China's research capacity will continue to grow as their scientists and scholars have access to greater resources. As an evolving player in the academic world - second only to the United States in the number of research articles published - China's steep upward trajectory has been an outcome of a 15-year missive outlined in the State Council's *Mid- and Long-Term Development Plan for Science and Technology: 2006 - 2020*, which aims to create a science and technology engine that is capable of driving 60% of China's national development projects. In order to do so, the council has recommended that R&D expenditure be pegged at 2.5% of the country's GDP by 2020. ⁶

Other emerging economies, besides China, are also spending more on R&D.⁷ According to former Undersecretary of Defense Jacques Gansler, France is the leader in night-vision devices, and the DOD chose an Israeli company to armor their next-generation infantry fighting vehicles. The Organisation for Economic Co-operation and Development (OECD) reports the U.S. is on track to be overtaken by China across all technology and innovation borne of R&D within ten years. Analysis of forecasters over the years found that the timeline projected for China to overtake the United States has steadily decreased. China relies heavily on the United States educational system to train its S&T community. A Chinese scientist describes the benefits of U.S. S&T and the perils of dramatic cutbacks:

*I work on invasive species, which absolutely requires international cooperation and the best exchanges, due to busy schedules, occur at conferences, **and the most influential in my career is the USDA Interagency Forum on Invasive Species.** I have been in China since being awarded an NSF postdoctoral fellowship in 2010-2012, and stayed after extending my fellowships and NSF-funded research projects with "domestic" international fellowships from the Chinese Academy of Sciences and research support from NSFC (National Natural Science Foundation of China).*

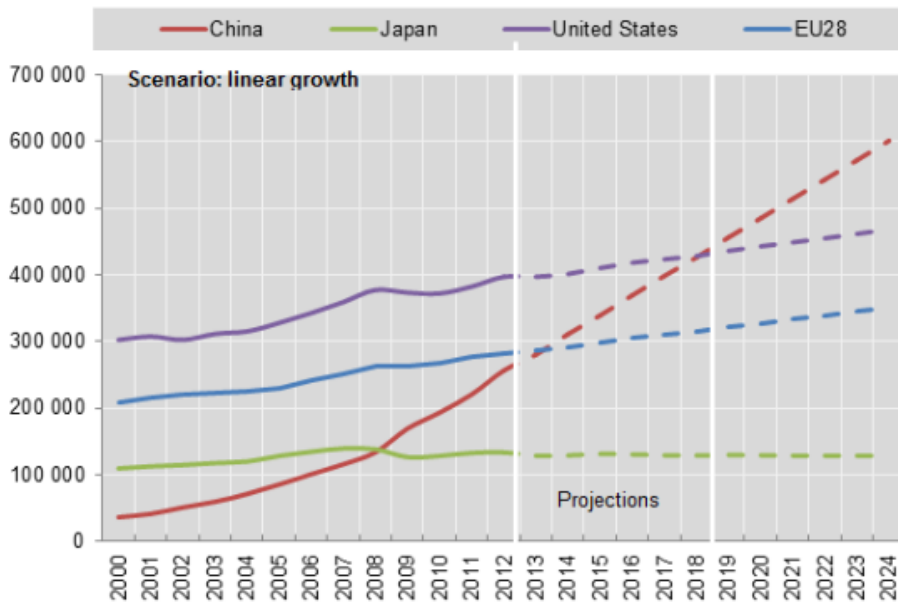
China's universities and research institutes are flush with money for research, travel, and conferences, and although there is plenty of bureaucratic red tape, it is navigable. Many of my superiors run international cooperation projects and work with American (and Canadian) scientists working for government agencies, and their absence from the international stage has really been felt, and international cooperation programs have suffered since all work-related travel, not just conference travel, was restricted. There are smiles of irony among some of the principal investigators here, that a country that had been the leader of science for the world for so long, has a grounded workforce, and China is ever more eager to take a large global role in science. – Institute of Chemistry, Chinese Academy of Sciences

⁶ *Innovations in Science: China Changing the Face of Global Research*, Huff Post Science, 12/4/15, Olivier Dumon

⁷ *China Set To Surpass U.S. In R&D Spending In 10 Years*, Computerworld, 12/24/12, Patrick Thibodeau

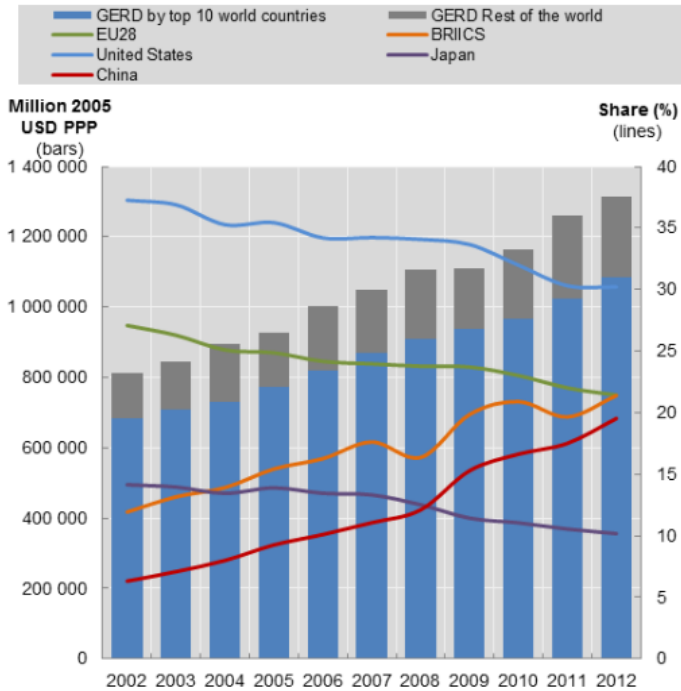
China poised to outpace the US in R&D spending around 2019

GERD, millions of 2005 USD PPP, 2000-12 and projections to 2024



Source: OECD (2014), *OECD Science, Technology and Industry Outlook 2014*, OECD Publishing, Paris.

Share of top players in world R&D spending



Sources: OECD Main Science and Technology Indicators Database, Eurostat and UNESCO Institute of Statistics, June 2014

Projected Impacts: National Security, Health & Safety

National Security: Role of US GOV S&T, Outputs and Projected Impacts

According to Undersecretary of Defense Frank Kendall, “The technological superiority of the United States is now being challenged by potential adversaries in ways not seen since the Cold War.” Undersecretary Kendall further expressed “an overriding concern that our technological superiority is at risk.” (April 9, 2015 Memorandum: “**Implementation Directive for Better Buying Power 3.0 – Achieving Dominant Capabilities through Technical Excellence and Innovation**”)

The United States confronts a real and present danger in the form of ISIS, an enemy that uses the Internet to recruit armies and technology to coordinate, plan and carry out increasingly complex terrorist attacks. These vengeful acts, carried out by fanatics united by the rallying cry “Death to America,” are on the rise in the U.S. and abroad. The relentless onslaught of radicalized fanatics continues to unsettle the free world. The November, 2015 massacre in California is the latest in a series of terrorist attacks instilling fear among U.S. citizens who, along with the rest of the world, turn a steady gaze upon the United States government to solve the crisis.

This war is being waged now, on American soil, through technology. Terrorists have hijacked social media to lure a disaffected, alienated and easily influenced group of young people. *They have turned the Internet into a potential weapon of mass destruction.* The advent of social media has given a global audience to people who put other human beings in cages, pour gasoline on them, and then set them afire; people who distribute videos of themselves sawing a living man's head from his body. Technology enables enemies who want to kill Americans to recruit armies and place boots on American ground through the Internet. Cyberspace is the new battlefield, and America needs the collective brainpower of government S&T to combat this insidious threat.

CASE STUDY: Army Research Lab Comparison of Budget to Presentations

Although the conference travel and participation record of any single department is unlikely to perfectly model the results of the entire government S&T enterprise, sufficient commonalities prevail across the scientific workforce such that value can be drawn from a close look at one department’s experience.

The Army Research Laboratory provided conference and budget data from which we conclude that the 2012 travel policies are responsible for:

1. A severe reduction in Army Research Laboratory scientists’ conference paper production.
 - **In 2012, ARL scientists co-authored 1497 conference papers. In 2014, only 823 papers were co-authored by ARL staff.** (2015 trends indicate an accelerated rate of decline.)
 - ***This represents a seven-year setback in ARL production and is likely an irretrievable loss for the Defense S&T enterprise.***
2. A similarly severe reduction in the number of Army Research Laboratory scientists’ conference paper presentations.
 - **For one conference examined, the historic presentation ratio (papers presented: papers co-authored) approximated 80%.**
 - **In 2012, the ratio dropped to 27%**

- In 2013, the ratio went to zero
 - In 2014, ARL did not participate in the conference at all; not a single paper was submitted that could be presented.
3. A significant reduction (~20%, or 100 accepted papers) in the number of Army Research Laboratory scientists' peer reviewed publications.
 4. An increase in cost per research paper produced. In 2012, the approximate cost per paper was ~\$600K; in 2014 the cost had increased to ~\$875K

The decrease in conference participation and paper production rates cannot be attributed to decreased appropriations: the ARL budget increased 9% year over year from 2011-2012; paper production decreased 4.3% in 2014 (production rates for any given year are closely correlated to budgets two (2) years previous).

Conference Collaboration: Outputs

58 National Security SMEs were identified in AAAS data collection. According to these SMEs, collaboration at professional conferences led directly to the following advancements in national defense that would not have happened if the government S&T members were excluded from collaborating with academic and private industry peers at technical conferences.

- **Improved Battlefield Lethality and Therapeutic Treatments:** U.S. Government basic research and collaboration with peers has led to innovations to improve battlefield lethality. Such innovations include hearing and vision protection, prosthetic limbs and advanced surgical equipment. U.S. government scientists were credited by an industry leader as the reason for supplements rich in DHA to support brain and heart health are being considered by the US Military to prevent PTSD and support the warfighters.
- **Technological and Armament Superiority:** Government S&T are trusted technical advisors who transfer knowledge and gain competency regarding the capabilities and limitations of current technology through conference collaboration. Conference attendance enables government S&T to present our research in order for the technology to transition to industry and thus the warfighter. For example, SPIE's Photonics West and Defense & Aerospace Conferences enable interaction and collaboration with peers, as well as aiding in market surveys for upcoming procurements. According to a Naval Surface Warfare Center scientist, however, *"This knowledge is now challenged due to the lack of focused, intelligent interaction resulting in waning knowledge of developing technologies. Decreased competency results in decreased performance of the NSWC mission."*
- **Adaptation of U.S. Government Research and Inventions to Improve Civilian Living Conditions:** A U.S. scientist reported noise reduction work that began through conference collaboration. This work is important to the health and prosperity of the U.S., since DOD operations are lawfully constrained by land-use impacts produced by noise generated on DOD installations and propagated into neighboring communities. Another example cited by private industry: *"As a result of collaboration with a federal scientists, we are able to gain deeper understanding of jet noise than either of us could do separately. With better insight into the physics, there is hope for creating significantly quieter aircraft engines. We would never have connected at all if we hadn't been at the same meeting."*

PMIC Findings: Projected Impact to National Security

The United States government S&T workforce has been undermined by the travel policies implemented in 2012 because the critical collaboration procedures intrinsic to their profession have been severely curtailed. **There is a high probability that the United States will see its national security and global scientific leadership deteriorate further if the policy is not amended.** Without changes, the current policies are likely to result in catastrophic damage to the national scientific agenda and our national security. In terms of National Defense and Security, projected impacts will accelerate at a potentially exponential rate because of the concurrent ascendance of other nations:

- **Inability to defend the United States from nuclear or bioterror attack caused by reduction in innovation to protect citizens and Warfighters.** Other nations continue to invest in R&D that leads to advanced munitions and armaments and bio-and terror-defense mechanisms. The advances of the interconnected world have led to some vulnerabilities against which U.S. S&T is the best defense; for example without U.S. S&T at the forefront of the war on terror, the likelihood of successful cyberattack or synthetic biology being used to facilitate bioterror increases.
- **Cost overruns and underperformance on weapons, communications, intelligence and other systems currently in development, and costly delays in national defense projects nearing fielding:** Those systems typically take a decade or longer to develop. Without collaborative S&T conferences, those technologies will take longer to develop, driving up cost, or they'll be eliminated from the deliverables, sacrificing performance.
- **US military equipment falling behind those of other nations:** Such a loss will result in potential cancellation of development projects with foreign partner nations, and loss of foreign military sales to superior non-U.S. suppliers. Given the elaborate networks in place in the interconnected world, fast-developing technologies created by other nations are on pace to eclipse U.S. advances, with potentially cascading negative effects to our combat readiness and global status as superpower and defender of Democracy.

Health: Role of US GOV S&T, Outputs and Projected Impacts

The federal government has a dominant role in healthcare funding and innovation. The National Institutes of Health has been a major source of basic science research that provides life-saving knowledge critical to development of innovative programs. As with early stage research that is the hallmark of the Government S&T Community, NIH has spurred innovation in the private sector and fueled advanced treatments for Alzheimer’s, diabetes, and cancer through the discovery and qualification of biomarkers to support drug development.

The Federal U.S. Food and Drug Administration, which straddles the sectors of health and safety, is a major contributor to federal-sponsored interchange that also plays a critical role in innovation and collaboration among the public and private sector.

FDA Travel and Conference Update Findings: Office of the Chief Scientist

Earlier this year the U.S. Food and Drug Administration conducted a survey to determine the impact of the 2012 restrictive travel policy on the FDA’s scientific staff. The survey assessed the importance of attending conferences, the negative impact of not attending conferences and denial of conference attendance requests. The FDA surveyed **10,416 scientists** with a 33.4% response rate.

On March 4, 2015, Leslie Wheelock, RN, MS, Director Office of Scientific Professional Development, in the Office of The Chief Scientist presented the following results to the FDA Science Board:

Importance of Conference Attendance	Negative Impacts of Reduction in FDA Scientists Conference Attendance
Collaboration – 91%	Loss and attrition of best qualified FDA scientific staff – 83%
Learning current trends in the professional field – 96%	Difficulty attracting top scientists to the FDA government service – 76%
Informing others about FDA policies – 70%	Reduced effectiveness of governmental research and review responsibility – 78%
Recruiting new scientists – 37%	Hindered professional development results in slowed leadership development, promotion and career advancement – 57%
Obtaining continuing education credits – 43%	

Conference Collaboration: Health Outputs

53 Health Sector SMEs were identified in AAAS data collection. According to these SMEs, “planned serendipity” arising from their attendance and participation at professional conferences resulted in collaborative efforts crucial to the following health care science advancements **that otherwise would not have happened:**

- **Thousands of Diagnosis, Therapies, Treatments, Cures and Medical Devices** resulted from US government collaboration with peers at technical and scientific conferences. Myriad examples cited include: a new treatment for pediatric neuroblastoma, a new leukemia drug currently in clinical trials, advances in medical imaging, the development of a new research field using *C. elegans* as a model for human disease, and, more than 8 million new dental implants in 2015.

- **Groundwork for Invention of Medicines:** 45 years of federal scientist conference attendance and derivative collaborations led to licensing of compounds and methods to pharmaceutical companies, who then created potentially life-saving medicines. U.S. government S&T also were responsible for basic research that prompted introduction of compounds into clinical trials for the treatment of the virus that causes mononucleosis and various pneumonias; directly led to the publication of approximately 100 papers, and are credited as contributing to at least 45 patent awards.
- **Discovery of Natural Pain Remedies:** Government scientists' conference collaboration with fellow S&T experts from UPenn, UFlorida, Hungary and Israel contributed to the discovery that a natural compound could kill the cells that carry the protein that detects painful stimuli. ***After US government scientists were prevented from participating in face-to-face meetings at scientific meetings, this group fell apart and has not collaborated since, resulting in the potential loss of a valuable therapeutic treatment for pain.***

PMIC Findings: Projected Impact to U.S. Health

The projected impact of the travel restrictions on U.S. health sector is dire, as agreed by more than 90% of the FDA survey respondents. Without United States S&T active participation and leadership, PMIC projects the following potential impacts to United States Health:

- **Inability to contain and cure epidemics.** All projections examined show that the future is one of worldwide populations concentrating in cities. Relatively inexpensive travel and routine shipments of cargo to and from foreign soil have introduced micro-bacterial pathogens that could trigger a catastrophic epidemic, which U.S. Government S&T may not have the advanced scientific knowledge needed to find a cure. As Banning Garrett, PhD, said, "Microbes don't need a visa!"
- **Loss of Skilled Medical Professionals:** The U.S. is currently experiencing a shortage of medical professionals, and the inability to collaborate at professional conferences has been cited as a mission-critical risk by more than 2,000 federal S&T members. If the government no longer attracts the best and brightest from universities, which is already happening as reported by more than 2,000 members of the U.S. S&T community surveyed and corroborated by U.S. Department of Education statistics, this "brain drain" will accelerate, leaving the U.S. at risk of a severe shortage of qualified professionals to prevent, diagnose and treat illness and disease.
- **Inability to Preserve and Maintain National Health:** As the U.S. Population continues to age, the inability to prevent and control age-related loss in cognitive and physical abilities is likely to be hindered, which is especially concerning to a population whose compromised ability to combat illnesses is exacerbated by age.

Safety: Role of US GOV S&T, Outputs and Projected Impacts

According to the powers set forth in the Constitution, the United States government is responsible for establishing critical standards that protect our way of life and our personal and societal safety. The government has no stake in the outcome of the standards setting process apart from its role in fully serving the public interest. Standards control chaos when competing interests vie for control, mitigate hazards, improve efficiency, reduce costs and prevent infrastructure failures.

Projecting impacts to U.S. safety requires a preliminary assessment of the nature of standards themselves. Standards help to determine the efficiency and effectiveness of the economy, the cost, quality, and availability of products and services, and the state of the Nation's health, safety, and quality of life. The United States of America and most governments play a key role in national and international standard setting processes. In fact, given the increasingly competitive global environment, many governments now link their standardization efforts to their trade policies, employing national standards as marketing devices to attract and lock in customers worldwide.⁸

The United States leadership as standard-setter ensures not only the protection of the citizens, but also the economic health of the nation. Other countries manufacture according to U.S. standards, enabling U.S. companies to manufacture and sell products domestically and overseas, and foreign countries vie to capture U.S. market share of products they manufactured in compliance with U.S. standards. Ceding a standard setting role has attendant impacts to U.S. economy, such as the cost of replacing aging infrastructure and retrofitting parts as U.S. standards are abandoned on a global scale. PMIC projects this as a moderate-to-high likelihood based on analysis of the data.

The U.S. Government has a longstanding track record of success in establish standards. Consider the railroad industry, widely recognized as accelerating the industrial age. In 1887, after private railroads' efforts to find common standards by experimenting with extremes ranging from cutthroat competition to pooling price fixing, the United States government stepped in to establish the Interstate Commerce Commission, which ensured the success of this important national industry. (Kolko 1970, Kennedy 1991). Nearly a century later, in accordance with its Constitutional mandate to protect the American people, the U.S. Congress formed the U.S. Occupational Health Safety Administration in 1970 to "assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance."⁹

In the area of accounting, the United States has held a leadership role in corporate governance and standard setting that also is at risk as the economy becomes global. Companies wishing to conduct business in the U.S., particularly those traded on U.S. stock exchanges, must adhere to U.S. Generally Accepted Accounting Principles (GAAP) as established by the U.S. Financial Accounting Standards Board (FASB). For the past decade, as reported by PricewaterhouseCoopers, FASB's agenda has been "***dominated by the goal of converging U.S. GAAP and International Financial Reporting Standards (IFRS).***" IFRS are a set of accounting standards developed by the International Accounting Standards

⁸ Source: *Standards For Standard Setting: Contesting The Organizational Field*, Publication-2050 by Dr. Linda Garcia, Georgetown University

⁹ Source: U.S. Department of Labor: <https://www.osha.gov/about.html>

Board (IASB) that are “*becoming the global standard for the preparation of public company financial statements.*”¹⁰

The United States’ dominance as a world power allows U.S. standard-setting bodies to select which of the standards adopted by many other nations our nation will follow. American leadership and market power is the only thing standing in the way of measurement standards being imposed upon the United States rather than the United States deciding for itself which internal standards are right for our people. If the world turned to another nation as the global standard-setter, the impact on U.S. citizens would be felt across our health, education, defense, economy and even day to day lives. For example, most of the world uses Celsius, not Fahrenheit, to measure the temperature. In the United States, however, when it’s 22 degrees outside, it’s time to hit the ski slopes, not the golf course. If the world looked to another nation to set global standards, the U.S. would have to convert to the metric system and Celsius thermometer, which would be costly in and of itself. Of greater significance, the U.S. also would bear the immense price of retraining our work force and retrofitting the American-based infrastructure, tools and equipment to conform to new global standards as our infrastructure ages.

In terms of global health and disease prevention, the FDA’s process for approving drugs through scientific clinical trials protects the safety of the American people by enabling citizens to see at a glance whether a product has undergone the rigorous, independent clinical trials necessary to demonstrate the efficacy and the side effects of approved drugs. This information informs our medical community and consumers. Because of our standards and our economic impact, other nations’ drug manufacturers aspire to meet FDA approval.

Conference Collaboration: Outputs

29 Safety SMEs were identified as Safety SMEs in AAAS data collection. According to these SMEs, collaboration at professional conferences led directly to the following advancements in standard settings and safety that would not have happened if the government S&T members were excluded from collaborating with academic and private industry peers at technical conferences:

- U.S. federal and private industry collaboration at conferences led to innovations that have **reduced jet engine failure rates by 80%.**
- Federal NASA S&T and private sector scientists collaboration led to the formation of The Gas Turbine Engine Technical Committee. Advancements include improved engine designs, testing procedures, and increased knowledge of the complex physics and properties of high temperature gas flows. Government S&T conference participation helped document thermal protection system test results and provided guidance on how to determine properties of the high temperature test gas flow. Both outputs are mission-critical for advances in vehicular safety and aircraft and rocket efficiency and effectiveness.
- U.S. government S&T and industry collaboration has prevented millions of dollars of losses after fruit harvests that limits fruit production efficiency and reduces food security. Ongoing collaboration – now effectively halted – has resulted in identification of biomarkers that predict disorder risk weeks to months in advance of symptom development. **Commercial utilization of this information would allow producers to market fruit well in advance of symptoms while fruit quality and edibility remains high.**

¹⁰ Source: <http://www.ifrs.com/index.html>

- As a direct result of conference collaboration, a single scientist cited about one hundred (100) publications in journal and proceedings, active participation in elaborating ISO standards, international and national round-robin experiments, and important tests for about twenty (20) NASA and industry developed power systems.

PMIC Findings: Projected Impact to Safety

- **Inability to Ensure Public Health and Safety:** If the U.S. loses its standing as the global standard-setter, the role of the FDA in establishing U.S., and by extension, worldwide standards for drug efficacy and safety will be severely curtailed.
- **Reduction in Air Traffic Safety:** Without training and standards, the safety of U.S. airtravel is projected to be impacted. An example illustrates this impact. As a direct result of Professional Conference attendance, a senior FAA scientist has become an expert in modeling and simulations. He reports, *“Without attending collaborative conferences in Europe, I wouldn't have discovered the current simulation software which has been extremely helpful in advancing concepts for our work in the Air Traffic Industry. Now our young people will be behind the learning curve.”*
- **Safe and Reliable Nuclear Power:** Nuclear Scientists were particularly concerned about the ongoing safety of nuclear power if U.S. S&T are absent from conferences. According to a private sector executive, *“industry conferences are essential to the safe and reliable product of nuclear power. Government employees are critical in this process.”*
- **Vulnerability to Foreign Energy Manipulation:** The United States energy grid is the envy of the world. If the U.S. fails to maintain its leadership in technology, the nation will be vulnerable to sanctions, energy manipulation, and even damage to our energy grid. Based on the data, it is conceivable that the U.S. could one day fall victim to another nation's desire to shut down power to entire cities, disrupting health, safety, food supply and the economy.
- **Loss of US Biotech Leadership:** Scientists cite the overuse of antibiotics in China's food supply as a threat to public safety because an antibiotic-resistant disease, such as bird flu, may mutate and spread globally. Weakened U.S. influence could hinder effective negotiations with China and other nations, where international cooperation is necessary for global wellness. A robust bio-defense program will help the U.S. maintain tech superiority and our readiness to meet these emerging threats.

Findings: Broader Implications

PMIC findings reveal the mission-critical function of government S&T community's participation in conferences not only to the specific sectors and areas identified in the solicitation, but also to the United States' overall place within the global geopolitical and economic landscape. According to the 2012 National Defense University paper *Globalization of S&T: Key Challenges Facing DOD*, "Maintaining an authoritative awareness of S&T around the world is essential if the United States is to remain economically and militarily competitive." (Coffey/Ramberg)

Global Security

In 1948, the Task Force on National Security Organization (the Eberstadt Report) warned, "**Failure to properly appraise the extent of scientific development in enemy countries may have more immediate and catastrophic consequences than failure in any other field of intelligence.**"

Curtailing U.S. S&T travel to technical conferences dilutes the efficacy of our nation's S&T community, even as China and other emerging nations host conferences and increase investment in S&T programs. China reports a tripling of researchers between 1995 and 2008, with substantial growth currently; South Korea doubled the number of researchers between 1995 and 2006 and continues its upward swing.¹¹ This emerging threat to the United States' S&T leadership presents grave national security risks, and imperils our position as a global standard-setter and technological leader. DOD's S&T workforce will experience a material reduction of mission-critical research as a result of the restrictive travel policy, which will accelerate the rate of decline as other nations' continue to invest in basic research. According to the OEDD, China and Korea are now the main destinations of scientific authors from the United States and experienced a net "brain gain" over 1996-2011.

PMIC Findings: Projected Impact to Global Security

PMIC weighted historical data and emerging patterns to inform baseline trends from which to project the future state of our nation compared to others. More than **100 mentions of threats to our global standing were identified in our data analyses. An additional 102 discrete mentions of U.S. loss of international standing, particularly in the area of technology and intelligence.**

These findings correlate with U.S. Government warnings that our adversaries' use of S&T increasingly challenges our nation's capabilities in critical areas¹², including:

- **Cryptography.** The availability and strength of high-grade encryption schemes continue to expand.
- **Assured Space Access.** Foreign countries continue to develop new technologies and methods for disrupting our space assets, necessitating the development of resilient approaches.
- **Cyber Attack and Defense.** As cyber-attacks grow in scale and scope, we struggle to defend against this rising threat.

¹¹ Scientific American, *Diversity in Science: Where Are the Data*, Fred Gutierl, 9/16/14

¹² *Report of the National Commission for the Review of the Research and Development Programs of the United States Intelligence Community*

- **Nuclear Technology and Forensics.** The proliferation of nuclear materials and technology will remain a high-priority national security threat.
- **Global Supply Chains.** Production and distribution chains are increasingly vulnerable to a variety of actions, including intentional disruptions.
- **All-Source Data Analytics.** The volume of data is challenging our ability to process and use it.

Exacerbating these challenges are U.S. policies that weaken the U.S. R&D talent base.

Economic Leadership

The totality of our preeminence as an economic superpower grants the U.S. government the ability to maintain its stature as a global standard setter, and underlies the willingness of other nations' to accord to United States standard-setting authority. Because the most powerful incumbents in a field create the "rules" that others follow, it is mission-critical to our national interests and economic development that the U.S. maintains its stature as the global standard setter.

The small investment cost (**1/10,000th of the federal budget**) of permitting government Scientists & Technologists to travel to professional and technical conferences is counterbalanced by the benefits to the economy commercial application of government inventions and private inventions borne of government-funded research contribute to the U.S. economy. ***Analysis of the AAAS submissions, the SME interviews and the FDA survey of 10, 400 scientists' findings reveal "retention" and "recruitment" as second only to the loss of collaboration as negative impacts of the restrictive travel policy.***

Education directly correlates to the health of a nation's economy.¹³ America was once the global leader in college completion and now ranks 12th in completion rates for young adults.¹⁴ The U.S. government S&T community is comprised of highly educated STEM professionals, many of whom were drawn to government service because of the opportunities to continue their pursuit of knowledge through collaboration with peers. American institutions of higher education attract students from across the globe, many of whom transitioned to the government S&T community that provided the collaborative "petri dish" that is now endangered by the restrictive travel policy. Millennial workers in all professions, not just STEM, rank "training and development" first and "flexible working conditions" second among the most highly valued working benefits, eclipsing wages, vacations, child care and other benefits.

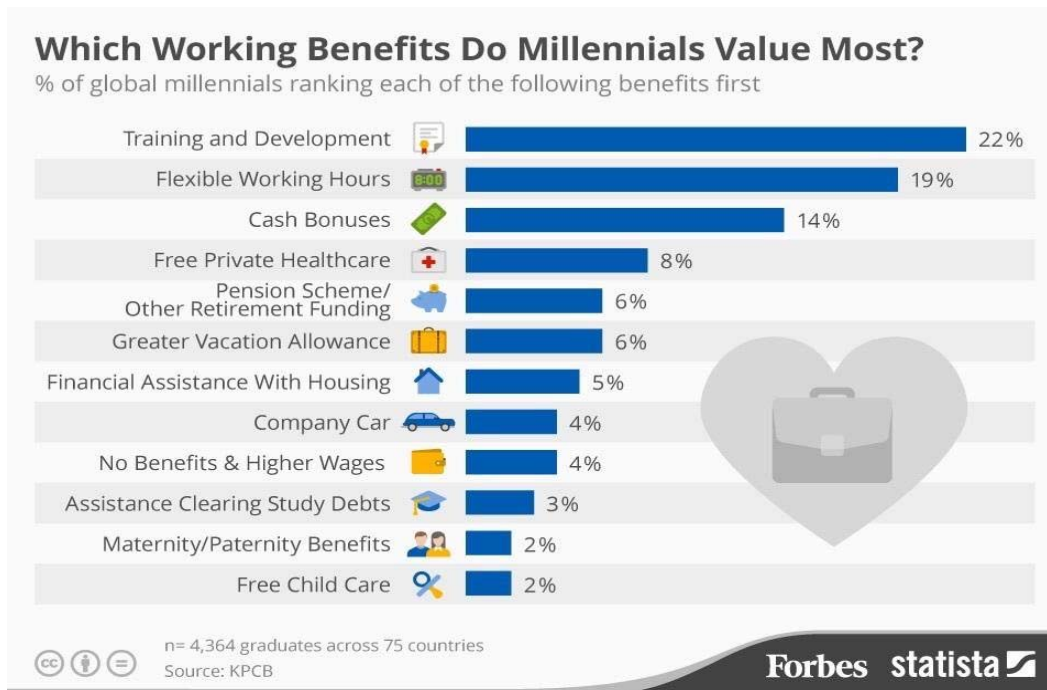
Given U.S. Department of Education reports a third of American students require remedial education when they enter college, and current college attainment rates are not keeping pace with projected workforce needs, the failure of the Government to provide opportunity for junior scientists to collaborate at conferences is likely to increase the brain drain the nation already confronts.

Researchers at the OECD, using bibliometric indicators, noted that there had been an upward rise of scientific authors from the United States migrating to China, South Korea and Chinese Taipei. An emerging brain drain from the United States to Asia is perhaps being exacerbated by a drop in Chinese graduates showing the intention to stay in America after being awarded PhDs or other doctorates. According to the report, between 2005 and 2012 this cohort dropped from 90% to 83%. The early return

¹³ ***Economic Analysis and Research Network Report***, Economic Policy Institute, 8/22/13

¹⁴ *Source: United States Department of Education*

of Chinese graduates could have a significant impact on American research capacity, particularly in science and engineering, as it has long relied on foreign-born talent. The restrictive travel policies present a disincentive to would-be scientists, technologists and engineers to pursue STEM degrees and work on behalf of the United States government.



Conference Collaboration: Outputs

- New Research Fields:** According to a private industry CEO, *“From 2006-2013, government S&T and we developed a community of EDL researchers that had never existed before. Due to travel restrictions, this has nearly come to a full stop. The restrictions that prevent us from having face to face forums for sharing innovations, discoveries and lessons ultimately costs US tax payers money in unnecessary duplication and wasted efforts.”*
- Qualified STEM Workforce:** According to an NRL scientist, *“I can directly attribute my attendance at the AIAA Space 20xx Conferences (particularly the 2008 event) as a strong contributor to introducing me to the world leaders in space robotics, and is the sole reason why I learned about Navy Research Lab and their research in robotics... which directly led to me being offered my current job.”* A Veteran’s Administration’s Training course and conference held in Japan by a Clinical society which was funded by Emory University funded a trip that helped refine a scientists clinical skills, enabling him to run the electroretinogram (ERG) clinic at Emory for the next seven (7) years. A third credited U.S. government training with a successful U.S. private sector career: *“My career began at the Idaho National Laboratory 25 years ago working with nuclear engineering experts in state-of-the-art modeling and simulation. After several years in that environment, an opportunity presented itself to transfer my experience-gained in the public sector to the private sector. That cross pollination reaped immediate benefits for my employer, who encouraged me to maintain my expert network through technical meetings and conferences.”*
- Robust Defense Contracting Industry:** Collaboration among government S&T and private sector counterparts contribute heavily to the economy by providing basic research that leads to

multiple defense and then commercial applications. Boeing cited four examples of invention stemming from collaboration with government S&T at professional conferences, just one of many government contractors crediting government research for underlying applications that provide jobs for thousands of people and create billions of dollars in value.

- **Innovative Public-Private Sector Collaboration:** Only government research can fuel small company goals of application to defense and commercial uses. One small company credited government S&T with creating “an opportunity to showcase multivariate analysis tools and services to a vast array of disciplines *at a reasonable cost compared to much larger companies.*” Another company explained the value of U.S. government S&T to business: “The primary dynamic of the interface between private researchers and government scientist and engineers is as follows: Government technical staff identify problems that their constituents need solved. (e.g. a wand to detect explosives under someone's clothing). Industry comes up with solutions. *Without technical conferences this coordination would be like blind man's poker – guessing what the problem is and guessing about the field of possible solutions defined by papers presented.*”

PMIC Findings: Projected Impact to Economic Security

The projected impacts to the U.S. economy are entangled with impacts to other sectors under study. In the area of national defense, for example, if the U.S. were to fall behind other nation's military advances in armaments and military equipment, the impact would cascade beyond the danger to our troops and national security to our overall economy. Funding S&T collaboration that allows government scientists to do their jobs is essential for the U.S. to remain our customers' top choice for their foreign military purchases. The U.S. is not their only choice. To retain the U.S. competitive advantage in foreign military sales, the Government must make smart, enabling, and strategic investments. PMIC Projects the following as potential **economic** impacts resulting from the policy:

- **Crises of Confidence in Economic System:** As emerging nations like China aggressively vie for economic influence and power, the U.S. public may lose confidence in the nation's financial reporting system. Just 75 years ago, the United States suffered a Great Depression as the result of a public crisis in confidence, and the prospect of a similar economic collapse is likely if investors fled from U.S. exchanges.
- **Mineral Wars:** rare earth metals such as lithium are critical to economic security. China has the world's largest rare earth mineral supply, and this impact correlates with the predicted emergence of China as a global R&D leader. According to a U.S. government scientist, “*Today, battery research is being done at an unprecedented rate, and developments are proceeding faster than can be captured by traditional peer-reviewed publication processes.*”
- **Food Shortages:** Scientists predict invasive species will migrate to new temperate zones, weather patterns will change, and new agriculture disease threats will emerge. Reduced readiness risks critical agricultural failure at a time much of the world relies upon the American breadbasket for basic staples. Because control of the world's food supply correlates highly to economic leadership, PMIC projects serious economic damage if the U.S. should lose its leadership in agriculture, farming and food production.
- **Brain Drain:** Coupled with challenges the government faces in recruiting high-caliber talent to the S&T community as a result of the policy, PMIC projects a high likelihood of an exacerbation of the shortage of STEM workers in the United States. Millennials, the workforce of the future,

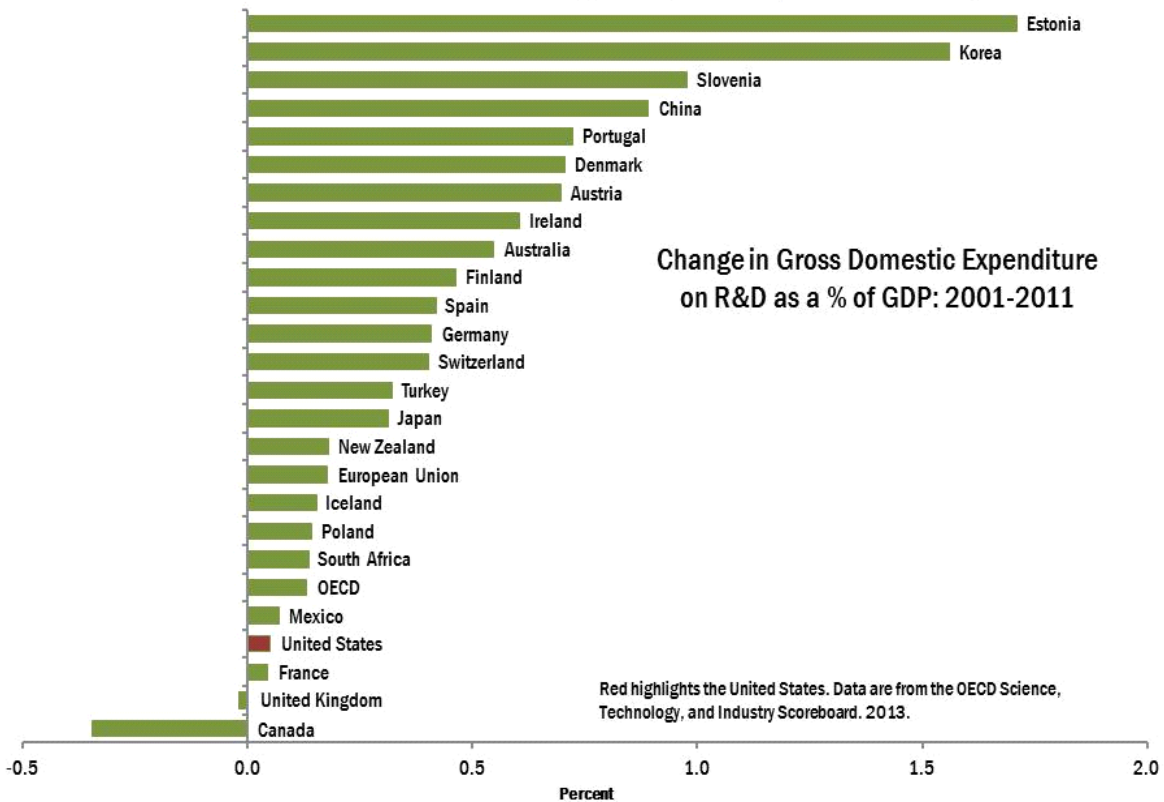
cite training as the top-ranked employer benefit. The loss of access to collaborative venues already is impacting our workforce and U.S. attraction as an employer of choice.

Technical Leadership

Global dependency on technology has long been a double edged sword. Technologists race to invent more secure technology; other S&T teams work to predict how those yet-undiscovered technologies might be hacked. Through collaboration, these brilliant minds shoot down each other’s ideas with the shared goal of creating impenetrable defense systems and technologies. Members of the U.S. GOV S&T are on the frontlines, collaborating to defeat the enemy on the new battlefield of cyberspace.

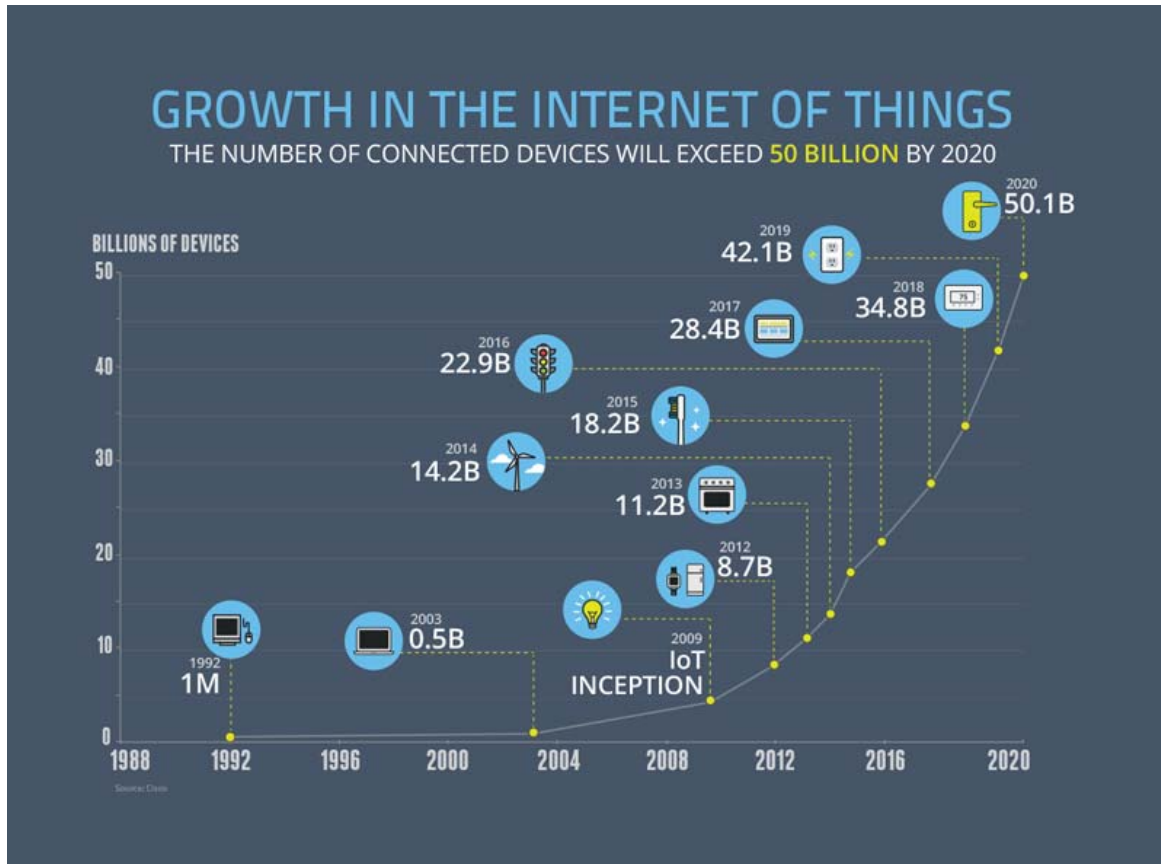
To protect U.S. citizens from economic damage caused by security breaches, the National Cybersecurity for Smart Manufacturing Systems project will deliver a cybersecurity risk management framework with supporting guidelines, methods, metrics and tools to enable manufacturers, technology providers, and solution providers to assess and assure cybersecurity for smart manufacturing systems while addressing the demanding performance, reliability, and safety requirements of these systems. Without collaboration this effort will fail as other nations outpace U.S. in innovation. As illustrated below, the U.S. already is falling behind in innovation:

U.S. Innovation Deficit
Growth in Investments in R&D Are Stagnating Compared to Many Other Nations



(Source: InnovationDeficit.org; OECD)

Projecting the impact of the restrictive travel policy to U.S. global standing over time is particularly challenging because of the exponential growth of technology. The interconnectivity of devices, also known as the “Internet of Things,” is expected to grow from 8.7B devices in 2012 to 50.1B devices in 2020, **an increase of nearly 600% in just eight (8) years.** “...governments need to consider the ramifications of systems that can sense, reason, act, and interact for us. We need to solve the trust and security issues inherent in a future world where we’re constantly surrounded by connectivity and information.” – **World Economic Forum**



Source: World Economic Forum, *Is This the Future of the Internet of Things?* D. Wellers, November 2015

PMIC Findings: Projected S&T Technological Impacts

Our world is experiencing exponential change in S&T advancements and capabilities, and S&T is a global phenomenon. Without the opportunities for both travel in the U.S. to discuss, share ideas, and collaborate with private and public sector experts, as well as travel outside of the U.S., S&T work and the capabilities of the United States will fall behind at an exponential rate. Because technology evolves at an exponential rate¹⁵, **the United States’ rapid decline as a leader in world technology is projected as “highly likely” unless the United States Government S&T’s community quickly regains access to professional and technical conferences.**

¹⁵ *Technology Will Keep Changing Everything – And Will Do it Faster*, B. Garrett, PhD The Atlantic Counsel, 2015

PMIC Recommendations

The quality, quantity and consistency of the information revealed through the multiple analyses of the data are alarming. Much like the FDA's "incredibly speedy move" in March 2015 to approve a lung cancer treatment in just one week¹⁶ because of the obvious benefits, PMIC's findings indicate that the policy presents a clear and present danger that should be eliminated *immediately and without delay*.

Recommendations

PMIC recommends an immediate exemption for members of the United States Government S&T community from compliance with conference and travel policies intended to curb abuse, not to harm United States' interests. *Given that the total costs associated with government S&T conference attendance account for only ~3 percent of the DOD's total R&D budget, the solution is relatively inexpensive and the cost-benefit ratio is enormous.*

If the United States Congress does not grant an exemption for the S&T community, PMIC recommends reclassification of "Influential Conferences/Professional Societies" as "S&T Mission-Critical" that are exempted from the policy. Such Professional Societies would be classified as exempt if they demonstrate certain characteristics common to Technical and Professional "Influential Conferences," such as training, collaboration that has led to invention, technical agenda, and speakers. **PMIC further recommends that government S&T members be permitted to hold leadership roles in Professional Societies that were formed with the intention of creating the collaborative venues necessary for the pursuit of innovation and informed research and development.**

PMIC recommends prerequisite characteristics of an S&T "Mission-Critical" Conferences and Professional Societies including a combination of empirical evidence demonstrating technical rigor and scientific collaboration as the primary function of the conference, for example, past performance as measured by key outputs, along with voluntary measures imposed by Conference Hosts.

¹⁶ **PharmaTimes Digital** (US regulators have approved Bristol-Myers Squibb's PD-1 checkpoint inhibitor Opdivo (nivolumab) for lung cancer just one week after officially agreeing to review the application)
By Selina McKee, March 4, 2015

Appendices

Acknowledgements

This Impact Study and Report is the result of some of the most brilliant minds in the country who willingly addressed the real-world potential dangers to America in areas of national security, health, safety, technology and economy. PMIC wishes to acknowledge the many individuals and entities who provided statistics, research and first-hand subject matter expertise that enabled PMIC to create an independent, rigorous, data-driven analysis informed by thousands of separate inputs.

As PMIC conducted the analysis, the team was particularly impressed with the demeanor and integrity of the S&T members who contributed data and information. These qualities are notably illustrated by **Dr. Joseph N. Mait**, Chief Scientist at Army Research Laboratory. Supported by the innovative leadership of Dr. Thomas Russell, Director of the U.S. Army Research Laboratory, Dr. Mait initiated a large group of subject matter experts to ensure compliance with the GAO recommendations regarding mission critical impacts of OMB Memo 12-12. As the main government Point of Contact, Dr. Mait provided fact-based statistics and data requested by the PMIC team. It was not until *after* CEO Kathleen Delano revealed PMIC's finding that "Planned Serendipity" occurs during Technical and Professional Conferences, and is a mission-critical scientific procedure embedded in the work of the nation's S&T community, that Dr. Mait shared an Op-Ed he had written about the topic. As it happens, the Op-Ed correlated with PMIC's findings, but it was not disclosed to PMIC until after the independent conclusion had been made.

Throughout the course of the Study, PMIC experienced similarly ethical and highly professional conduct from the brilliant scientists, engineers and technologists we had the great privilege to interview. PMIC's interactions with the S&T community in private industry, academia, professional societies and government agencies lend additional weight to our finding that there is very low risk of malfeasance on the part of government scientists' attendance at technical and scientific conferences.

PMIC appreciates the extraordinary assistance provided by the world's leading subject matter experts from government, academia and private industry who provided both hard data and commentary based on first-hand experience. Of special note are the following (in alphabetical order):

- **John. J. McGowan, PhD:** Dr. McGowan provided actual conference attendance numbers (costs, presentations and trends) compiled by NIH staff, as well as fulsome first-hand SME commentary.
- **Hon. Jacques Gansler, PhD, former Undersecretary of Defense, Chief Executive Officer, The Gansler Group:** Dr. Gansler provided PMIC with testimony given before the United States Senate Armed Services Committee, as well as SME commentary related to the impact of the current policy as related to United States' national defense and foreign nations' activity in mission-critical areas.
- **Banning Garrett, PhD,** former Director, Asia Program Atlantic Council of the United States; Director of the Strategic Foresight Initiative; Senior Fellow, Global Federation of Competitiveness Councils and Faculty, Singularity University: For countless hours spent educating PMIC on matters pertaining to the evolution of technology and particularly the role of Asia and its ascendance as a global leader in R&D and the economic value of basic research conducted by U.S. government S&T.

- **William P. Roach, Chief, Physical and Biological Sciences, Air Force Office of Scientific Research:** Dr. Roach provided extensive SME commentary based on three decades experience serving as a U.S. government scientist, and ensured PMIC had access to information to compile an independent analysis.
- **Leslie Wheelock, RN, MS, Office of The Chief Scientist, U.S. Federal Drug Administration:** In support of GAO's recommendation for a large data set from which to draw conclusions, the FDA surveyed more than 10,000 scientists, analyzed results with the support of a statistician, and provided the findings to PMIC, along with SME commentary as reflected in the study.
- **Professional Societies:** PMIC also wishes to thank professional society leaders including **Jennifer Douris, SPIE; Tracy Schario, OSA, Mike Hirschberg, AHA; Steve Sidoreck, AIAA, Ray Garant, ACS,** and **Josh Shiode, AAAS** for providing proprietary data that enabled PMIC to calculate the decrease in U.S. Gov S&T attendance at technical and professional conferences since the enactment of the policy. Josh Schiode and his AAAS team provided a tremendous service through a public appeal to S&T members collected through a dedicated url. The narratives gathered and analyzed provided key specific outputs directly related to conference attendance, as well as the data that led PMIC to conclude that "chance" encounters at technical and professional conferences are the lifeblood of the scientific process of discovery and invention.

PMIC wishes to acknowledgment the following individuals and organizations for their contributions.

U.S. Government

- **Gail Allen**, Executive Assistant to the DDM, National Institutes of Health
- **Colleen Barros**, Deputy Director for Management, Chief Financial Officer, National Institutes of Health
- **Captain Mark Bruington**, Naval Research Laboratory
- **Kelly Foster**, Associate Director for Executive Staff, U.S. Army Research Laboratory
- **Anne Garvey**, National Institutes of Health
- **Kevin Kimball**, Chief of Staff, National Institute of Standards of Technology
- **Joseph N. Mait, PhD**, Senior Technical Researcher (ST) for Electromagnetics, Chief Scientist, US Army Research Laboratory
- **John J. McGowan, PhD.**, NIAID Deputy Director for Science Management, National Institutes of Health
- **William P. Roach**, Chief, Physical and Biological Sciences, Air Force Office of Scientific Research (AFOSR)
- **Thomas Russell, PhD**, Director, U.S. Army Research Laboratory
- **Colonel Roger Vincent**, Air Force Research Laboratory

Private Industry

- **Hon. Jacques Gansler**, Former Undersecretary of Defense; CEO, The Gansler Group
- **Tom Roslik, PhD**, Leeds Metropolitan Institute; Motorola
- **Lewis (Lou) Von Thayer**, Chief Executive Officer, DynCorp International

Professional Society

- **Gregg Balko**, Chief Executive Officer, Society for the Advancement of Material and Process Engineering

- **Gary Blank**, President, Institute of Electrical and Electronics Engineers
- **Heather Bloemhard**, John N. Bahcall Public Policy Fellow, American Astronomical Society
- **Scott Bruce**, President, American Helicopter Society, Patuxent River Chapter
- **David Bruggeman**, Public Policy Analyst, ACM
- **Jennifer Douris**, Government Affairs Director, SPIE
- **Damon Dozier**, Director of Government Affairs, Materials Research Society
- **John Durrant**, Managing Director, Engineering Programs, American Society of Civil Engineers
- **H. Frederick Dylla**, Executive Director and CEO, Emeritus, American Institute of Physics
- **Mark Elsesser**, Senior Policy Analyst, American Physical Society
- **Ray Garant**, Director, Public Policy, American Chemical Society
- **Scott Glisson**, Interim Co-Executive Director at American Institute of Biological Sciences
- **Brendan Godfrey**, Institute of Electrical and Electronics Engineers
- **Erik Hanken**, Program Manager, Student Programs, American Geophysical Union
- **Mike Hirschberg**, Executive Director, AHS International – The Vertical Flight Technical Society
- **Kathryn Holmes**, Director, American Society of Mechanical Engineers
- **Madeline Jacobs**, President and CEO, The Council of Scientific Society Presidents
- **Elizabeth Landau**, Public Affairs Manager, American Geophysical Union
- **Rudy Ludeke**, AVS
- **Brandie Neifert**, Senior Program Associate for Operations & Member Services, the Council of Scientific Society Presidents
- **Joel Parriott**, Director of Public Policy, American Astronomical Society
- **Steve Pierson**, Director of Science Policy, American Statistical Association
- **Miriam Quintal**, SIAM
- **James Robinson**, Secretary, Executive Director, The Minerals, Metals and Materials Society
- **Nick Saab**, American Geophysical Union
- **Mary Samsa**, Professional Development, The Minerals, Metals and Materials Society
- **Tracy Schario**, Chief External Relations Officer, The Optical Society
- **Emily Sheketoff**, Executive Director of Washington Office of American Library Association
- **Steve Sidoreck**, Manager, Public Policy and Government Relations, American Institute of Aeronautics and Astronautics
- **Josh Shiode**, Senior Government Relations Officer, AAAS
- **Laura Uttley**, HFES
- **Ron Wasserstein**, Executive Director, American Statistical Association

Academia

- **Thomas Baer, PhD**, Executive Director, Stanford Photonics Research Center, Photonics Chair, Stanford University
- **David Bray, PhD**, Eisenhower Fellow; Executive In-Residence at Harvard University
- **Banning Garrett, PhD**, former Director, Asia Program Atlantic Council of the United States; Director of the Strategic Foresight Initiative; Senior Fellow, Global Federation of Competitiveness Councils and Faculty, Singularity University

The PMIC team also wishes to thank the many unnamed statisticians, analysts and researchers who were involved in creating the robust data set that helped inform this Impact Study and Report.

PMIC Team and Consultants

- **Ambassador Cindy Courville, PhD**, Executive Consultant
- **Kathleen Delano**, Chief Executive Officer, PMIC
- **Samuel Delano**, Intern
- **Kimberly Edwards**, Graphic Design and Project Management
- **Emily Flanigan**, Paralegal
- **Anne Giotta**, Founder, PMIC
- **W. Michael Stark, Esq.**, Executive Consultant

Chief/Senior Subject Matter Expert Comments

United States Government

- **Capt. Mark Bruington, Naval Research Laboratory:** “Face to face contact is crucial. There is no substitute for working out a problem in a room with experts from sister organizations who contribute valuable insight that improves the overall solution. Planned collaboration among scientists, technologists and engineers can help us make better decisions about future investment and acquisition programs early. This can result in significant long-term savings.”
- **Dr. Joseph N. Mait, Senior Technical Researcher (ST) for Electromagnetics, Chief Scientist, U.S. Army Research Laboratory:** “The mission of each federal agency defines the application of the research conducted. Most of us who work in the federal S&T community do so out of a commitment to service. We forsake monetary gain for the breadth of exposure offered by opportunities to collaborate, discover and invent for the good of our nation. Establishing a strategic research posture is essential if the United States wishes to remain globally competitive. The federal government funds research that is given freely to private industry, creating safer, better and less costly inventions to defend our national security, and commercial applications that fuel our economy. Today, teams of scientists, engineers and technologists are collaborating on next-generation secure networks to defend the U.S. and protect the American citizens from cyber-attacks.”
- **Dr. John J. McGowan, National Institutes of Health:** “Planning ahead enabled NIH to maximize the benefit of conference participation and extract the greatest return on investment. For example, 200 of the world’s leading experts collaborated on critical HIV research during a session NIH planned to coincide with the weekend after a conference. Such efficiencies can’t happen since the policy went into effect because of delayed approval times. Technical and professional forums S&T attends are not retreats. They are incubators of invention where scientists meet to talk through ideas, generate new partnerships, and refine research initiatives. Now, conference decisions are sometimes based on optics. A focus totally on the reduction of costs and expense is wrong. The focus should be on creating opportunities for sharing cutting edge ideas that challenge researchers and help lead to collaboration and cross fertilization in science. A policy designed to reduce costs resulted instead in **an increase in per-person costs, attendance at fewer conferences, and the costly price of missed opportunities.** This is a dangerous policy with serious implications in the area of national health. “
- **William P. Roach, Chief, Physical and Biological Sciences, Air Force Office of Scientific Research (AFOSR):** “Face to face collaboration that happens at conferences is irreplaceable. The interchange of problems and concepts between government and industry through the collaborative process that happens when we team up at technical conferences is essential for continued positive outcomes on a large-scale basis over the long term. We are hamstrung by approval delays and an inability to plan. In the past, we have added on one-day meetings at minimal incremental cost, but the delay in approval has prevented us from seizing these opportunities. I am concerned about the unintended damage this policy might have across the board on medical, safety standards, in biology, chemistry, engineering, mathematics and physics.”
- **Dr. Thomas Russell, Army Research Laboratory:** “The basic research conducted by government S&T results in outcomes that are significantly greater and more encompassing than most Americans know – and that is because we focus on our mission and work with others who apply our work to create security, technological and economic advantages to the U.S. Reductions in combat mortality

rates because of government innovation is a well-known outcome of government research. Those innovations make their way to the private sector. What many people don't realize is the overall benefit to society and the economy when government-funded basic research is applied by academia and industry. We don't want to be a black box – we encourage industry and academia to contact us and we publish our S&T Campaigns for public review. We are accessible. The government conducts basic research, gives it to industry and the result is a ripple effect that is all around us. Imagine the world without iPhones and GPS systems – and imagine if the United States was not the nation behind these world-changing inventions.”

- **Col. Roger Vincent, Air Force Research Laboratory:** “Science is a contact sport. When scientists meet up at conferences, they are together morning, noon and night. Serendipitous discoveries happen because the conversations happen before, during and after conferences. Just think about the inventions – radar, lasers, medicines, armaments – that are the product of S&T collaboration.”
- **Leslie Wheelock, Office of The Chief Scientist, U.S. Federal Drug Administration:** “FDA conducted a survey of more than 10,000 scientists to assess validity of observations about the impact of the policy. We see the loss of innovation from collaboration as the biggest negative impact of the travel policy. Retention and recruitment problems may directly result from the loss of interaction with other scientists. Without a robust interchange between government S&T and the rest of the scientific community, we face a loss of talent. I am especially concerned about the effects this policy has on young scientists who are told ‘no’ and who no longer ask to participate in future opportunities. Even more alarming is being able to keep informed of cutting-edge science and in the long run, the impact this may have on meeting our mission and the nation’s health.”

Academia

- **Dr. Thomas Baer, Executive Director, Stanford Photonics Research Center:** “The three biggest impacts of the policy are the loss of a problem rich environment, which is the most important to ensure our government, academic and private industry scientists are collaborating on real-world problems; the loss of STEM talent because the best people will not enter public service if collaboration continues to be cut off; and the loss of government S&T talent attributable to the dramatic lowering of morale caused by the policy. The red tape is astonishing. Stanford offered to pay travel costs for government S&T to attend a symposium, but even then, the request was denied. This is a significant loss to our nation that will become increasingly severe over time. We are shooting ourselves in the foot by imposing this policy on government scientists.”
- **Banning Garrett, PhD, former Director, Asia Program Atlantic Council of the United States; Director of the Strategic Foresight Initiative; Senior Fellow, Global Federation of Competitiveness Councils and Faculty, Singularity University:** “The rest of the world is pouring increasing resources into scientific research, including benefitting from the knowledge and collaborations gained through conferences and other scientific meetings. Currently, US restrictions on participation in this process risks marginalizing the United States in global scientific research and losing its leadership position, which could result in technological surprise and loss of economic competitiveness. The total cost of sending government scientists to conferences is small enough to be a rounding error in the total budget. I’m glad the government is rethinking this penny-wise and pound foolish policy, at least as it applies to government scientists.”

Private Industry Sector

- **Jennifer Douris, Government Affairs Director, SPIE:** *“Many federal program managers use technical conferences as opportunities to engage with a wide collection of researchers for program reviews, future program planning, and to efficiently examine a large collection of independent research projects. Because the alternative is multiple visits to individual research laboratories, this approach represents a significant savings of both cost and time.”*
- **Hon. Jacques Gansler, former Undersecretary of Defense; CEO, The Gansler Group:** *In the past, U.S. defense and economic competitiveness strategies have been based on “technological superiority.” But today, the commercial and international worlds are greatly exceeding the federal government’s expenditures on R&D. Since there is a correlation between R&D expenditures and results achieved, there are many critical national security areas in which the DOD is no longer leading. Clearly, the Congressional and DOD cutback in the share of budgets going to R&D must be reversed in order for the DOD to achieve technological leadership in the 21st Century.*
- **Lewis F. (Lou) Von Thaeer, Chief Executive Officer, DynCorp International; Science Committee:** *“Technology has always been the method by which the US competed on the world stage. Today we have reduced research funding dramatically and are counting on the commercial industry to provide research. But unlike the past, today the companies doing the research are multi-nationals and it’s uncertain how they would/could support the US in a crisis. In the defense world, many of our systems today are built with parts anyone can buy, reducing the advantage our country has enjoyed since WWII.”*
- **Private Sector Executive (U.S. Army Lt. Col., Ret., Currently in Defense Industry)** *“It’s vitally important for the S&T community to attend all the various professional conferences because these events are the single most important venue for the open exchange of information and ideas that have and will continue to enable the technological edge upon which the U.S. Army depends to anticipate threats, dominate on the battlefield, and protect the force, our Nation’s most valuable asset.”*

CASE STUDY: American Helicopter Society: Perspectives – Two Sides of the Same Coin

The following discussion related to one professional society was chosen from many examples because it illustrates the impact the policy has had on Government S&T and on the Professional Societies that host the technical venues for collaboration and innovation.

AHS International: Impacts of Conference/Travel Cuts

The Secretary of the Army issued a directive on October 17, 2012 “suspending Army attendance at non-DoD conferences between now and 31 December 2012 unless ... an exception is granted.”

As a result, the AHS Hampton Roads Chapter was forced to cancel its Helicopter Military Operations Technology (HELMOT) conference scheduled for October 30 through November 1, 2012. There was not sufficient time between the release of the directive and HELMOT to have a waiver request processed, even if it were to be approved. HELMOT had 100% government speakers, with about 80% US Army employees. Venue cancellation fees were avoided, but there was about \$10,000-15,000 of lost net revenue for the AHS Hampton Roads Chapter.

The next conference was the AHS Unmanned Rotorcraft Specialists Meeting planned for Scottsdale, Arizona, Jan 22-24, 2013. **Not a single DOD employee attended.** Including secondary impacts, the overall attendance was 75, significantly down from the 100-150 who normally attended. Again, the loss was in the \$10,000 - \$15,000 range.

The AHS Airworthiness, CBM and HUMS Specialists' Meeting, in Huntsville, Alabama, was held Feb 11-13, 2013 by the AHS Redstone Chapter. Here, to avoid the Army travel ban, all US Army personnel were allowed to attend at no charge, resulting in healthy attendance, but again a significant financial loss to the Chapter on the same order as above.

The AHS Annual Forum & Technology Display is held every year. It is the world's largest and longest running (72 years) technical conference on helicopters and other vertical flight aircraft (e.g. F-35B, quadcopters, etc.)

The Forum in May generally attracted about 125 US Army attendees (including speakers), plus another 50 from NASA, a dozen from the Navy, and another dozen or so from FAA and other agencies, or a total of around 200 US Government attendees, then about 15% of the total attendees. The below table summarizes the approximate numbers:

Year	2015	2014	2013	2012	2011
Total attendees	1050	1177	1100	1300	1200
Approx US GOV	75	50	25	200	200
Percentage	7%	4%	2%	15%	17%

AHS – Government S&T Experience

The AHS International is a professional technical organization dedicated to vertical flight that conducts an Annual Forum and Technology Display. This annual event is the world's leading international technical gathering for vertical flight technology. In 2015 the 71st Annual Forum included more than 250

technical presentations on every discipline from Acoustics to Unmanned Systems. The Technology Display is the most extensive exposition of cutting edge vertical flight technologies in the world.

In December 2014 the Aviation Development Directorate had requested 165 Army participants to attend the 71st Annual Forum of the American Helicopter Society. The initial projected cost for this level of participation was \$215,000. By March 2015 this number was reduced to 93 with a total expense to the Army of \$85,507. There were five levels of priority identified for Army participation.

In March discussions with the organizer of the Annual Forum were conducted to find ways to reduce the cost to the Army and maximize the benefit of attendance. **At that time the registration cost for DOD participants was reduced from \$780.00 to \$340.00 to be consistent between government civilian and military personnel. The organizer also made the offer to provide blanket registration to 200 members of the Army for a single registration payment of \$40,000 (nearly a 75% reduction in the original \$780 registration if we had allowed this many participants).**

The final list of only 45 official registrants was approved on 30 April 2015 (Thursday before the Monday, 4 May event start). This limitation was directed to keep total Army cost below the Army Materiel Command approval level of \$50,000.

Significant difficulties encountered in final participation for this event:

- **Conference approval occurs far too late to be effective in shaping the Army's use of conferences to its best advantage.** In this case approval was given two business days before the start of the event. This delay in approval results in insufficient time or at a minimum significant difficulty in completing travel plans and authorizations for many essential participants. This delay prevents the government from taking maximum advantage of early registration discounts and lower priced accommodations.
- **Difficulties in providing the required details when the request is initially made.** Specific travel details were required more than 120 days in advance, before the conference hotels were identified and before the specific details of the conference were known. For example, in some cases, speakers had not been notified early enough to be identified in the approval documentation.
- Although the organizer, American Helicopter Society International, worked to enable strong Army participation in this event, **the Army could not guarantee a specific number of participants until two days prior - long after all of the logistic arrangements have been made.**
- **The actual registration cost was reduced from the published rate to entice additional Army participation.** But the conference guidelines only take into account total cost including the travel and lodging cost. In this case, the number of attendees was limited based on the Army Materiel Command approval limit of \$50,000. Additional funding would have permitted a number of local attendees to participate at a relatively small per capita expense.

John D. Berry, Ph.D., Deputy Director, Aviation Applied Technology Aviation Development Directorate, AMRDEC Fort Eustis, VA

AHS Perspective Two – AHS Society President

I use the Medical Doctor analogy for training our government engineers. Can you imagine going to a doctor who hasn't received any updated medical information or training since he left Medical School?

The American Helicopter Society, Patuxent River Chapter used to host a bi-annual symposium entitled "Vertical Lift Aircraft Research, Development, Test & Evaluation."

This is a very professional symposium with world-class papers and speakers, and is ***the only symposium in the world that focuses on RDT&E for Vertical Lift Aircraft***. Our last event in August 2014 was rendered extremely difficult by the uncertain, ambiguous, and varied interpretation of the DOD rules and regulations regarding travel.

We are not planning on having another event until the travel and symposium attendance policies are publicized, well-understood, and universally applied to the degree that having a symposium makes sense, is not a money losing proposition, and can be planned without the uncertainty of our last event.

Our symposium was held at a facility about 5 miles outside the gate of the base [Naval Air Station Patuxent River, home of several important organizations, e.g. the US Naval Test Pilot School, Naval Air Systems Command). We had many folks who were presenting or speaking, but were not event attendees (because of the limitation on attending symposia) so had to drive out to the venue. Questions were raised whether it was even legal to do that because it was against travel regulations and it was giving something away for free. Finally, after a tremendous amount of churn, a one-star Admiral signed a memorandum, especially for our event, stating that government employees could drive off the base to present their brief.

Of particular concern by the Navy lawyers for our local attendees, was that the conference fee did not cover food if the attendees were not travelling, as that would be giving something away for free. Yet, a last-minute determination by the lawyers was that we had to let any military in uniform attend for free. So, our chapter ended up having to foot the bill for all military in uniform, that included Naval Academy Midshipmen, US Naval Test Pilot School Students and Instructors - a roughly \$235 value for each. No one could explain how that was not considered giving something away for free.

Impact to the United States Government

- 1) The loss of educating our employees at a very reasonable rate. Similar two-day events taught by other for-profit organizations would be \$1500 for the same thing we charge \$235.
- 2) The lack of recurrent technological training results in higher risk for our programs, resulting in cost and schedule increases.
- 3) Increased program costs due to duplication of efforts. Often technical developments are being done by multiple organizations, and attending these forums allows us to find out about, and to leverage each other's testing and test results, saving precious R&D funding.
- 4) Having attended both the \$1500 courses and the \$235 symposia, the overall result in personnel morale and learning retention is much greater at these [conferences/symposia run by non-profit professional societies]. They are a whole lot more fun, and you learn a lot more in this type of venue. But that is highly subjective, cannot be quantified without torturous and costly testing and analysis.
- 5) The value of having contacts within your professional technical field outside of your organization is another intangible capability that is undervalued by our leadership. The ability to reach out to other Subject Matter Experts to help solve problems is extremely helpful.

Scott A. Bruce

President of the American Helicopter Society, Patuxent River Chapter

Professional Society Comments

SPIE International Society for Optics and Photonics

SPIE has seen significant delays in travel approval time resulting in increased travel and registration expenses and expressed concern about appointing government employees to leadership positions, such as Conference Chair, that drive the technical focus of our symposia. Presenting researcher at a Symposia requires advance planning. Conference paper abstracts must be submitted six to seven months prior to the conference date. **A recent example of an approval delay is the participation approval for 157 Army researchers received on 17 April 2015 for the Defense and Sensing Symposia that started on 20 April.**

The Optical Society

In a recent survey of persons who had attended at least 3 of the past 5 CLEO conferences, some comments noted the impact of government travel restrictions. When asked, "If your frequency of attending CLEO changed, why?" the following comments were received:

- "DoD travel restrictions, budget, and the move of CLEO to the west coast."
- "As a government scientist, the US government has recently severely restricted employee travel to conferences."
- "Government restrictions on conference travel affected my ability to attend CLEO in the last year."

IEEE-USA

"Unlike many professions, the nature of scientists' work requires them to share research findings with their peers and colleagues at scientific conferences and meetings. This peer collaboration process is fundamental to scientific advances and is unlikely to be achieved without this personal interaction. The impact is seen in national security, energy, health sciences, and many other fields of endeavor from which our country has benefited over many years."

Current Impact: Government S&T Comments

- **Naval Research Laboratory:** *The program managers who fund my research need us to attend conferences and present our research in order for the technology to transitioned to industry and thus the warfighter. I have significantly reduced my conference attendance since the paperwork and issues related to travel are too burdensome on my time. My time is better spend developing new materials for the warfighter than justifying why I need to go to a conference and present my research findings.*
- **Oak Ridge National Laboratory:** *I'm a young professional in the field of nuclear engineering. I've had the opportunity to attend a dozen or so conferences, few of which have been since the new GSA restrictions. My view of the recent restrictions is that by limiting our ability to attend scientific conferences, our country's scientific programs are put at a disadvantage. Furthermore, **the overhead of these restrictions, and the fact that it causes registration fees and airline tickets to be closer to deadlines and thus more expensive, brings into question whether these restrictions are even a net positive economic impact. By loosening conference travel restrictions and encouraging the freer exchange of ideas between professionals at scientific conferences, the field of nuclear engineering and science at large will greatly benefit.***

- **Department of Veteran's Affairs:** *I was inspired to pursue board certification in Rehabilitation Psychology and led a group of psychologists to develop the first APA-accredited Rehabilitation Psychology fellowship in VHA. Each of the graduates of this two-year program is working in VHA or DOD and contributing actively to the care of our nation's heroes, especially those with TBI/Polytrauma. I have lost count of the number of professionals at our station who have basically 'thrown up their hands' and refuse to travel to conferences given the dense and ambiguous regulations. I am one of these individuals and it is source of personal and professional pain – because I know many of us have substantive things to contribute to professional organizations and the larger clinical/scientific community.*
- **Los Alamos National Laboratory:** *I have worked at a DOE NNSA National Laboratory for over 35 years. Restrictions of the past several years on conference attendance (as well as very late approval notifications) have severely impacted our ability to recruit, retain, and reward our scientific staff. These limitations have also impacted the quality of science overall through inhibiting broad professional interactions. A very specific benefit of an international conference about 20 years ago was our ability to meet, recruit, and hire a staff member who has made substantial contributions in the National Interest during these past two decades. Without the opportunity afforded by that conference, it is unlikely we would have made the connection with the individual.*
- **U.S. Navy Scientist:** *The current travel restrictions make it inordinately difficult for early-career scientists and engineers to interact directly with their colleagues. They are essential for early-career scientists to learn about cutting edge scientific advances from the people who are making them. If early-career government scientists are not able to travel easily to conferences and workshops they will leave government service, depriving government research labs of new ideas. Travel restrictions keep many mid-level scientists and engineers from attending conferences and workshops at the exact time they need to find solutions to problems in the mission-critical work they are responsible for. Hearing from and talking to other researchers in their field of research (and in closely-related fields) allows cross-fertilization of ideas and leads to first-class basic and applied research. Travel restrictions keep many senior government scientists and engineers from attending conferences and workshops. This is especially harmful to government science and technology since these senior scientists and engineers have substantial responsibility and are key players in setting the direction for research and development activities. Conference and workshop attendance is essential for spreading this message to the wider research community.*
- **US Air Force S&T:** *I'm an active duty Air Force Officer and have spent two assignments in the Science and Technology area. What a huge mistake this rule has been. It is so important to go these conferences to find out what is going on through out DoD and the other military services. We always found out about new S&T efforts which were not widely known about at these conferences and it significantly helped us solve problems. After the travel restrictions were put into place, I felt like I was being treating like a child. If the gov't wants to control waste in travel, prosecute those who fail to follow the rules which were already in place. My S&T office was punished for other people's poor decisions and these rules directly impact the effectiveness and efficiency of my office.*
- **Idaho National Laboratory:** *I work at a DOE National Lab on advanced reactor technology. New research is often disseminated at American Nuclear Society conferences. Therefore, it is the best use of my limited project funds to meet with my colleagues at side meetings held during the ANS conferences rather than through separately scheduled business travel. I have attended the last 4 ANS conferences without support from my employer. I used frequent flyer miles to fly and avoided some hotel expenses if my wife, a professor at a nearby university, was supported by her employer. My wife's travel budget and my FF account have both been depleted yet I still must find a way to go*

*in order to meet my professional obligations. **At the next meeting, I will be presenting my latest research and discussing FY16 plans with distant colleagues. This will be the last time I can do so unless my employer (the Idaho National Laboratory) is allowed to sponsor my participation.***

- **U.S. Air Force Col (Ret.):** *I believe that the U.S. government limits and lack of encouragement for technical conferences was a major reason that **a 2014 conference agenda was more like a trade show. Given the reduced level of technical exchange, the decreased technical content of the papers make me much less likely to advise a colleague to attend or to fund an attendee.***

Subject Matter Expert Comments – Planned Serendipity

- *Had it not been for this conference, I may not have secured a highly competitive AAAS Fellowship, now serving as a springboard for my career in science, engineering, and public service. Scientific and technical conferences encourage attendees to expect the unexpected, to break out of their silos, and to become greater than the sum of their parts with diverse peers.– **AAAS / USAID***
- *My most important and longest collaboration started from a chance encounter at a meeting. We agreed on a collaboration that completed and published that genome sequence in *SCIENCE* with 12 undergraduate authors (Goodner et al., 2001). That collaboration led to several other joint genome sequencing efforts and 4 more publications with undergraduate authors. I am convinced that more such collaborations between large research groups and primarily undergraduate institutions are possible if we can bring them together to brainstorm.– **Hiram College***
- *I have initiated at least 10 fruitful long-term collaborations based on connections made at scientific meetings. Several of these collaborations have been with intramural NIH scientists and other direct government employees or contractors. Without these connections, my scientific discoveries and career would have been severely hampered.– **The Johns Hopkins University School of Medicine***
- *I have participated in one conference that used to be in-person but was mandated to be a video conference, and I felt that it was only about 30% as effective...basically a failure. Scientists are human beings, science is a social as well as an intellectual endeavor, and until we have holodecks, in-person meetings are essential.– **Southwest Research Institute, Dept. of Space Studies***
- *Conferences are a great way to learn a lot in a short amount of time. I think researchers and their managers should decide which conferences they will attend. Thus those in the higher ranks of administration should defer to their judgment so that they can participate in the most useful conferences.– **Rensselaer Polytechnic Institute***
- *Because I was allowed to attend a NATO Advanced Study Institute in Cambridge, Britain (1987), I could complete my PhD. I received the computer code I needed from a colleague in Sweden who also attended the conference. Attending annual meetings has kept me current not only in my own field, but also in other fields on the periphery of mine. The face-to-face interactions at these meetings have been invaluable.– **US Naval Observatory/retired***
- *I attended a FASEB conference on Biological Methylation at Vermont Academy in 2001. This was a critical event in my scientific career, resulting in a new line of research for me. A discussion over breakfast with an investigator from Canada stimulated a new line of research on methylation of small GTPases. This resulted in my being honored with a Scientific Achievement Award from the American Thoracic Society in 2005.– **Alpert Medical School of Brown University***
- *Worry greatly about the waste in undiscovered talent if workshops and conferences were not available to allow people to connect with others who can help nourish that talent and put it to good scientific and societal use.– **University of Michigan***

- *Their laboratory has incorporated my NIRS methodologies and we have used his clinical expertise in our teaching and research on peripheral arterial disease in older adults. I would never have 'found' him and learned about arterial damage in endurance athletes if I had not had the spirited conversation with strangers at a scientific poster, and later invited him to dinner. That can only happen at a scientific meeting.– **University of Georgia***
- *Several people suggested that my mathematical and analytical skills would be gratefully accepted in some labs doing hard genetic analysis related to the Galapagos research. My conclusion is that if I had been able to attend a conference like this 10 or 15 years ago, I probably would have changed fields; therefore, perhaps the cross-disciplinary aspect of my story might be useful in conversations with some policymakers.*
- *Conferences foster collaborations in a way no other venue does, since experts from many different areas are usually represented. For example, without industrial hygiene input, most occupational epidemiology studies would be worthless.– **MD epidemiologist***
- *A chance elevator interaction at a local ASM Branch meeting changed my life and started my career in molecular biology and my professional service in microbiology and virology.– **Princeton University***
- *In 2003 I attended the annual conference of the Cognitive Science Society. I had been doing research on computational models of human cognitive, resulting in the COGNET/iGEN architecture. Although it had just been shown to generate the best match to live human performance in a US Air Force multi-model comparison, I came to the conference with doubts about that generation of cognitive models and their inability to simulate social intelligence, personality and emotion. There, I met, by chance, Dr. Lynn Miller and Dr. Stephen Read, social/personality psychologists working on the opposite coast, who came with their own concerns about the lack of predictive models of personality, emotion, and social intelligence in their fields. In a long "hallway" conversation, we excitedly sketched out a new approach to cognitive architecture based in personality theory and neurobiology. This began a collaboration that continues to today, evolving a model and cognitive simulation software called PAC (for Personality, Affect, and Culture). Drs. Miller and Read have applied PAC to stem the spread of AIDS by teaching individuals how to better negotiate for safe sex, while I have used it to train US armed forces in cultural familiarization and to train doctors in clinical communication skills. None of this would have happened without the opportunity to attend this conference and encounter scientists with different backgrounds but convergent interests and complementary scientific skills.– **CHI Systems Inc. and Starship Health Technologies, LLC***
- *The benefit is both for the community as well as for the federal employee. My chance meeting of the program officers and the division director of DMS in in early 2000s lead me to submit a successful research and training grant to train problem solvers and critical thinkers (NSF VIGRE grant) and enhance diversity among our U.S. Students at all levels.– **Oregon State University***
- *My interactions with SRL personnel led to improved methods for evaluating vitrification processes, not to mention the personal growth of the professionals. In the last 10 -20 years of my work experience DOE started restraining travel more and more. They cancelled decade long conferences such as the Gaitlinburg Conference on Analytical Chemistry and probably others that I'm unaware of. The damage this has done to the growth of personnel and and advancement of technology at different sites is incalculable. Today young scientists and engineers are no longer encouraged to document and present their work at technical society meetings because - why bother if you can't travel.– **CH2MHill, NUMATEC, Westinghouse, GE, ARHCO***
- *Conferences are excellent for meeting existing collaborators and fostering new collaborations. In spite of communication technologies, nothing even remotely approaches in depth face-to-face*

discussions. Only direct discussions are sufficiently in depth to assess if a project is worth doing and also feasible. Only direct discussions are sufficiently informative for whether a collaboration is possible for reasons of scientific style, qualifications and trustworthiness.– **Harvard Medical School**

- *Attending conferences is essential for fostering the relationships and knowledge that drive scientific innovation and growth.* – **Buttonwood Consulting, Inc.**
- *One of the major questions remaining in our understanding of how the Earth and other planets formed is the formation of mile-size planetesimals from boulders. One of the currently best supported ideas on how to answer this question came about from a meeting at Protostars & Planets V in 2005 on the Big Island of Hawaii between myself and a director of the MPI for Astronomy in Germany. We agreed that our PhD students should exchange visits. During this exchange they completed under our guidance a model that combined gas drag on rocks with gravitational forces. The results, published in Nature, have now been cited over 400 times, and have become an accepted part of the history of our planet.*– **American Museum of Natural History**
- *Attendance and participation in scientific and engineering conferences was important to NASA and my career at the Johnson Space Center. American Institute of Aeronautics and Astronautics (AIAA) and American Physical Society conferences enabled me to display new research of my organization and make contacts with other researchers having similar interests. With these contacts we later collaborated on further research that resulted in better understanding of the heating environment of the Space Shuttle during reentry and other spacecraft, including the Orion capsule that is being developed today. In particular, I was able to meet with colleagues from industry, Ames Research Center, and Langley Research Center in the AIAA Thermophysics conferences of 1980, 1983, 1984, as well as many others. Participation also gave me the opportunity to contribute to the AIAA by serving as Technical Program Chairman in 1985 and General Chairman in 1988 for AIAA Thermophysics conferences. Since retiring from NASA I have been serving as a consultant to NASA and have provided information and services to a number of people that I met at conferences in the past helping document thermal protection system test results and providing guidance on how to determine properties of the high temperature test gas flow.*– **NASA Johnson Space Center**
- *I was presenting some results of a DARPA project in 2005, and afterward I was approached by Bob Sackheim (AIAA Fellow and then NASA's Chief Engineer for Propulsion. He complimented my work, which was to invent a catalyst compound for decomposing nitrous oxide. He said too many "n's and not enough "o's. We put our heads together, and found we could dissolve nitrous oxide into nitrogen tetroxide. A self pressurizing oxidizer results with almost the same total specific impulse as LOX, but not cryogenic.* **Patents pending**– **Government Energy Solutions**

Tables and Charts

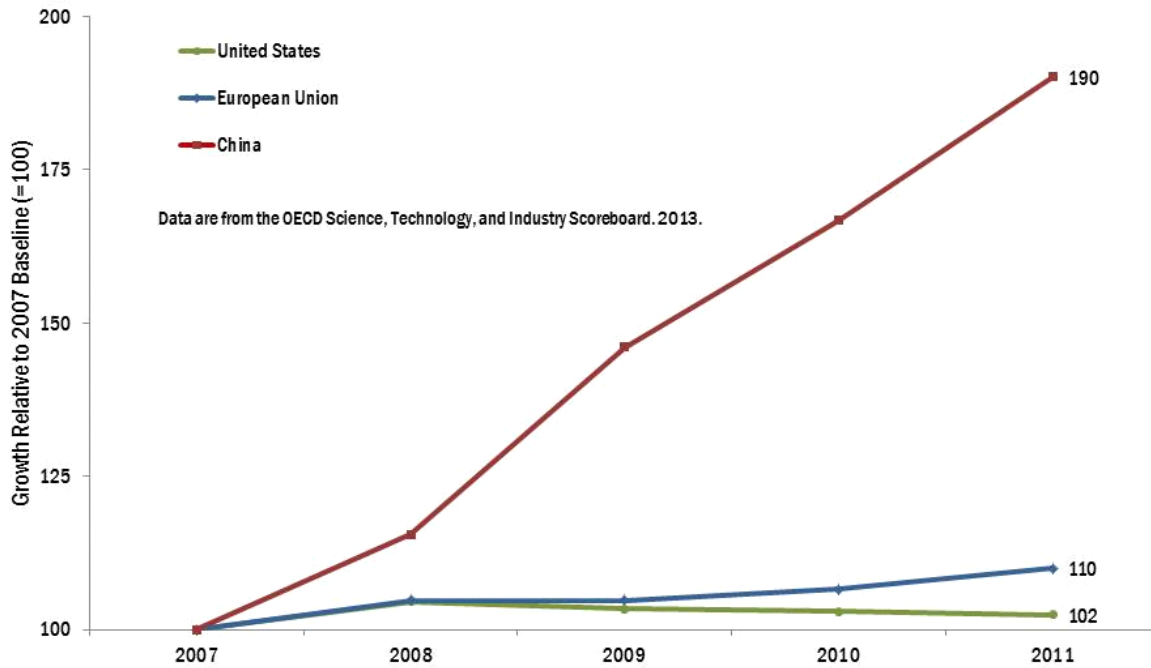
Federal Obligations and Outlays for Research and Development, By Agency (\$Millions)

	2014
All Federal	131,969.90
Department of Defense	
Defense Advanced Research Projects Agency	2715
Department of the Air Force	23826.9
Department of the Army	7619.5
Department of the Navy	15456.5
Other defense agencies	15259.1
Department of Commerce	
National Institute of Standards and Technology	672.5
National Oceanic and Atmospheric Administration	665.3
National Telecommunications and Information Administration	9.2
Department of Energy	
Advanced Research Projects Agency–Energy	68.5
Electricity Delivery and Energy Reliability	59.4
Energy Efficiency and Renewable Energy	772.8
National Nuclear Security Administration	4396
Nonproliferation and Verification	226.8
Office of Science	4655.2
Department of Health and Human Services	
Agency for Healthcare Research and Quality	333.7
Ctrs. for Disease Control and Prevention	340
Ctrs. for Medicare and Medicaid Services	20
Food and Drug Administration	343.1
National Institutes of Health	29251.6
Department of Homeland Security	
Science and Technology Directorate	656
National Science Foundation	5589.00

Source: <http://www.nsf.gov/statistics/fedfunds/>

U.S. Innovation Deficit

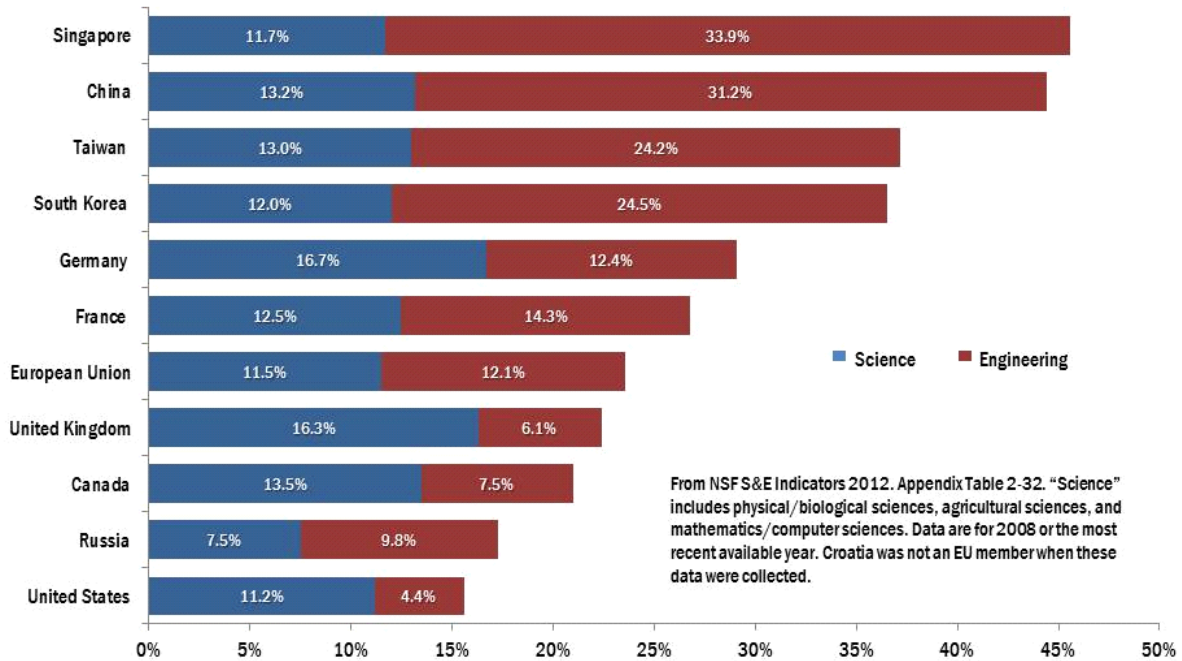
R&D Performance Through the Recession: Total R&D Gross Expenditures Compared to 2007 Baseline



(Source : Innovation Deficit.Org)

U.S. Innovation Deficit

Undergraduate Degrees in Selected Nations: Percentages Awarded in Science and Engineering



(Source : Innovation Deficit.Org)

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ARL	ARL Budget to Presentation Comparison
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ARL	ARL Productivity Trend per S&E
ARL	Army Research Laboratory S&T Campaign Plans 2015-2035
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