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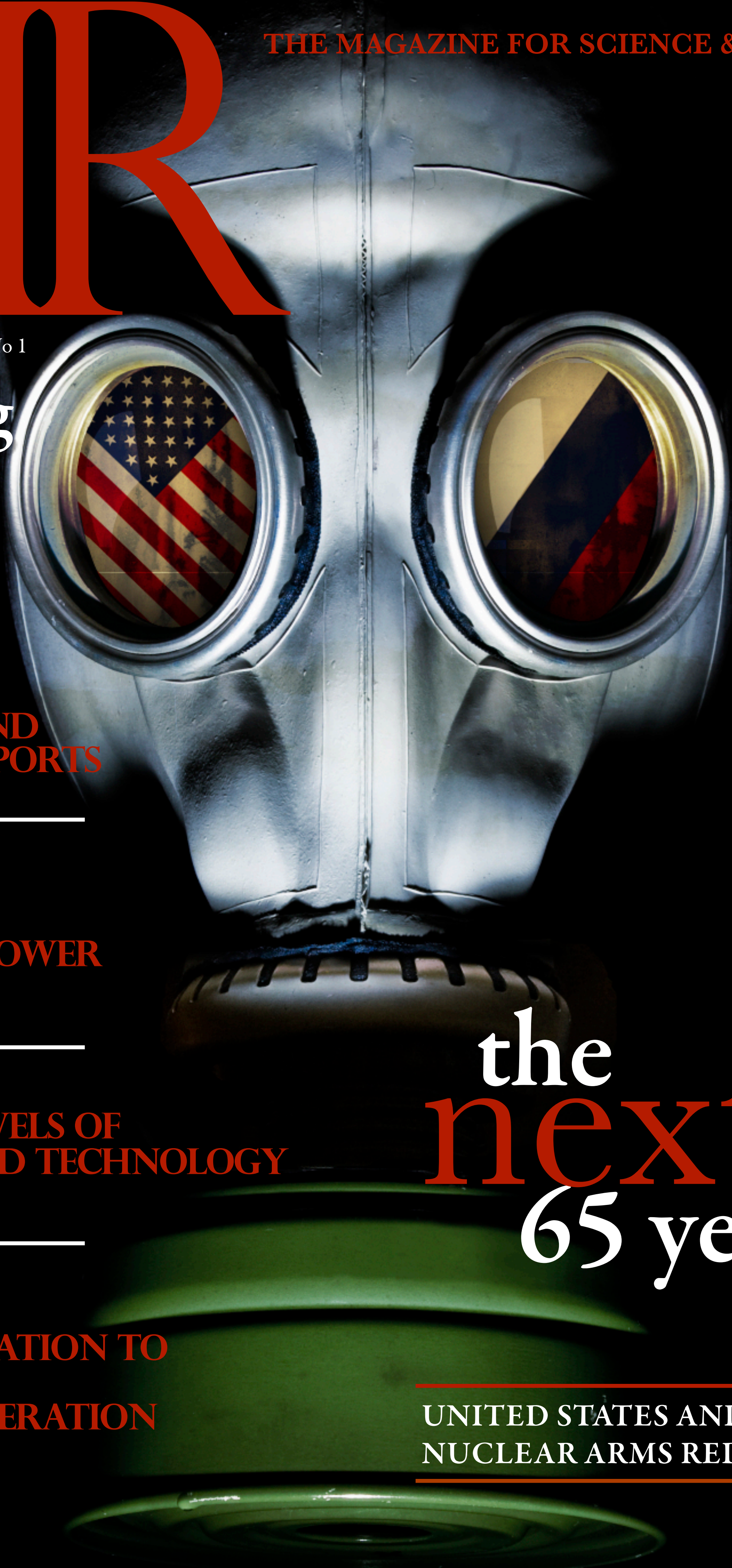
THE MAGAZINE FOR SCIENCE & SECURITY

Spring 2011 Volume 64 No 1



Detecting Enriched Uranium

FOREIGN BRIBERY AND ILLEGAL EXPORTS

FUTURE OF NUCLEAR POWER

CROWN JEWELS OF SCIENCE AND TECHNOLOGY

SELF-REGULATION TO PROMOTE NONPROLIFERATION

the next 65 years

UNITED STATES AND RUSSIA - NUCLEAR ARMS REDUCTIONS

New from Oxford University Press

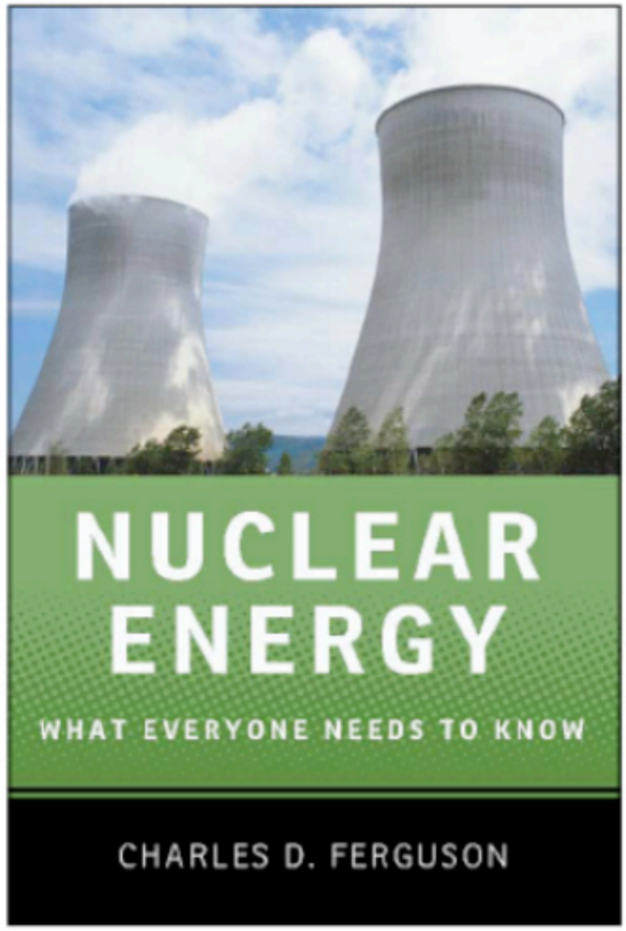
Nuclear Energy

What Everyone Needs to Know

By Charles D. Ferguson

Originally perceived as a cheap and plentiful source of power, the commercial use of nuclear energy has been controversial for decades. Worries about the dangers that nuclear plants and their radioactive waste posed to nearby communities grew over time, and plant construction in the United States virtually died after the early 1980s. The 1986 disaster at Chernobyl only reinforced nuclear power's negative image. Recent years have seen a marked change, however. The alarming acceleration of global warming due to the burning of fossil fuels and concern about dependence on foreign fuel has led policymakers, climate scientists, and energy experts to look once again at nuclear power as a source of energy.

In this accessible overview, Charles Ferguson provides an authoritative account of the key facts about nuclear energy. What is the origin of nuclear energy? What countries use commercial nuclear power, and how much electricity do they obtain from it? How can future nuclear power plants be made safer? What can countries do to protect their nuclear facilities from military attacks? How hazardous is radioactive waste? Is nuclear energy a renewable energy source? Ferguson addresses these questions and more in a book that is essential for anyone looking to learn more about this important issue.



May 2011
232 pp. Paper $16.95
ISBN: 978-0-19-975946-0

Key Features

- Easy to navigate, accessible Q&A format is ideal for an introduction to the subject of nuclear energy.
- In a clear, engaging style, the book provides a comprehensive survey of this controversial topic.
- Readily accessible and suitable to readers with various levels of background knowledge on the topic.
- Includes updated information on the nuclear crisis in Japan.

Charles D. Ferguson is President of the Federation of American Scientists and an Adjunct Professor in Georgetown University's Security Studies Program. Trained as a physicist and nuclear engineer, he has worked on nuclear policy issues at the U.S. Department of State and the Council on Foreign Relations.

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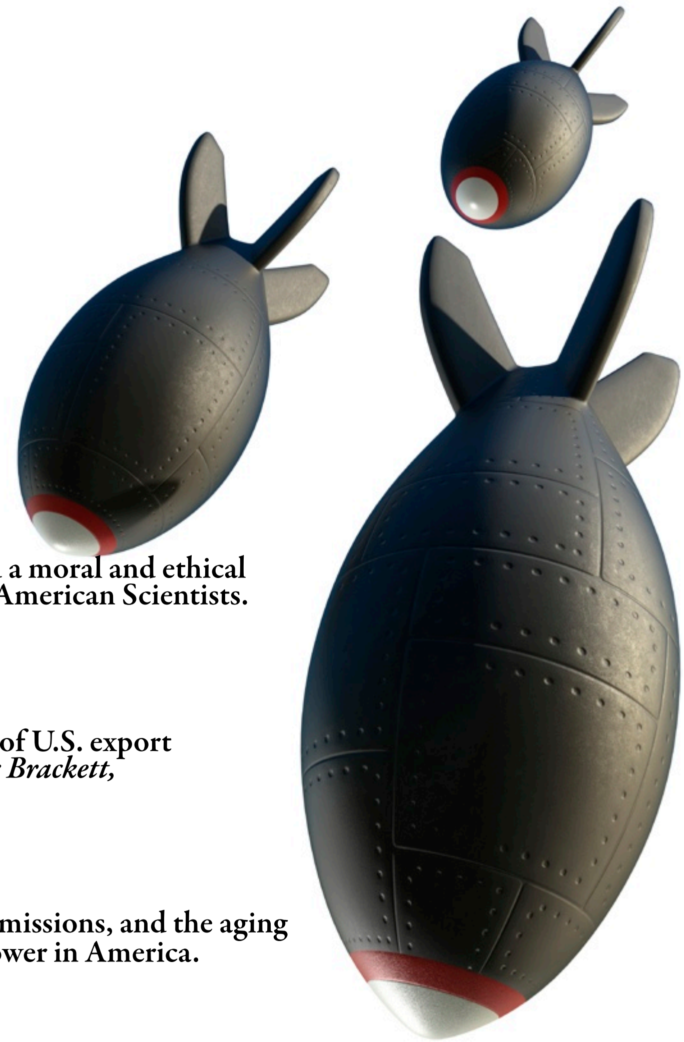

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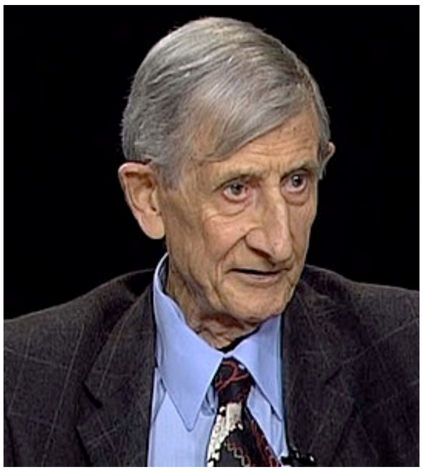


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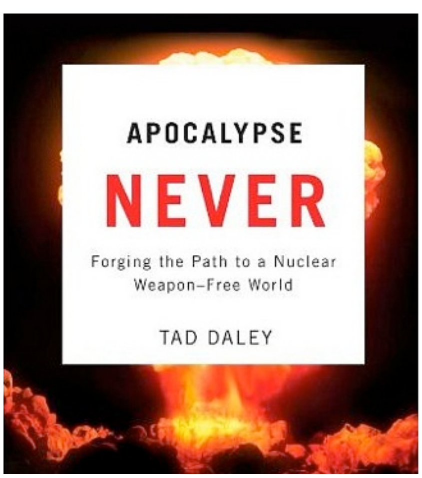
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www.FAS.org/blog/secrcy

Nuclear Crisis in Japan

Watch and listen to clips of FAS President Charles Ferguson explain the implications of the accident at the Fukushima Dai-ichi Nuclear Power Plant for the global expansion of nuclear power. Read opinions, reports, and news stories about the catastrophe.

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Learn more about biosecurity issues and national policy as it relates to health, biological sciences, and dual-use technologies.

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Demise of Osama bin Laden

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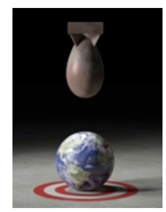

Letter Urges Release of New START Data

Linton Brooks, former chief U.S. START negotiator and administrator of the National Nuclear Security Administration; Jack Matlock, former U.S. ambassador to the Soviet Union and Special Assistant to President Ronald Reagan for national security affairs; and William Perry, former U.S. Secretary of Defense joined FAS in urging the United States and Russia to continue to declassify the same degree of information about their strategic nuclear forces under the New START treaty as they did during the now-expired START treaty.

At issue is whether the U.S. and Russia will continue under the New START treaty to release to the public detailed lists – known as aggregate data – of their strategic nuclear forces with the same degree of transparency as they used to do under the now-expired START treaty.

In the joint letter, the three former officials joined FAS President Charles Ferguson and Hans Kristensen in urging the U.S. and Russia to "continue under the New START treaty the practice of releasing to the public aggregate numbers of delivery vehicles and warheads and locations." This practice contributed greatly o international nuclear transparency, predictability, re-assurance, and helped counter rumors and distrust, the letter concludes.

Read the letter online at: http://www.fas.org/blog/ssp/2011/05/startetter.php.

PRESIDENT'S MESSAGE

FUKUSHIMA DAI-ICHI: THE NUCLEAR BLACK SWAN

"A nuclear accident anywhere is a nuclear accident everywhere." This aphorism has encapsulated the nuclear industry's creed that one major accident can sink the global nuclear fleet. Since March 11, the accident and ongoing crisis at the Fukushima Dai-ichi Nuclear Power Plant have been testing this zero tolerance policy.

In the past two months since the start of the accident, I have heard some interesting narratives that are trying to put this crisis in context. One view from some people in the nuclear industry is that this accident will ultimately be good for the industry because it will demonstrate that even a "worse-case" accident has resulted in no near-term deaths from exposure to ionizing radiation. In comparison, the earthquake and tsunami killed many thousands of people. So, even though the economic damage from the nuclear accident will soar into the tens of billions of dollars, the industry still has a good news story to tell in terms of the harm to human health.

A related view is that this extraordinary event was well beyond the normal design basis for this nuclear plant. That region of Japan had not experienced such a powerful combination of earthquake and tsunami in more than 1,000 years. The implication here is that this is a freak event and should not cause undue alarm for almost all other nuclear plants. An opposing view is that this accident shows that nuclear power is too dangerous and that countries need to phase out the existing plants and not build additional plants.

I propose that this event was an example of a "Black Swan," a high consequence catastrophe that deviated far from the statistical norm. But it should not have come as a surprise as I argue below. The norm for nearly 25 years since the Chernobyl accident was an industry that appeared to have steadily improving safety at almost all plants that were generating more and more electricity by operating the plants near maximum capacity.

This improvement in safety and power performance was a huge success story that partially renewed interest during the past decade for a "nuclear renaissance." But even before the accident, that renaissance was having trouble lifting off because of the high capital costs (several billion dollars) for a large reactor and long time (typically 8 to 12 years) for licensing and building a reactor at least in the United States. The U.S. nuclear industry had asked for and received additional financial incentives in the Energy Policy Act of 2005 for the next handful of new plants. But these incentives were not enough for utilities to place a bet on a risky construction project.

The Fukushima Dai-ichi accident will erect additional barriers to new nuclear plants unless the industry comes to terms with the major lessons. The magnitude of the damage to the plant would not have been as great as it was if the authorities (plant owners, inspectors, and regulatory agencies) had not put a damper on the safety concerns that were repeatedly raised for decades. By allowing the plant to fail inspections early on, the authorities would most likely have avoided the substantial damage to multiple reactors by either fixing the problems or shutting down any reactors permanently if corrective action could not meet high safety standards.

As recent news reports have described, this nuclear plant had accumulated numerous safety concerns and problems. For example, according to a March 11 *New York Times* story, the emergency diesel generators had known stress cracks. Also, after the license extension was approved for reactor one just one month before the accident, the Tokyo Electric Power Company, the owner, admitted that it had not inspected 33 pieces of safety equipment associated with the plant's cooling systems. Furthermore, according to a 2004 investigation, the company had falsified information from a number of plants, including Fukushima Dai-ichi. Critics of the Japanese regulatory system have often warned about the unhealthy ties between the plants' owners and the regulators.

Thus, one of the primary lessons is to ensure that regulatory agencies have the independence and authority they need to order unsafe plants shut down and corrective safety measures implemented before a plant is allowed to operate. A related lesson is to ensure that the whistleblowers are protected. Moreover, the industry should not have been in a rush to extend the licenses of older design plants especially when newer designs have significantly improved safety features. Until Japan and other nuclear power producing countries seriously address these problems, the world should not be shocked to witness other nuclear Black Swans.

Charles D. Ferguson
President, Federation of American Scientists

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Spring 2011 Volume 64 No 1

ESTABLISHED 1945

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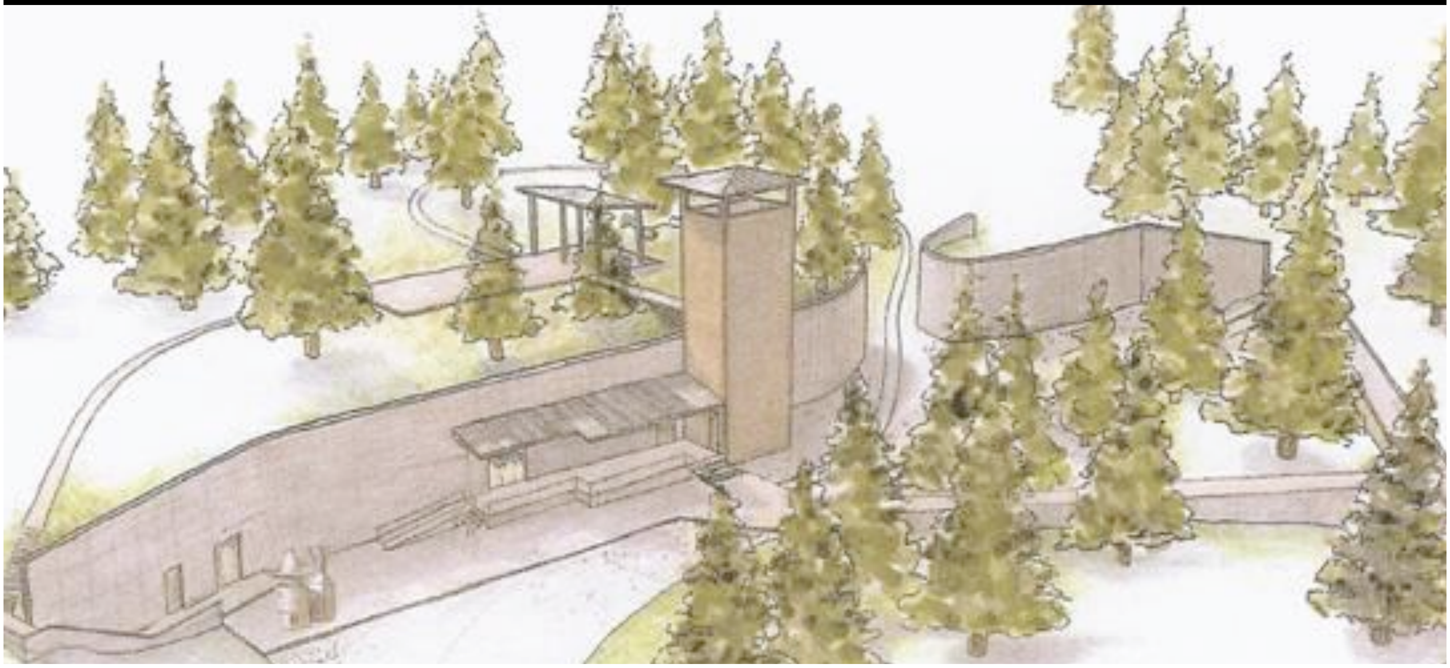

Artist rendition of Little Boy site.

The Manhattan Project 65 Years Later

BY CYNTHIA C. KELLY

INTRODUCTION

This year marks the 65th anniversary of the end of the Manhattan Project, the top-secret effort by the United States to build the world's first atomic bombs. Manhattan Project scientists, engineers and others who believed they had a moral and ethical responsibility over their technological contributions created the Federation of American Scientists (FAS), originally the Federation of Atomic Scientists. FAS sought to ensure that nuclear energy research was directed towards peaceful applications and to prevent the future use of nuclear weapons. Sixty-five years later, the work of FAS continues.

On August 6, 1945, Secretary of War Henry Stimson announced the dropping of the bomb on Hiroshima and declared that the atomic bomb was "the greatest achievement of the combined efforts of science, industry, labor and the military in all history."[1]

More than 85 percent of the public polled at the time supported the dropping of the atomic bomb as it brought an end to a long and devastating war. Dr. Karl Compton said, "It was not one atomic bomb, or two, which brought surrender; it was the experience of what an atomic bomb will actually do to a community, plus the dread of many more, that was effective." [2]

The threat of nuclear weapons persists today, one of the lasting legacies of the Manhattan Project. As J. Robert Oppenheimer said to Los Alamos scientists on November 2, 1945, the atomic bomb arrived in the world with "a shattering reality" that changed the relationship between science and society.[3] Pressed into service during the war, scientists not only provided the foundation for atomic weapons but were instrumental in making them.

What about the remains of the Manhattan Project? For decades, the Manhattan Project was enshrouded in secrecy. Production facilities and laboratories were located "behind the fence," where only those with the proper security clearances were allowed. By the early 1990s, hundreds of Manhattan Project properties were slated to be destroyed as part of a nationwide cleanup of the former nuclear weapons facilities. Few members of the public were aware that almost all that remained of this important chapter of history would soon be lost.

This article tells the story of the Atomic Heritage Foundation's efforts to preserve the most important Manhattan Project properties and to create a Manhattan Project National Historical Park. Founded in 2002, the Atomic Heritage Foundation has spent nearly a decade working to preserve this chapter of American and world history.

[1] Statement of the Secretary of War Henry L. Stimson, August 6, 1945, from Cynthia C. Kelly, ed., *The Manhattan Project*, (New York: Black Dog & Leventhal, 2007), 343.
[2] Dr. Karl Compton as quoted by Stimson, *Ibid*. 388.
[3] J. Robert Oppenheimer, Speech to Los Alamos Scientists, November 2, 1945, *Ibid*. 366.

THE V SITE BUILDINGS OF LOS ALAMOS NATIONAL LABORATORY

At Los Alamos, the original technical buildings around Ashley Pond had been torn down more than forty years ago. By 1997, only fifty Manhattan Project properties scattered in remote parts of the laboratory remained. Most were built to last the duration of World War II and had been abandoned in the mid-1950s. By the mid-1990s, nature had begun its own process of demolition. While the laboratory was required to mitigate the loss of historic properties, preservation was not considered an option. Isolated in space and time, few people even knew these buildings existed.

A cluster of humble wooden buildings called "V Site" are surrounded by ponderosa pines as occasional herds of mule deer trot across the sur-rounding meadows. The central building has high-bay doors that once swung open for the "Gadget," the world's first atomic device tested on July 16, 1945.

In its report to New Mexico's environmental authorities on the V Site buildings, the laboratory condemned the buildings, citing contamination with asbestos shingles and possible residues of high explosive materials. Fortunately, the Advisory Council on Historic Preservation (ACHP), a small federal agency, agreed to take an independent look at the V Site properties.

The council members were struck by the contrast between the simplicity of structures and the complexity of what took place inside them. Designing the world's first atomic bomb was the most ambitious scientific and engineering undertaking in the twentieth century. Yet the buildings put up hastily in the summer of 1944 more closely resembled a common garage or work shed.

Bruce Judd, an architect whose parents had worked on the Manhattan Project at Los Alamos, commented that the V Site properties were "monumental in their lack of monumentality." Who could believe that the world's first atomic bomb was designed and assembled in such an unimpressive structure? The birthplace of the atomic bomb was like the garage in Palo Alto, CA, where Bill Hewlett and David Packard invented one of the world's first personal computers in 1938. Humble.

Somewhat chastened, the Los Alamos National Laboratory management agreed to remove all of the V Site buildings from the demolition list. However, funds for restoration would have to come from some other source.

The birthplace of the atomic bomb was like the garage in Palo Alto, CA, where Bill Hewlett and David Packard invented one of the world's first personal computers in 1938. Humble.

Fortunately, Congress had set aside $30 million to commemorate the millennium by preserving significant federal properties that were in danger of being lost. Department of Energy (DOE) Secretary Bill Richardson competed for the new Save America's Treasures grants and the V Site was awarded a $700,000 grant.

Today the V Site gives the Manhattan Project a tangible reality, connecting us to the "galaxy of luminaries" recruited by J. Robert Oppenheimer to build the world's first atomic bombs. When we stand within its walls, we can imagine Oppenheimer and his colleagues inspecting the "Gadget" as it hung from the metal hook above our heads.

SIGNATURE FACILITIES OF THE MANHATTAN PROJECT

Inspired by the restoration of the V Site, in 2000 the DOE listed eight properties as Signature Facilities of the Manhattan Project. The list included the V Site and Gun Site at Los Alamos, the X-10 Graphite Reactor, Beta-3 Calutrons and K-25 Gaseous Diffusion Plant at Oak Ridge, and the B Reactor and T Plant at Hanford. This was a major step forward but did not guarantee the preservation of these facilities.

Having been to Los Alamos, the Advisory Council convened a special task force to go to Oak Ridge and Hanford. In February 2001, the council's report urged the preservation of the Signature Facilities at those sites as well as properties in the communities. Preservation was gaining traction.

In 2003, Congress required the DOE to develop a plan for preserving its Manhattan Project history. Under a cooperative agreement with DOE, the Atomic Heritage Foundation took on the task, beginning with a series of public meetings at Oak Ridge, TN; Los Alamos, NM; and Richland, WA.

The Foundation's report released in 2004 recommended a Manhattan Project national historical park at the three major Manhattan Project sites. The plan also listed properties that were essential to tell the story of the Manhattan Project.

THE MANHATTAN PROJECT NATIONAL HISTORICAL PARK STUDY ACT

In September 2004, Congress passed the Manhattan Project National Historical Park Study Act [PL 108-340] that authorized the National Park Service to study whether to create a Manhattan Project National Historical Park.

Early this year, the National Park Service is expected to submit its recommendations to Congress for a park with units at Los Alamos, Oak Ridge and Hanford. Over time, a number of affiliated areas could be created at the University of Chicago, University of California at Berkeley, Wendover Air Force Base in Utah, the Trinity Site at Alamogordo, NM, sites in Dayton, OH, and Tinian Island.

In the meantime, the Atomic Heritage Foundation is continuing its work to preserve key Manhattan Project properties. A top priority is to ensure that at least a portion of the mile-long K-25 plant in Oak Ridge is preserved. In May 2010, the Tennessee Trust for Historic Preservation named the K-25 plant as one of the state's ten most endangered historic sites. The department recently released an expert evaluation that suggests that saving a piece can be done in a cost-effective and safe manner. A decision is anticipated by June 2011

A second preservation priority is the Gun Site at Los Alamos. The Gun Site (TA-8-1) was where Manhattan Project scientists and engineers developed and tested the uranium-based weapon design. Here the "Little Boy" bomb dropped on Hiroshima on August 6, 1945, was assembled. We hope that restoration of the bunker-like buildings and a 45-foot periscope tower will be completed in time for New Mexico's Centennial in 2012.

In 2007, the Atomic Heritage Foundation published an anthology, *The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses, and Historians* (Black Dog & Leventhal).

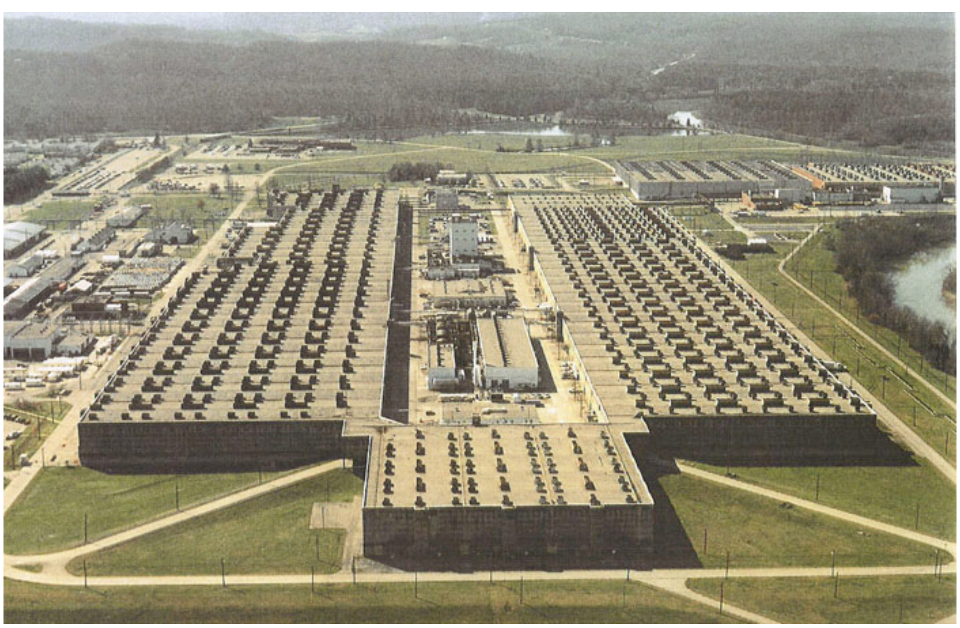
In June 2010, the Foundation produced a Guide to the Manhattan Project Sites in New Mexico that provides an overview of the history and preservation efforts in New Mexico with colorful illustrations and stories. We are now preparing similar guides to the Manhattan Project in Tennessee and Washington to be published this summer.

A NATIONAL TRAVELING EXHIBITION

With the likely designation of a Manhattan Project National Historical Park, the Atomic Heritage Foundation is planning to develop a national traveling exhibition on the Manhattan Project and its legacy. The exhibition will attempt to bridge the gap between the two cultures of science and the humanities, and address the science and engineering challenges as well as the historical, political, social and cultural legacy. Working with FAS and other partners, the exhibition will address the continuing challenges of dealing with nuclear weapons today.

When future generations look back on the 20th century, few events will rival the harnessing of nuclear energy as a turning point in world history. Having some of the authentic properties where the Manhattan Project scientists and engineers achieved this is essential. As Richard Rhodes, Pulitzer Prize winning author of *Making of the Atomic Bomb*, has said, "When we lose parts of our physical past, we lose parts of our common social past as well." With the prospective Manhattan Project National Historical Park, our vision of having some tangible remains from the Manhattan Project to educate and inspire future generations may become a reality. Sixty five years is not too long to wait.

Cynthia C. Kelly is the president of the Atomic Heritage Foundation.



K-25 is a former uranium enrichment facility of the Manhattan Project at Oak Ridge, Tennessee.

Q&A: Freeman Dyson

This year the Federation of American Scientists is celebrating its 65th anniversary. Many of the issues of concern to the FAS founders exist today. Freeman Dyson, Professor Emeritus at the Institute for Advanced Studies at Princeton University, former FAS Chairman and long time FAS Member, was interviewed and supplied his answers to FAS questions via email.

Learn more about Professor Dyson by visiting: http://www.sns.ias.edu/~dyson/

One of the objectives of the FAS founders was for nuclear materials and technology to fall under international supervision. What is your advice to improve the international nuclear nonproliferation system?

I consider that the International Atomic Energy Agency (IAEA) has done a very useful and competent job for many years in supervising nuclear technology and materials. They have done especially well in negotiating compromises with governments that are not fully cooperative. The original FAS program of full international ownership of nuclear facilities failed, and instead we have a program of compromises that works pretty well. The FAS should support IAEA and not make unrealistic demands for more intrusive supervision.

What can FAS do to improve the nuclear non-proliferation system?

To improve the nuclear non-proliferation system, FAS should concentrate on the U.S. weapons program over which we have some influence, and stop concentrating on countries such as Iran and North Korea over which we have no influence. We should fight for a U.S. no-first-use policy, and for drastic reductions in U.S. nuclear weapons. We should hold up South Africa as a good example for the rest of the world to follow. (Editor's note: South Africa is the only country to have dismantled a nuclear weapons program.)

I am not saying that we should not work on the problems of nuclear weaponry in Iran and North Korea. Obviously we should try to understand and to influence what is going on in these countries. But we should put far more effort and urgency into the problems of our own weapons, which are a bigger threat to the planet. They are useless for any sane military purpose and they are within our power to reduce or abolish if we have the will to do so. An unconditional No First Use policy should be a priority objective for FAS to pursue.

What is your most striking recollection as FAS Chair in 1962?

My main concern as FAS Chairman in 1962 was to persuade the FAS Council to adopt a strong public statement advocating No First Use. Our vote occurred at a meeting in New York in January while a record-making blizzard raged outside. The statement was approved by the FAS Council. The next day, the newspapers were full of stories of the blizzard and did not mention No First Use. I did not succeed in making No First Use a question for serious public debate. I still think that No First Use must be a key part of any program for decreasing reliance on nuclear weapons.

In 2007, George Shultz, William Perry, Henry Kissinger, and Sam Nunn published an op-ed in the Wall Street Journal *that called for a global consensus to prevent the proliferation of nuclear weapons and eliminate them from the world. Do you think a goal of zero nuclear weapons is feasible? Why or why not?*

It is important to understand that the phrase "zero nuclear weapons" has two very different meanings. It can mean "physical zero" or it can mean "legal zero." Physical zero means that there are no nuclear weapons anywhere. Legal zero means that nuclear weapons are legally prohibited; there is no open deployment of nuclear weapons, but there is no assurance that the Israelis or the Russians do not have some nuclear weapons hidden away. In my opinion the goal of physical zero is unfeasible and unwise. It demands a verification system so intrusive that it would be politically unacceptable. Too much verification is likely to lead to frequent false alarms and consequent instability. In my opinion, the goal of legal zero is feasible and also preferable. Legal zero should be the goal for FAS. Legal zero is the situation achieved by the existing biological weapons convention, and it would be a good model for nuclear weapons too.

This year the U.S. is retiring its space shuttle program. As a leader of Project Orion, what are your thoughts on present U.S. space policy?

Space policy is a big subject. Project Orion has nothing to do with present-day problems. Project Orion intended to explore planets in 19th century style, like Darwin exploring the Galapagos Islands. The 21st century will have unmanned missions doing the job much better with vastly smaller payloads and greater outreach. I strongly support the NASA policy of retiring the shuttle and replacing it with new manned launch systems developed by private companies.

The manned space program should be honestly promoted to the public as an international sporting event. It should not be misrepresented as a science program. The public is willing to pay a lot for sporting events. Meanwhile, the science program should continue with unmanned missions and steady funding.

How would you advise the United States in terms of its investment in technology? Where should the U.S. focus its R&D funding?

The main problem with U.S. government investment in technology has been the excessive support for big projects such as the National Ignition Facility (NIF) and the International Space Station (ISS) and neglect of small projects. In the political competition for funds, big projects tend to win regardless of their merits, because they provide more jobs. FAS should fight for a balanced program with roughly equal total budgets for small and large projects. The government should avoid "picking winners" among the small projects.

The question "where should the U.S. be focusing its R&D money?" makes the wrong assumption that focusing is good. I believe that focusing is bad because it implies picking winners. We should not be focusing our money on narrow objectives. Broad support for a variety of fields and a variety of small enterprises should be our goal.

At the United Nations Climate Change Conference in Cancun, Mexico, Dr. Hasan Mahmud, Bangladesh's State Minister for Environment and Forests, stated that skeptics need look no further than his nation to see climate change in action. What are your thoughts on climate change?

Concerning climate change, I should first tell you that *The Atlantic* article by Kenneth Brower seriously misrepresents my views. He did not interview me and he did not give me a chance to see the article before it was published.

It is true that I am highly skeptical about the claimed understanding of climate change. Of course I do not deny that climate change is happening. I am skeptical of any claims that we understand it or that we can predict it or that we know what to do about it. Unfortunately the public debate on this subject has become highly political. I would strongly urge that FAS stay out of the debate as much as possible. It is a distraction from more important problems, such as nuclear weapons and public education and the regulation of biotechnology, where the competence and the influence of FAS is greater.

What issues should FAS tackle in the next 65 years?

I do not have any brilliant suggestions for the activities of FAS during the next 65 years. I would maintain the goal of reducing nuclear weapons to legal zero as the chief concern of FAS. This goal might well take 65 years to achieve, or it might be achieved much sooner. The most important changes that will happen are likely to be unpredictable. I believe that unilateral moves to abolish weapons will be more effective than multilateral negotiations in reaching the goal. Unilateral moves do not need ratification by the U.S. Senate, and they do not need to be coupled with complicated verification systems. Unilateral discarding of weapons is the best way to show the world that we do not consider them essential to our security. I urge FAS to give serious attention to unilateral moves as the key to a better future. ■

Foreign Bribery and Illegal Exports

What the Scientific Community Should Know

— BY MARK BRZEZINSKI and ALEX BRACKETT

INTRODUCTION

As research, exchanges and other opportunities take American scientists to the four corners of the globe, travelers must be aware of two sets of regulations that are witnessing unprecedented upticks in enforcement: U.S. export controls and U.S. anti-bribery laws (formally known as the Foreign Corrupt Practices Act or FCPA). Understanding the basics of these laws—and key pitfalls to avoid—is vital not just for industry, but for any individual or organization actively engaged in activities with non-U.S.[1] colleagues, customers or fellow researchers. This is particularly true as globalization offers a growing number of opportunities for partnering with foreign concerns and engaging with non-U.S. persons in settings such as universities.

U.S. EXPORT CONTROLS AND THE "DEEMED EXPORT" ISSUE

The Cautionary Tale of Professor Roth

On July 1, 2009, former University of Tennessee professor John Roth was sentenced to 48 months in prison for violating the Arms Export Control Act through his export of technical data related to a U.S. Air Force research and development contract. Roth's conviction and sentencing, which were upheld by the Sixth Circuit Court of Appeals on January 5, 2011, set off alarm bells in the halls of academia and beyond, and offer lessons that all scientists who rely on foreign research assistants must heed.

Roth's crime was the export of technical data related to the development of specialized plasma technology for use on advanced forms of unmanned aerial vehicles (UAVs). Roth ran afoul of U.S. export control laws by traveling to China with project plans in hard copy, on his laptop and on a memory stick, sharing project data with a Chinese colleague, and having two non-U.S. students work with him on the project. All of these activities occurred without government knowledge or approval, and in spite of warnings from the university and its Export Control Officer to not share sensitive data with foreign nationals.

Roth's case clearly demonstrates the risks associated with export control violations, and the willingness of U.S. law enforcement to pursue severe penalties against individual violators. It also illustrates the risks of "deemed exports," which in Roth's case occurred when he shared controlled technical data with non-U.S. persons (his foreign students) who worked for him inside the United States.

1 For purposes of U.S. export control laws and regulations, a "U.S. Person" is a citizen or permanent resident alien of the United States.

Understanding Deemed Exports

The export of U.S. goods and technology is governed primarily by two regimes. Defense articles and services categorized by the United States Munitions List (USML), as well as related technical data, fall under the control of the International Traffic in Arms Regulations (ITAR), enacted under the Arms Export Control Act and administered by the U.S. Department of State. All other U.S. goods and technology[2] fall under the Export Administration Regulations (EAR), which are administered by the U.S. Department of Commerce.

If an item-related technical data or defense service is ITAR-controlled, a license is typically required before it may be exported. By contrast, whether a license is required for EAR-controlled exports will vary substantially based on the items and countries involved. In general, most items and technology that are EAR-controlled do not require a license for export to most countries.

"Deemed exports" are the release or transfer of technology or technical data, whether ITAR or EAR-controlled, to a non-U.S. person inside the United States.[3] Physical export out of the United States is not required, and a release can occur simply by sharing information, such as providing access to drives containing the information. Such transfers of data or technology are "deemed" to be exports to the home country of the recipient, and are subject to the same licensing requirements as if the information were being physically exported from the United States to that country.[4]

Although most non-military goods and technology do not require a license for export to most countries, determining whether an item is subject to particular export controls can be a complicated, fact-intensive and highly technical process. Case-by-case analysis is often required because EAR licensing requirements can vary substantially from country to country. Accordingly, organizations and individuals must understand and take care in handling the technology with which they work, particularly when they collaborate with non-U.S. persons or entities, inside or outside the United States, even in academic and other research settings.

"If an item, related technical data or defense service is ITAR-controlled, a license is typically required before it may be exported."

This is all the more critical given a recent increase in export enforcement, marked by cases such as Roth's, as well as greater cooperation and coordination among immigration officials, export control agents, and prosecutors.

THE NEW FCPA ENFORCEMENT CONTEXT

An Aggressive Enforcement Agenda

For some, the word bribery connotes an image of corrupt businessmen with briefcases full of cash. But over the last decade, U.S. law enforcement has made clear that the forms of corruption it deems improper under the FCPA[5] can appear in many shapes and sizes. As a result, scores of companies, industries and individuals have come to learn that practices they had previously considered fairly innocuous may bring them within the sights of FCPA enforcement efforts that have become increasingly aggressive, high profile and costly for those caught in the enforcement crosshairs.

The FCPA prohibits corrupt payment or offer of payment by any U.S. person (wherever located), or on behalf of any U.S. person, of any thing of value to foreign officials for the purpose of obtaining or keeping any business or business advantage (the anti-bribery provisions). It also penalizes any publicly-held company that maintains inaccurate books and records or inadequate internal accounting controls (the books-and-records provisions). Recent FCPA enforcement efforts have been marked by expansive interpretations of jurisdictional reach, including theories of liability that remain largely untested in U.S. courts. They are also noteworthy for substantial settlements regularly reaching into the tens and hundreds of millions of dollars, with eight of the ten largest settlements of all time occurring in 2010.

And enforcement efforts have by no means been limited to U.S. companies and persons.

[2] "Technical data" and "technology" are essentially the same concepts, just using different terminology for the different export control regimes.
[3] *See* 15 C.F.R. § 734.2(b)(2)(ii); 22 C.F.R. § 120.17(a)(4).
[4] The EAR and ITAR consider citizenship differently. The EAR looks to the foreign national's most recent country of citizenship or permanent residence, while the ITAR looks to the foreign national's most restrictive country of citizenship.
[5] Foreign Corrupt Practices Act of 1977, as amended, 15 U.S.C. §§ 78dd-1, *et seq.*

In fact, it is quite to the contrary. As of January 2011, eight of the top ten FCPA settlements of all time involved foreign companies.

The Focus on Pharmaceutical and Medical Device Companies

Within the last 18 months, FCPA enforcement has included a growing shift into industry-targeted enforcement efforts, most notably of the pharmaceutical and medical device industries. These industries have seen rapid growth in international research and development efforts, as well as expanded overseas manufacturing, marketing and sales. They are grappling with an anti-bribery challenge few considered to be a significant issue just a few years ago.

Assistant Attorney General and Department of Justice ("DOJ") Criminal Division Chief Lanny A. Breuer announced the so-called "Pharma Initiative" during his November 12, 2009, keynote address at the Tenth Annual Pharmaceutical Regulatory and Compliance Congress in Washington, D.C. Breuer's speech outlined an aggressive FCPA enforcement agenda focused on companies and individuals. Since then, Breuer and a number of other DOJ and Securities and Exchange Commission (SEC) officials[6] have cemented the message that FCPA enforcement will only increase in the years to come, as part of a more proactive approach to white collar enforcement. This includes deploying tools not typically used in white collar cases, such as wiretaps and the use of undercover agents.

The Pharma Initiative presents an intriguing case study in FCPA enforcement. As described by Breuer in his November 2009 remarks, it is estimated that U.S. pharmaceutical companies generate one third of their sales, worth $100 billion, outside the United States "where health systems are regulated, operated and financed by government entities to a significantly greater degree than in the United States." Per Breuer, this means that many healthcare providers in foreign countries could be considered "foreign officials" and "it is entirely possible, under certain circumstances and in certain countries, that nearly every aspect of the approval, manufacture, import, export, pricing, sale and marketing of a drug product in a foreign country will involve a 'foreign official' within the meaning of the FCPA."

In November 2009, the DOJ and SEC had at least six active FCPA investigations of major medical device companies. Since then, at least five pharmaceutical and medical device companies, both large and small, have confirmed receiving subpoenas and/or letters from the DOJ and SEC putting them on notice that they are under investigation for their international activities. Several practices appear to be under scrutiny, including:

- Bribery, kickbacks or other improper inducements provided in order to drive drug and device sales;
- Drug trials conducted in foreign locations, and the possibility that improper inducements are being offered to influence their outcomes, either directly or through third parties;[7] and
- Increasing investment in facilities located in regions with poor reputations for corruption.

Because FCPA liability can be triggered by provision of any thing of value in exchange for an improper action by the recipient, and there is no de minimis exception, even the offer of low-level benefits can raise difficult questions. This has forced the pharmaceutical and medical device industries to take a close look at their international activities in anticipation of possible scrutiny.

Targeting Individuals

While Breuer's November 2009 speech caused alarm across the targeted industries, its assertion that a significant focus of the enforcement effort would be the investigation and prosecution of senior executives has had a wider and equally significant impact. According to Breuer, "[e]ffective deterrence requires no less . . . . [F]or our enforcement efforts to have real deterrent effect, culpable individuals must be prosecuted and go to jail." Subsequent speeches by Breuer and other law enforcement officials have pressed the same theme.

In a February 25, 2010 speech before the American Bar Association's 24th Annual National Institute on White Collar Crime in Miami, Breuer warned that "the prospect of significant prison sentences for individuals should make it clear to every corporate executive, every board member, and every sales agent that we will seek to hold you personally accountable for FCPA violations." He described "the aggressive prosecution of individuals" as a cornerstone of the DOJ's "very robust FCPA program," which he held out as a model that "typifies how we are approaching crime in corporate America."

These comments were preceded by a July 2009 civil FCPA settlement between the SEC and Nature's Sunshine Products, Inc. where liability was imposed on two company executives based on a "control person" theory. The individuals were held accountable for failing to adequately oversee personnel charged with maintaining accurate books and records and adequate internal controls, even though the executives were not alleged to have engaged in or been aware of the improper payments.

That same month, Frederick Bourke, co-founder of the high-fashion handbag company Dooney & Bourke, was convicted of an FCPA violation and subsequently sentenced to more than a year in federal prison.[8] Bourke was accused only of having known or consciously avoided knowing about a bribery scheme related to the sale of a state-owned oil company in Azerbaijan, demonstrating the risk of third parties creating liability. Bourke, an

[6] The DOJ and SEC share FCPA enforcement jurisdiction.

[7] According to a June 22, 2010, report by the Office of Inspector General of the Department of Health and Human Services, it is "estimated that between 40 percent and 65 percent of clinical trials investigating FDA-regulated products are conducted outside the United States," with 78 percent of all subjects who participated in clinical trials enrolled at foreign sites and 54 percent of all trial sites located outside the United States. HHS, Office of Inspector General, *Challenges to FDA's Ability to Monitor and Inspect Foreign Clinical Trials* (June 22, 2010), at http://oig.hhs.gov/oei/reports/oei-01-08-00510.pdf (last visited Mar. 13, 2011).

[8] FCPA trials are rare. Of the few that have gone to trial since 1991, none has resulted in acquittal.

investor who did not pay any bribes and actually lost money, was convicted because he put his "head in the sand" regarding a deal that was too good to be true in a country with a reputation for corruption.

The DOJ and SEC have since secured convictions, pleas or other settlements in a number of individual prosecutions,[9] including the March 2011 guilty plea of Jeffrey Tesler, a UK citizen involved in the payment of $180 million in bribes over ten years to Nigerian government officials in order to secure $6 billion in contracts to build liquefied natural gas facilities. As part of his plea, Tesler agreed to forfeit nearly $149 million. Cases such as this indicate that law enforcement has no intention of backing off Breuer's mandate to hold culpable individuals accountable.

EMPHASIS ON COMPLIANCE PROGRAMS

Organizations faced with the complex issues and aggressive enforcement environments outlined above have valid reason for concern. However, there are simple, direct steps they can take to insulate themselves from deemed export and FCPA-related risks, such as deploying a risk-based compliance program.

Compliance programs are an increasingly familiar concept, strongly endorsed and encouraged by U.S. law enforcement and the U.S. Sentencing Guidelines. While not mandated by law, the presence or absence of risk-based compliance programs is often one of the first avenues of inquiry in any government investigation. As Breuer stated in his February 2010 speech, organizations can expect to face criminal charges "when the criminal conduct is egregious, pervasive and systemic, or when the corporation fails to implement compliance reforms, changes to its corporate culture, and undertake other measures designed to prevent a recurrence of the criminal conduct."

At their core, compliance programs should derive from a comprehensive risk analysis that categorizes the level of risk and what parts of the organization are most likely to be impacted. This should be supported through tiered training that provides base-level awareness to a wide audience, and more in-depth instruction to a targeted audience of personnel in key positions relevant to risks and program responsibilities. The program should be actively overseen by a high-level official, with regular program audits and reviews conducted to ensure it remains appropriately tailored to the organization's activities and risk profile. The organization should continually reassess and revise the program based on audit and review results, and based on the resolution of specific compliance issues.

Although these efforts do require commitment of resources, such investment is minimal in comparison to the potential downside of an export control or FCPA enforcement action occurring in the absence of a compliance program.

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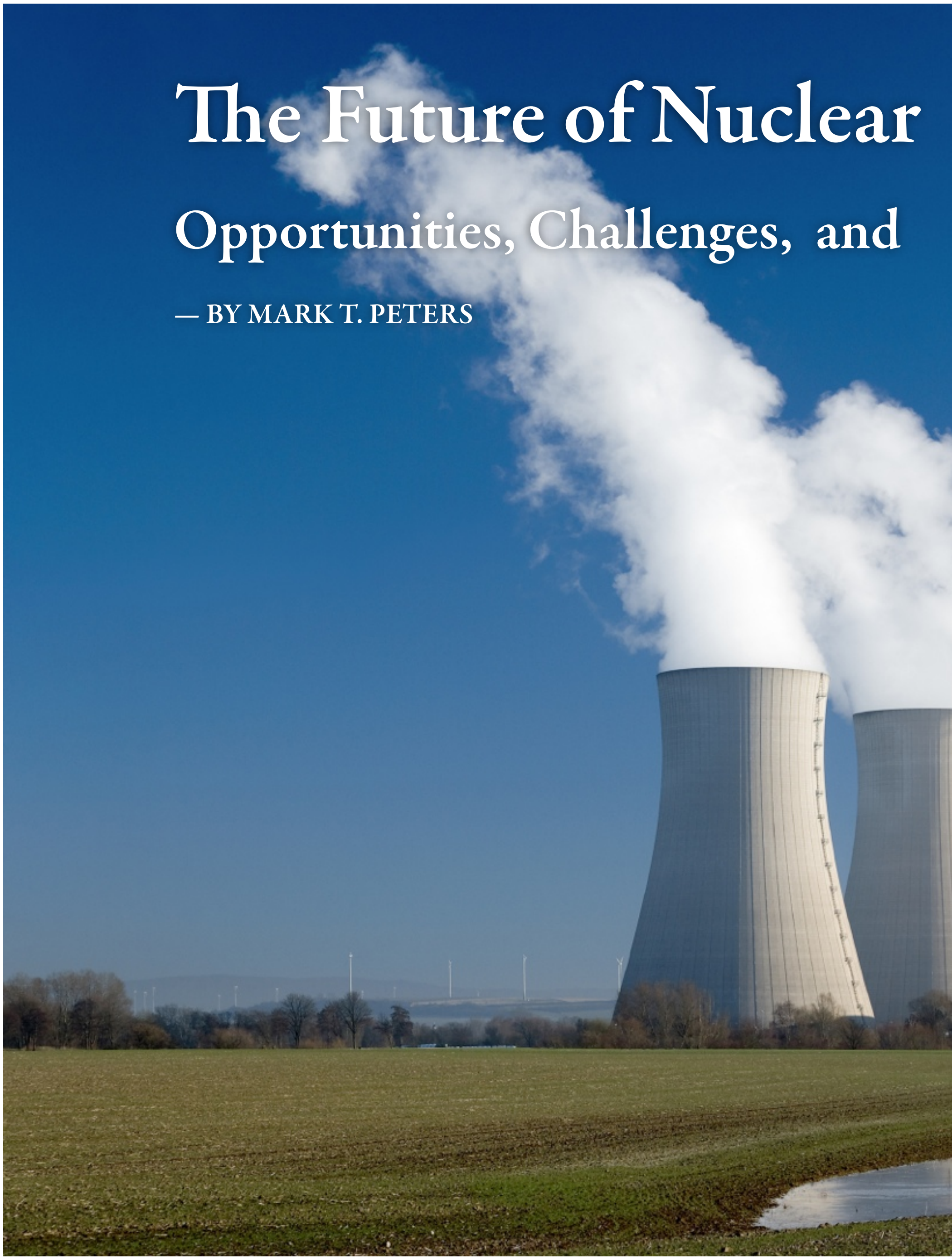
[9] Both the DOJ and SEC have been focused on FCPA enforcement actions against individuals overall, with a significant recent rise in such cases. Reports indicate that between 2005 and the third quarter of 2010, approximately 104 individuals have faced such enforcement actions. This breaks out by year as follows: 2005 (8 individuals charged), 2006 (9), 2007 (17), 2008 (16), 2009 (42), 2010 (12, as of September 2010).

[10] Pursuant to the U.S. Sentencing Guidelines and the DOJ's Filip Memo governing charging decisions for corporate defendants, a key consideration regarding whether a company has an effective ethics and compliance program is whether the program was in place before law enforcement scrutiny began. See USSG § 8B2.1; USAM, Title 9, Chapter 9-28.000. Recent amendments to the Sentencing Guidelines, effective as of November 1, 2010, include key changes impacting how ethics and compliance programs and the lines of reporting within them should be organized, and provide guidance as to how the compliance program should respond to issues "including assessing the compliance and ethics program and making modifications necessary to ensure that the program is effective."



The Future of Nuclear

Opportunities, Challenges, and

— BY MARK T. PETERS

Since the late 1970s, when safety fears and economic factors converged to halt construction of new nuclear power plants, the nuclear energy industry has stalled in the United States. Meanwhile, other nations have made substantial investments in new nuclear power plants and advanced nuclear energy technologies. Today, however, the soaring cost of petroleum, increasing concerns about carbon emissions, and the aging nuclear power plant fleet have revived the national conversation on nuclear energy in America.

The Obama administration has signaled its willingness to support America's nuclear energy industry through additional loan guarantees for new plant construction. In his 2011 State of the Union address, President Obama set a goal of generating 80 percent of America's electricity from clean energy sources by 2035, and he included nuclear energy in his list of clean sources.

However, these positive signals from the White House must be balanced against some important hurdles: The events at the Fukushima Daiichi plant have reopened questions about operating safety; the relatively low price of electricity makes the substantial upfront costs of new nuclear power plant construction difficult to justify in the short term; the availability of plentiful, affordable natural gas reserves undercut the perceived future need for expanded nuclear power generation capacity; and last year's decision to withdraw the license application for a high-level nuclear waste repository at Yucca Mountain leaves open the continuing problem of providing safe, permanent disposal for America's legacy, current, and future nuclear wastes. Despite these short-term hurdles, the need to address the challenges of energy security and climate change, combined with continued robust safety, security, and oversight of existing plants and development and deployment of next-generation technologies, should strengthen and expand the role of nuclear energy in America's 21st-century energy portfolio.

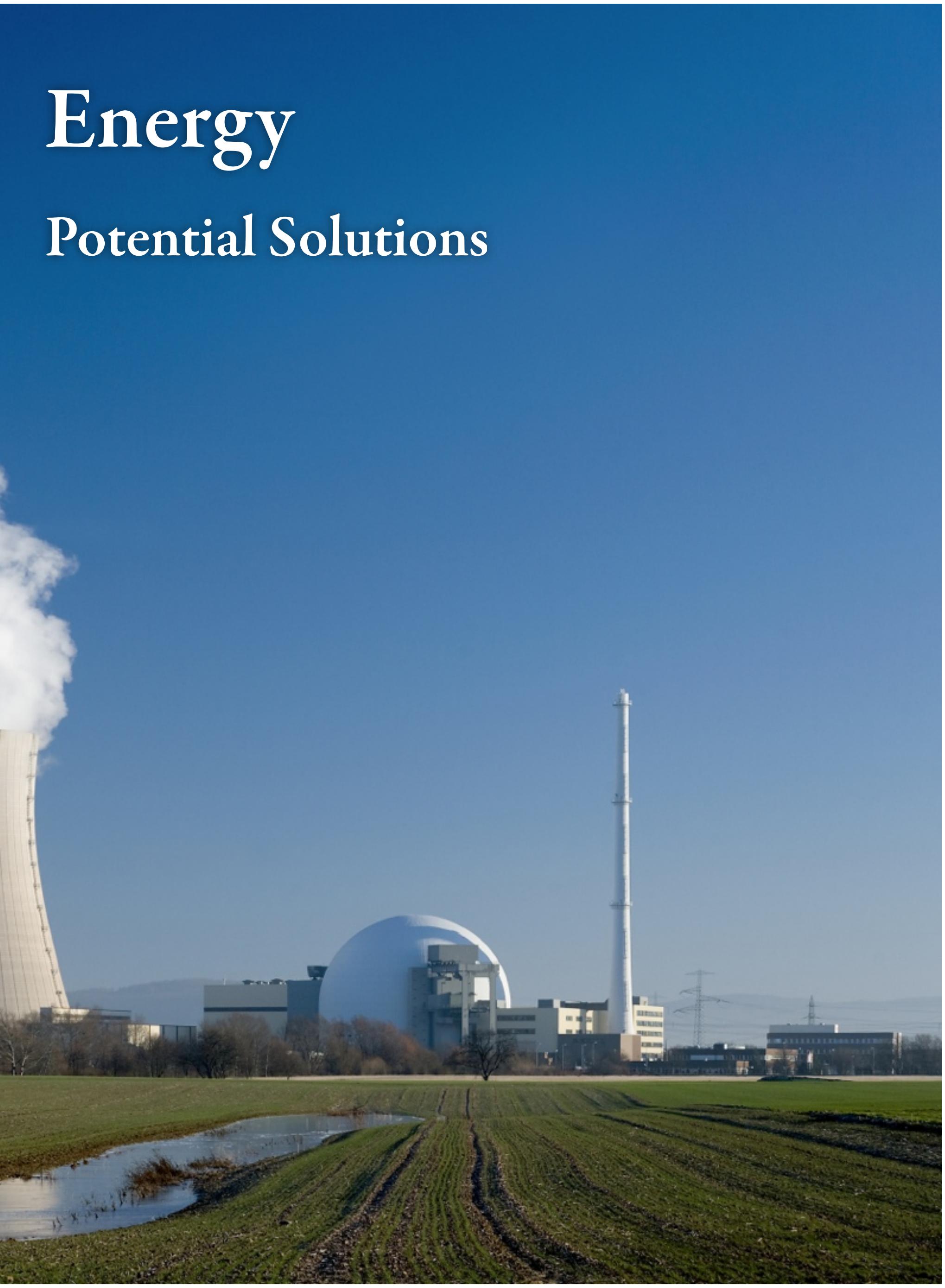
NUCLEAR ENERGY SINCE THE LATE 1970s

Although the power of the "peaceful atom" was initially welcomed as a generation source that would provide electricity "too cheap to meter," the economics of the industry were upended after the oil crisis of 1973-74. With the national economy stagnant and interest rates as high as 20 percent, the cost of building new nuclear capacity spiked from an average of $161/kW in 1968-1971 to $1,373/kW in 1979-84.[1] During the same period, U.S. environmentalists and other opponents of nuclear energy were galvanized by the highly publicized partial core meltdown at the Three Mile Island plant in Pennsylvania, which caused the release of

[1] *Nuclear Assessment,* by Charles K. Ebinger and John P. Banks, the Energy Security Initiative at the Brookings Institution. April 30, 2010. http://www.brookings.edu/articles/2010/0430_nuclear_energy_banks_ebinger.aspx.

Energy

Potential Solutions



small amounts of radioactive gases. The combination of extraordinary costs and public opposition brought U.S. nuclear power plant construction to a halt. After 1978, no new units were ordered for more than 30 years,[2] although power uprates and license extensions for many existing plants have been granted since then. (Work began recently on preparation for new reactors at the Vogtle nuclear plant site in Georgia; the Nuclear Regulatory Commission (NRC) is expected to issue the combined construction and operating license for the new reactors by the end of this year.)

The environmental and economic tradeoffs that have resulted from the national decision to halt investment in new nuclear power plants in the United States were predicted with some accuracy by a number of researchers, including nuclear scientist Alvin M. Weinberg, then director of the Institute for Energy Analysis in Oak Ridge, TN, and the former director of Oak Ridge National Laboratory. In his article "Is Nuclear Energy Necessary?" published in *The Bulletin of the Atomic Scientists* in March 1980, he cautioned that a moratorium on new nuclear plants would "place great pressure on coal or imported oil, or both," and would raise the specter of a "carbon dioxide catastrophe."[3]

Three decades later, the imminent risks of climate change have become increasingly apparent. The developing understanding of the true "cost of carbon" includes a better understanding of the widespread – if not immediately visible – health impacts of greenhouse gas emissions. For example, coal-fired generating plants emit large volumes of particulates and fly ash; a 2009 report by the Clean Air Task Force estimated that 13,200 people in the United States would die prematurely in 2010 from fine particle pollution emitted by coal plants. Those premature deaths represent huge financial costs in terms of healthcare-related expenses and lost productivity. When we factor in the hidden social costs of carbon emissions, we gain a new perspective on the economics of new nuclear power plant construction.

By 2030, most existing nuclear power plants in the United States will reach the end of their 60-year operating licenses. At present, it is unlikely that renewable energy sources, such as solar, wind, water, and geothermal energy, will be sufficient to replace that reliable, base load capacity when those nuclear plant licenses expire. The United States must devise an economically viable plan for more nuclear power plants, which now produce nearly 20 percent of U.S. electricity.[4]

[2] *Nuclear Assessment,* by Charles K. Ebinger and John P. Banks, the Energy Security Initiative at the Brookings Institution. April 30, 2010. http://www.brookings.edu/articles/2010/0430_nuclear_energy_banks_ebinger.aspx.
[3] "Is Nuclear Energy Necessary?" by Alan Weinberg, *Bulletin of Atomic Scientists*, March 1980 p. 34.
[4] "A Lifetime of Service: Safely Operating Nuclear Power Plants for 60 Years or Longer," U.S. Department of Energy, Office of Nuclear Energy. (print brochure) http://www.ne.doe.gov/pdfFiles/NE_Trifold_LifetimeofService_Web.pdf

AMERICA AND THE NEXT GENERATION OF NUCLEAR REACTORS

In looking at the possibility of a "nuclear renaissance" in the United States, Americans can build on the experience of other nations. Today, 14 percent of the world's electricity is generated from nuclear energy, and 16 nations rely on nuclear energy to generate more than 20 percent of their electricity. France derives more than 75 percent of its electricity from nuclear energy and is the world's largest net exporter of electricity. In Asia, South Korea's 21 reactors provide almost 40 percent of the country's electricity. Japan has relied on nuclear energy for 30 percent of its electricity; however, the events at Fukushima Daiichi may change the Japanese situation, as the accident has taken at least four reactors permanently off-line. China has completed nine new nuclear plants in the past decade, with dozens more currently under construction.

Concerns about energy security and carbon reduction have reduced opposition to nuclear energy in a number of European countries. Last year, the Swedish Parliament voted to allow replacement of reactors at 10 nuclear power plants, reversing a 1980 referendum that called for their eventual phase-out. In July 2010, the Finnish Parliament approved construction of two nuclear power plants. Italy has ended a ban passed in 1987 and is actively considering sites for new plants.[5] Switzerland's citizens have allowed its moratorium on new plants to expire. In total, there are 195 nuclear power plant units operating in Europe, with 19 more units under construction.

Today, almost all currently operating nuclear power plants rely on light-water reactors derived from research done at Argonne National Laboratory in the 1950s and 1960s.[6] These reactors rely on water to cool the reactor and transport its heat to large steam turbines that generate electricity. Light-water reactors are fueled with uranium that has been processed, or "enriched," increasing the amount of the isotope uranium-235 it contains to 4 percent of its total weight. By contrast, uranium straight from the mine contains about 0.7 percent U-235, weapons-grade uranium is defined as 20 percent U-235, and military weapons designs are based on a U-235 content of 90 percent or more.

Although the basic designs for these light-water reactors are decades old, advances in nuclear technologies have improved efficiency and upgraded both equipment and fuel, enabling existing nuclear plants to increase electricity generation. In the United States, those technological improvements have made it possible to increase existing plants' electricity generation by 178 billion kilowatt hours (kWh)—equivalent to the output of 23 new power plants.

As we look to the future, new nuclear power plants built from next-generation designs can offer improved fuel technology, thermal efficiency and safety systems, longer operational life, and reduced construction and maintenance costs. The designs of these next-generation reactors, which are currently under construction worldwide, address many of the concerns about safety, proliferation, and waste disposal that have shaped public opposition to nuclear energy over the years.

SAFETY

It is important to put safety concerns about nuclear power in perspective. Certainly, the recent events at Fukushima, along with the accident at Three Mile Island and the Chernobyl disaster, have raised serious international concerns about nuclear plant safety. However, it should be remembered that Three Mile Island caused no deaths or injuries to plant workers or residents living nearby, and the incident led to tightened regulatory oversight by the U.S. NRC, as well as sweeping changes in worker training, emergency response planning, radiation protection, and many other areas of nuclear power plant operations. Ultimately, the accident led to improved design and enhanced safety in U.S. nuclear power plants.

The story of the Chernobyl disaster is, of course, far more troubling. The accident, which was caused by a sudden surge of power on April 26, 1986, destroyed a reactor at the nuclear power station at Chernobyl in the former Soviet Union, now Ukraine. The accident released massive amounts of radioactive material into the environment and claimed the lives of several dozen workers. The resulting contamination forced evacuation of nearly 350,000 people living within a 30-km radius of the plant. However, it must be noted that Chernobyl's reactor

[5] "Sweden Reverses Nuclear Phase-out Policy," *Issue Brief*, by Johan Bergenäs of the James Martin Center for Nonproliferation Studies at the Monterey Institute for International Studies. November 11, 2009. http://www.nti.org/e_research/e3_sweden_reverses_nuclear_phaseout_policy.html

[6] See PHOTO: http://www.flickr.com/photos/argonne/4460350224/ or http://www.flickr.com/photos/argonne/5039459604/ (historical).

was based on a Soviet design – using high-power, pressure-tube reactors, moderated with graphite and cooled with water – that has never been used in the United States.

United States. It also was operated without a containment shield, a design that would not be allowed anywhere in the world today. Although the Chernobyl experience was tragic, it also has helped the nuclear industry and its regulators to gain a fuller understanding of nuclear reactor safety. And overall, the world's 400-plus commercial nuclear reactors have logged an excellent safety record.

Recent events at the Fukushima Daiichi nuclear power plant, due to the earthquake and tsunami in Japan on March 11, 2011, are very concerning. The nuclear power industry and regulatory authorities, both in America and internationally must respond to this by further improvements in reactor safety systems, wet storage systems for spent nuclear fuel, and emergency response. (Note: At the time this article was submitted for publication, the earthquake and tsunami in Japan had only just occurred. More information will, of course, shed light on safety issues for the future.)

In the nuclear plants currently operating in the United States, reactor safety has been based on a "defense-in-depth" approach, using a diverse set of safety measures that include many layers of reinforced physical barriers, including thick steel and concrete walls around the reactor that are built to withstand tornado-strength winds, earthquakes, and aerial aircraft assault. American nuclear plants also are protected by control systems designed with multiple back-ups.[7]

The newer generations of advanced reactors include additional fail-safe measures, including improvement in emergency core cooling systems. Areva, a French company, is building the European Pressurized Water Reactor, which increases the number of emergency core cooling systems from two to four. The extra cooling systems provide increased safety and also allow the plant to keep running while one of the systems is down for maintenance.

Wherever possible, "active" systems that are dependent on pumps, valves, and human operators are replaced by "passive" systems that use natural forces, such as gravity and convection, to respond to malfunction. For example, in next-generation designs, the reactor may be engineered so that, if core temperature rises above normal levels, the efficiency of the fission reaction decreases and it slows down automatically. Control rods that stop the nuclear reaction can be suspended above the reactor and held in place with electricity, so that any interruption to the station's electrical power will automatically insert the rods into the reactor. Also, any closed loop with a heat source at the bottom and cooling on top will develop a flow that sends the heated stream rising to the top and the cooled stream to the bottom. Called "natural circulation", this allows coolant to move in the core without the aid of pumps. This means that if the plant loses power, as happened at the Fukushima Daiichi plant in Japan, the reactor does not require electricity to cool the core after shutdown.

Westinghouse's next-generation AP1000 design, which features a number of "passive" safety systems, requires only half as many safety-related valves, one-third fewer pumps, and 83 percent fewer safety-related pipes than the company's currently operating reactors.[8] The reduced need for pumps and controls means that next-generation reactors can improve safety performance while costing less to construct and operate.

[7] U.S. Department of Energy, Department of Science. http://www.er.doe.gov/bes/reports/files/ANES_rpt_print.pdf.
[8] "AP1000 at a Glance," Westinghouse: http://www.ap1000.westinghousenuclear.com/ap1000_glance.html.

PROLIFERATION

Advances in nuclear energy technology also are addressing concerns about proliferation – the possibility that fuel for nuclear reactors could be converted to weapons-grade materials through enrichment or reprocessing. These concerns date back to 1974, when India exploded a nuclear device using plutonium produced in a research reactor. Canada had manufactured the heavy-water research reactor, and the United States had provided the heavy water. In addition to heavy-water reactors, fast reactors, which offer a "closed" fuel cycle, have prompted misgivings about the diversion of that technology for nuclear weaponry. Fast reactors – so-called because they are cooled by a liquid metal, such as sodium, that slows the movement of neutrons in the reactor's core less than a moderator such as water – actually can produce more fuel than they consume. Theoretically, fast reactors and a closed fuel cycle (full recycling) could use nearly all of the energy available in uranium (see discussion below).

Before it can be recycled, a reactor's used fuel must go through an aqueous or electrochemical process, which also could be used to separate out weapons-grade plutonium from the spent nuclear fuel. The danger of nuclear weapons proliferation prompted President Jimmy Carter to ban reprocessing for commercial purposes in 1977, although it is still used in France, Japan, Great Britain, and other countries that rely on stringent security procedures to protect the products of reprocessing. In 1981, President Ronald Reagan lifted the ban, but the business case for commercial reprocessing no longer existed in the United States. In 2001, the George W. Bush administration revisited the issue of developing forms of reprocessing that would decrease proliferation risk by not separating pure plutonium.

In exploring reprocessing methods for reducing proliferation risk, U.S. scientists and engineers have developed new techniques, including pyroprocessing, which uses electric current to separate fission products from the heavier uranium, plutonium, and other actinides.[9] The fission products, which remain radioactive for millennia, are removed for permanent disposal. The remaining radioactive materials are recast into fresh fuel rods. Pure plutonium – a critical component of most nuclear weapons – is never separated out during pyroprocessing. The resulting fuel materials are highly radioactive and are extremely difficult to handle without

The challenge of nuclear waste management has become more pressing in the United States.

specialized equipment and facilities. Pyroprocessing facilities can be built directly on fast reactor sites, reducing transportation of dangerous materials and the associated risk of diversion. Reprocessing of spent reactor fuel also could dramatically reduce the need for uranium mining and enrichment, lessening the risk that militant groups or terrorists could acquire uranium enrichment technology.[10]

THE CHALLENGE OF NUCLEAR WASTES

The challenge of nuclear waste management has become more pressing in the United States, from a policy perspective, since the 2009 decision to halt operations at Yucca Mountain. Given advanced technologies that limit the risk of proliferation, closing the fuel cycle could offer a workable solution to the challenge of nuclear waste management. A closed fuel cycle would greatly limit the amount of radioactive waste generated by a given reactor: Where a commercial light-water reactor produces about 20 metric tons of waste per year, a fast reactor with the same power output creates one metric ton of waste. The resulting waste can be shaped into more stable forms, such as a solid vitrified glass, for long-term disposal. Because it is less radioactive, this waste generates less heat and can be stored more compactly than waste from light-water reactors. Ultimately, fast reactors could also allow reprocessing of waste from light-water reactors currently in operation.

In contrast with fast reactors in a closed fuel cycle, light-water reactors are highly inefficient in their use of uranium, consuming only about 5 percent of the available energy before the fuel becomes contaminated with other isotopes and must be discarded. This spent fuel, which is highly radioactive, is currently stored on site at each nuclear reactor. Two storage methods are used: Waste must cool in a pool to reduce heat, and then can be moved to dry-cask storage, sealed in steel and concrete tanks surrounded by inert gas. Spent nuclear fuel is currently stored in pools and dry casks at sites across the country.[11] Ultimately, these wastes will require reprocessing or disposal in a geologic repository for many thousands of years.

Despite the long-term advantages of the closed fuel cycle, the extra cost it imposes has served as a disincentive to widespread adoption of fast reactor and advanced recycling technologies. In Europe, reprocessing has generally added 5 to 6 percent to the cost of producing electricity.[12] Given that fresh uranium remains plentiful and inexpensive -- the price of uranium accounts for only 2 to 4 percent of the price of electricity – the added cost of nuclear fuel reprocessing has been viewed as prohibitive.

[9] Argonne scientists conduct research on minimizing waste from reactors. PHOTO: http://www.flickr.com/photos/argonne/4074828015/.
[10] "Smarter Use of Nuclear Waste," *Scientific American*, Hannum, Marsh and Stanford. Dec. 2005.
[11] Cooling cores at Idaho National Laboratory. PHOTO: http://www.flickr.com/photos/argonne/3954062594/.
[12] Testimony by Dr. Alan Hanson, Areva, before the U.S. House Science & Technology Committee, June 17, 2009.

However, the combined effect of the costs for spent fuel management from light-water reactors and need for sustainable use of uranium resources could alter the financial equation and make fuel reprocessing and closing the fuel cycle viable.

ECONOMICS

Currently, the estimated cost of construction of a twin-unit nuclear power plant is uncertain, but is several billion dollars to as much as $10 billion. By any measure, those costs are substantial, and it can take a decade for a new plant to be designed, approved, built, permitted, and brought online. Due to delays and cost overruns on nuclear plants in the 1980s and 1990s, many private U.S. investors have been reluctant to invest in new power plants. Although 2007 saw a resurgence of interest in the private sector, the discovery of vast new reserves of natural gas in the United States has made less-expensive gas-fired power plants more attractive to investors.

However, most cost comparisons between natural gas and nuclear energy fail to address the full environmental cost of carbon emissions. Although natural gas burns more cleanly than coal, it is not carbon-neutral. The U.S. Department of Energy estimates that every megawatt-hour of electricity produced by conventional coal-fired technology produces 1 metric ton of CO_2; generating a megawatt-hour of electricity through natural gas produces 0.6 metric tons of CO_2.[13] (This means that, each year, American nuclear plants avert the release of almost 800 million tons of CO_2 into the atmosphere.[14]) The imposition of a clean energy standard, carbon taxes, or cap-and-trade incentives could substantially reduce the economic advantage of natural gas over nuclear power.[15]

Over the past two years, the Obama administration has shown strong support for nuclear energy. Last year, the White House announced $8 billion in federal loan guarantees for construction of two new conventional reactors at the Vogtle site in Georgia, and President Obama's proposed 2012 budget would triple the amount available for nuclear power plant construction loan guarantees.[16] The NRC also is reviewing applications for about 30 new reactors.[17]

There are a number of technological and procedural options that could reduce the cost of nuclear power plant construction. For example, upfront capital costs could be reduced by adoption of general design standards, which would allow utilities to choose from an array of pre-approved, standardized plant designs. Such an initiative is currently under-way in the United States and should make it possible for newer, advanced reactor designs to come online later this decade.

The combined effect of the costs for spent fuel management from light-water reactors and need for sustainable use of uranium resources could alter the financial equation and make fuel reprocessing and closing the fuel cycle viable.

Costs could also be reduced by using small modular reactors (SMRs) as an alternative to conventional light-water reactors. Components for these scaled-down reactors, which are about one-third the size of current power plants, could be built on assembly lines in advanced factories instead of more expensive on-site construction. President Obama's proposed 2012 budget would invest $500 million in SMR research and technology over the next five years. These small reactors could replace aging coal-fired power plants that already are served by grid connections, reducing costs even further. Estimates of the cost of building an SMR have ranged from several hundred million dollars to as much as $2 billion. The units could benefit initially from a built-in initial market at federal sites facing an executive order to reduce carbon footprints by 28 percent by 2020.[18] However, the cost per KW of SMRs will be higher than larger plants in the early stages of deployment. Nonetheless, given their lower initial costs, SMRs could prove more attractive to private investors, with time, than full-sized nuclear power plants. The combination of regulatory reform, federal loan guarantees, and lower upfront costs for smaller reactors could help to make nuclear power cost-competitive with gas and coal.

Going forward, federal investment in fundamental nuclear science and engineering research could help to bring improved reactors and better fuel recycling technologies to the market. Given our long track record of expertise and success in nuclear engineering, Argonne and our sister national laboratories are well positioned to lead basic scientific research, translational research, and applied engineering in nuclear energy generation and advanced nuclear fuel cycles. Already, we are using our experimental and supercomputing capabilities to enable improved operation of existing reactor plants,[19] and create affordable and efficient designs of future-generation nuclear energy systems. We also are using the expertise derived from our broader nuclear energy capabilities to develop new non-proliferation strategies and tools, including conversion of research reactors to low-enrichment fuels, technology export control, risk and vulnerability assessments, and information systems.

[13] "Nuclear Energy Research & Development Roadmap," Report to Congress, U.S. Department of Energy. April 2010. http://www.ne.doe.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf, p.20

[14] 798.74 billion kilowatt-hours = 798 740 000 megawatt-hours * 1 metric ton CO2 saved per megawatt hr (figure from Energy Information Administration). http://www.eia.doe.gov/ask/electricity_faqs.asp#nuclear_generation)

[15] "The Future of the Nuclear Fuel Cycle", an Interdisciplinary MIT Study, Massachusetts Institute of Technology, 2010. http://web.mit.edu/mitei/docs/spotlights/nuclear-fuel-cycle.pdf p.19

[16] "Obama Would Triple Guarantees for Building Nuclear Reactors," *Bloomberg News*, February 14, 2011: http://www.bloomberg.com/news/2011-02-14/obama-would-triple-guarantees-for-building-nuclear-reactors.html

[17] "Expected New Nuclear Power Plant Applications," Nuclear Regulatory Commission, April 13, 2011: http://www.nrc.gov/reactors/new-reactors/new-licensing-files/expected-new-rx-applications.pdf

[18] "Administration to Push for Small 'Modular' Reactors," *New York Times*, February 13, 2011: http://www.nytimes.com/2011/02/13/science/earth/13nuke.html

[19] Simulation of a nuclear reactor subassembly, created on Argonne's supercomputer, the Blue Gene. PHOTO: http://www.flickr.com/photos/argonne/4192798645/.

CONCLUSION

In July 2011, the Department of Energy's Blue Ribbon Commission on America's Nuclear Future is scheduled to deliver its draft conclusions on the best strategies for U.S. nuclear waste management. This report, along with the proposal by the Obama administration to create a clean energy standard, should serve as the opening for a new national conversation on nuclear energy and nuclear waste management policy. Certainly, there are many concerns that must be addressed. However, advances in nuclear technology have significantly altered the cost-benefit equation that led the United States to interrupt its significant investment in nuclear power three decades ago.

National consumption of electricity is large and growing, and the majority of usage in homes, schools, hospitals, and businesses requires a steady, reliable, around-the-clock power supply.[20] At present, solar and wind energy provide intermittent energy, and we must rely on nuclear- or coal-generated power to provide base load electricity when the sun isn't shining and the wind isn't blowing. Although widespread use of electricity generated by renewable sources remains an important goal, it may take up to 20 years to develop cost-effective, scalable energy storage and grid technology that would make that goal a reality.

U.S. Energy Secretary Chu has stated: "Nuclear energy provides clean, safe, reliable power and has an important role to play as we build a low-carbon future." As the nation's current and future energy options come under review, a new generation of nuclear power technologies can restart America's nuclear industry and assure an adequate, environmentally sound source of electricity for the decades to come. ■

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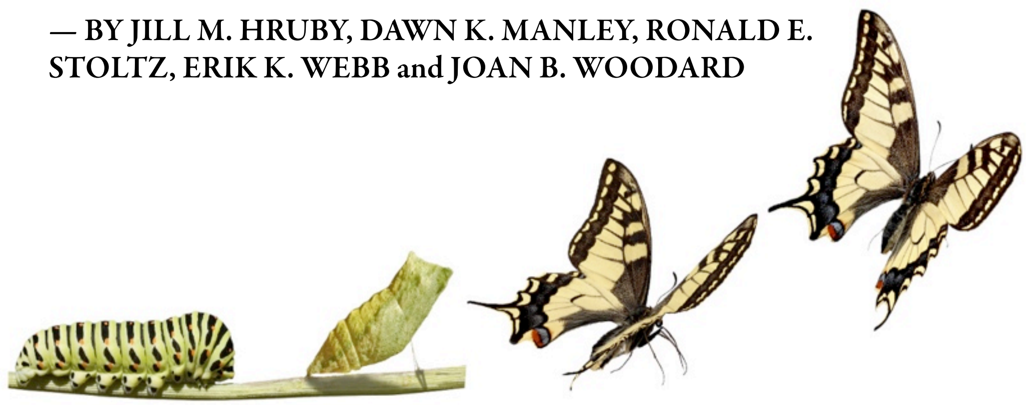
[20] "Myths and Facts About Nuclear Energy Supply," Nuclear Energy Institute: http://www.nei.org/newsandevents/nei-backgrounders/myths--facts-about-nuclear-energy/myths--facts-about-energy-supply

The Evolution of Federally Funded Research & Development Centers

— BY JILL M. HRUBY, DAWN K. MANLEY, RONALD E. STOLTZ, ERIK K. WEBB and JOAN B. WOODARD

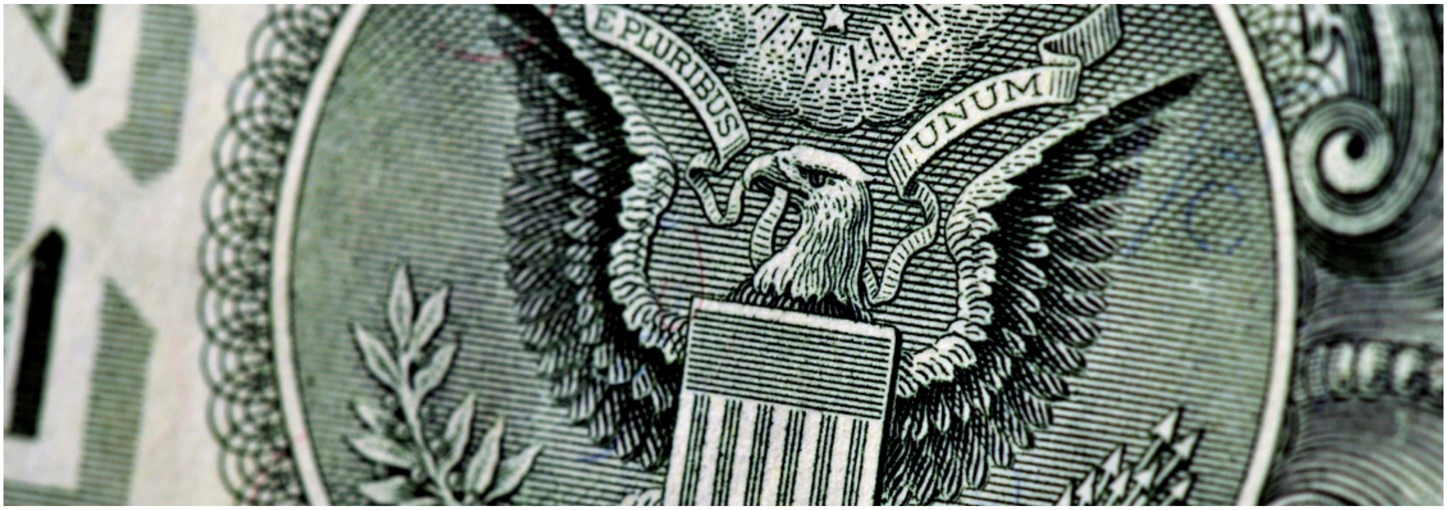


INTRODUCTION

Federally Funded Research and Development Centers (FFRDCs) have thrived, struggled, and evolved to tackle national security missions for more than 70 years. FFRDCs were instituted in the early 1940s to mobilize the country's scientific and engineering talent. They came into national prominence during World War II and again during the Cold War as a mechanism to focus scientific and engineering expertise on pressing national security challenges that demanded intense, sophisticated, and sustained technical talent. Because of the urgency and complexity of their missions, creating and maintaining this body of top technical capability required flexibility and practices not available in the government.

Over the decades since their inception, FFRDCs have become more diverse both individually and collectively in response to expanding national security needs. The government has examined and reexamined their existence, charters, and mission. Today, the FFRDC system finds itself at a crossroad. The national security environment is more dynamic than ever, while simultaneously the budgetary pressures, government accountability, and federal workforce initiatives are forcing reviews of government contracting including FFRDCs.

This article reviews the characteristics of FFRDCS and describes how they have adapted to shifting national security needs and during intense periods of government scrutiny. Two recent incidents, the attempted airline bombing on Christmas Day 2009 and the Gulf of Mexico oil spill in 2010, serve as examples of challenges that relied on the technical expertise of the nation's FFRDCs. Each FFRDC should be held to high standards, and the collection of FFRDCs should be considered systemically, in order for the nation to be prepared to meet 21st century security challenges.



FFRDC HISTORY

Formally established under Federal Acquisition Regulation 35.017, FFRDCs are federally constituted research and development (R&D) organizations that meet special, long-term needs that cannot be met by existing government or contractor resources.[1] Although RAND was established in 1947 as the first FFRDC,[2] its origins date back to World War II when U.S. defense organizations required a rapid and focused R&D capability to apply advanced technologies to the war fighting effort. In 1942, the Office of Scientific Research and Development (OSRD) established the first of these institutions—the Applied Physics Laboratory (APL)— to direct an association of universities and industrial contractors building conventional weapon systems. The APL at the Johns Hopkins University was closely followed by additional hybrid organizations operated by non-federal organizations that supported the war effort like Harvard's Underwater Sound Laboratory, which focused on developing detection equipment for underwater sound; the Radiation Laboratory at the Massachusetts Institute of Technology, which developed microwave radars; and the Jet Propulsion Laboratory at the California Institute of Technology, which developed rocket propulsion systems.

When the war concluded, a critical need remained for the continued development of independent, highly technical capabilities for national security missions such as defense systems and nuclear weapon development. FFRDCs flourished in the 1940s, 1950s, and early 1960s, attracting top talent and expanding missions and sponsoring agencies. By 1969, the number of FFRDCs peaked at 74 with a diversity of federal sponsoring agencies, including the National Science Foundation (NSF), the Atomic Energy Commission (AEC), the Department of Defense (DOD), and the National Aeronautics and Space Administration (NASA).[3]

With federal R&D funding for FFRDCs growing from 0.4 percent in 1960 to 1.2 percent in 1970, the decade brought on a wave of grim analyses from Congress, industry, academia, and the military. This contributed to a precipitous drop in the number of FFRDCs, as illustrated in Figure 1. Prominent critics questioned the very characteristics and freedoms that made FFRDCs successful in their work. Detractors argued there was too little Congressional control, too much influence over policy, higher costs relative to other government and contractor organizations, unfair advantage in obtaining R&D work, and sponsor-biased R&D.

Critics also argued that FFRDCs had outlived their original purpose. Many government and private R&D organizations had expanded and matured in ways that made them capable of undertaking missions associated with FFRDCs. University-affiliated FFRDCs were pressured by campus anti-war sentiment and the armed services were dissatisfied with several aspects of FFRDC performance. The services believed that the work was too academic and not responsive to military needs. Congressional critics wanted DoD to reduce its presence on American campuses. The 1969 Mansfield Amendment to the Military Authorization Act, which prohibited the DoD from using funds for research that did not have an explicit military purpose, contributed to a 45 percent drop in DoD's basic research portfolio from 1967 to 1975. By 1976, only eight DoD-sponsored FFRDCs remained from the peak of 39 in the early 1960s.[4] While some FFRDCs were terminated, others were maintained in other forms, such as private sector or not-for-profit organizations. For example, the Applied Physics Lab changed status to a University Affiliated Research Center (UARC). UARCs share characteristics with FFRDCs with the exceptions that they have a university affiliation, have education as part of their mission, and have more flexibility to compete for work than DoD FFRDCs.

[1] https://www.acquisition.gov/far/html/Subpart 35_0.html#wp10851, accessed on August 24, 2010.
[2] Bruce L. R. Smith, *The RAND Corporation: A Case Study of a Nonprofit Advisory Corporation* (Cambridge, MA: Harvard University Press, 1966).
[3] U.S. Congress, Office of Technology Assessment, *A History of the Department of Defense Federally Funded Research and Development Centers*, OTA-BP-ISS-157 (Washington DC: U.S. Government Printing Office, June 1995).

In 1984, the Office of Federal Procurement Policy issued a statement that codified the requirements for the creation of FFRDCs. These requirements were reiterated in the 1990 Federal Acquisition Regulation.[5-8] Despite the clarity of the 1990 FAR, the 1990s saw a second wave of pressures on FFRDCs. Several studies on DoD FFRDCs emphasized that these institutions should adhere to their core mission rather than diversifying their programs. For example, the DoD Inspector General recommended that, "DoD strengthen controls over the screening and assignment of work to FFRDCs, to include ensuring the performance of market surveys."[9] The 1997 Defense Science Board Task Force Report further supported the focus on core mission by stating that the DoD "must carefully define those limited special R&D activities that demand the attributes of an FFRDC."[10] The Task Force emphasized that outside institutions could conduct much of the work. Then Undersecretary of Defense for Acquisition and Technology, Paul G. Kaminski, instituted principles that today are reflected in the FAR.[11]

Currently, specific FAR requirements include that FFRDCs should:

- Meet a special long-term government R&D need that cannot be met as effectively by the government or the private sector.
- Work in the public interest with objectivity and independence, and with full disclosure to the sponsoring agency.
- Operate as an autonomous organization or identifiable operating unit of a parent organization.
- Preserve familiarity with the needs of its sponsor(s) and retain a long-term relationship that attracts high quality personnel.
- Maintain currency in field(s) of expertise and provide a quick response capability.

The DOE National Laboratory system, a subset of FFRDC institutions, faced similar scrutiny. In 1995, the Secretary of Energy Advisory Board examined alternative futures for the laboratory complex.[12] They observed the laboratories as "having clear areas of expertise, yet limited to their traditional mission areas of national security,

Despite the pressures of the 1990s, the system has expanded with three new FFRDCs for the Department of Homeland Security, and one each for the IRS and Department of Veterans Affairs. This reflects a trend of creating new laboratories for new challenges.

Spring 2010:

In spring 2010, the *Deepwater Horizon* oil spill in the Gulf of Mexico was one of the largest offshore environmental incidents in U.S. history. In late April 2010, at the request of President Obama, DOE Secretary Steven Chu convened a small group of national laboratory executives, senior university professors and government advisors to serve as his scientific advisory team. More than 200 scientists and engineers from the DOE and National Nuclear Security Agency (NNSA) laboratories (Sandia, Lawrence Livermore, and Los Alamos National Laboratories) provided real time analysis, technical input and oversight.[1] For five months, a group of laboratory technical experts rotated through Houston to provide on-site support in addition to support at the laboratories.

[4] Presentation: "History of Federally Funded Research and Development Centers (FFRDC): Contributors to national security, science, and engineering through a turbulent history", Clifford Jacobs, 2010, NSF
[5] http://www.nsf.gov/statistics/ffrdclist/archive_ffrdc.cfm. Accessed 10/19/2010.
[6] Developing a Sustainable Future for Federally Funded Research and Development Centers, Master of Science Thesis, S.B. Bowling, Massachusetts Institute of Technology, 1997.
[7] National Science Foundations, Federal Funds for Research and Development: Fiscal Years 1990, 1991, and 1992, vol. XL, NSF92-322, 1992.
[8] Office of Federal procurement Policy, Office of Management and Budget, OFPP Policy Letter 84-1, Federally Funded Research and Development Centers, April 4, 1984.
[9] Contracting Practices for the Use and Operations of DoD-Sponsored Federally Funded Research and Development Centers, Audit Report No. 95-048, Office of the Inspector General, December 2, 1994.
[10] Report of the Defense Science Board Task Force on Federally Funded Research and Development Centers (FFRDC) and University Affiliated Research Centers (UARC) Independent Advisory Task Force, January 1997.
[11] Presentation: "History of Federally Funded Research and Development Centers (FFRDC): Contributors to national security, science, and engineering through a turbulent history", Clifford Jacobs, 2010, NSF
[12] Alternative Futures for the Department of Energy National Laboratories, Secretary of Energy Advisory Board Task Force on Alternative Futures for the Department of Energy National Laboratories, February 1995.

Deepwater Horizon Oil Spill

The earliest phase was characterized by a steep learning curve on the part of both the government scientists and the oil industry production engineers. While the industry experts had specific domain knowledge of the subsea equipment and geology, the federal team provided extensive technical expertise in stress analysis, fluid flow, advanced diagnostics, and geologic modeling.

Over the intervening weeks, the federal team shifted from providing strict analysis to giving recommendations and alternative approaches to safely capping and eventually killing the leaking well. Once the incident response leadership transitioned from an industry to a government-led effort, the laboratory support team worked closely with government agency representatives.

The federal response highlighted a number of features of the FFRDC system. First, while national laboratory personnel are contractor employees, not federal staff, the Secretary of Energy authorized them to marshal resources and solve time-critical national problems. Second, the NNSA laboratories provide a great depth and breadth of technical expertise. While the DOE/NNSA team in Houston did not have specific knowledge of the oil extraction business, their technical expertise helped complement the industry sector's operational knowledge. Third, because the well containment effort rose to an "all government" response, the DOE scientists supported a domain outside of their agency mission space. Although regulation of petroleum exploration and development is officially a Department of Interior function, close collaboration between Secretary Chu and DOI Secretary Ken Salazar enabled this cross-agency and cross-mission collaboration.

The Gulf oil spill revealed gaps in how the FFRDC system's expertise can be best used. The system for government and industry experts to solve problems of critical and national importance remains a work in progress. The oil spill involved infrastructure that was owned by the private sector. Despite private ownership, there is an expectation of government involvement, either through regulation or because of national security.

The role of FFRDCs in support of national incident command responses has not been fully institutionalized, especially since multiple cabinet agencies may be involved. For events like those in the Gulf, establishing hybrid organizations, with sustained industry and government involvement, may provide a new construct. The outcome would be to embed and sustain a core of government expertise to assist in potential future oil spills or other problems at the intersection between public agencies and private industry.

ENDNOTE:
http://www.energy.gov/open/oil_spill_updates.htm. Accessed 1/7/11.

energy, and environmental science and technology, as well as in the fields of fundamental science which underpin these missions and in basic science associated with high energy, nuclear, and condensed matter physics." The advisory board also urged the labs to "provide more disciplined focus on the new research needs within the traditional set of mission areas."

Despite the pressures of the 1990s, the system has expanded in recent years with three new FFRDCs established for the Department of Homeland Security (DHS), and one each for the IRS and Department of Veterans Affairs. This reflects a trend of creating new laboratories for new challenges. Today, there are 26 R&D FFRDCs, nine Systems Analysis FFRDCs, and five Systems Engineering FFRDCs, ranging in size from about $6 million to $2,200 million.

ENDURING INSTITUTIONAL CHARACTERISTICS

Although the required characteristics are legislated, there is substantial diversity in mission and operating modes in practice amongst FFRDCs. Those institutions that have endured and thrived exhibit the following characteristics:

- A commitment to their prime sponsor and the FFRDC charter – Successful institutions demonstrate commitment to the original intent of their charter as an FFRDC and to the objectives of their prime sponsoring agency. The mission success of their prime sponsor remains their highest priority. Thriving FFRDCs have also instituted processes to ensure objectivity and independence in their technical and engineering advice to their sponsoring agency and to all other government agencies with which they contract or interact.
- Continuity of expertise – Thriving FFRDCs have maintained technical excellence in critical technical areas, sometimes attracting new or additional sponsors in order to maintain this expertise. In addition to providing successful missions, this continuity fosters an environment that attracts and retains a loyal and highly technical workforce. This "patient intellectual capital"[13] is able to rapidly respond to government needs by providing a depth of understanding of the technological needs for evolving national problems.

• An anticipation of national needs – Successful FFRDC executives anticipate and respond to new developments, especially in the area of national security. While maintaining their core missions, vibrant FFRDCs actively seek 21st century national challenges. This has resulted in a significant diversification of their sponsorship base.

• Facilities to address long-term, large-scale problems – Successful FFRDCs address complex technical challenges that often require high risk experiments and large facilities, such as supercomputers or light sources, which are beyond the scale or role of purely academic or commercial entities. They provide a resource for, and partner with, academia and industry. Moreover, these institutions maintain infrastructure and personnel to work with sensitive or classified national security information. Broad, interdisciplinary teams tackle problems that are beyond the scope of university professors or departments.

• Independent evaluation – Successful FFRDCs invite independent external evaluation of their capabilities, R&D activities, organizational approaches, and business practices. This occurs through external review boards and the use of nationally recognized standards and metrics for research institutions. This has lead to a culture of continuous improvement, both in the programmatic impact of their work and in the management and operations of their facilities.

CURRENT PRESSURES AND DRIVERS

The nation is again re-evaluating the FFRDC system, driven in part by the expansion of multi-program portfolios. For example, the budget for nuclear weapons work at Sandia is 43 percent of the overall operation revenue. The remainder encompasses a diverse program that includes projects for the Departments of Defense, Homeland Security and State among others. This gradual diversification at Sandia and other FFRDCs has attracted criticism that suggests the FFRDCs should focus on their core missions.[14]

The current federal budget crisis provides additional pressure on these R&D institutions. Other commercial and academic providers of R&D expertise and services feel the need to compete with the FFRDC system. This is especially true for the defense contracting community and the nation's research universities.

Lastly, there is a concerted move by the federal government to "in-source" more functions and to re-scope the size of the federal workforce while reducing the size of the contractor base. Section 852 of the National Defense Authorization Act FY08 created the Defense Acquisition Workforce Development Fund (DAWDF) to help recruit and retain a highly skilled set of program managers, engineers, and contracting officials that are hard to find and retain.[15] "Qualifications need to include a much higher percentage of acquisition professionals who also have scientific, mathematic and engineering backgrounds… it is also important to ensure that they [contracting professionals] have the technical skills to understand what a best value solution is and why one technology or solution is better than another."[16] At the same time, there is a vigorous discussion regarding "inherently governmental functions" and the legitimate boundaries of work by the federal workforce and by those outside of government. FFRDCs are positioned at this intersection.

The current federal budget crisis provides additional pressure on these R&D institutions. Other commercial and academic providers of R&D expertise and services feel the need to compete with the FFRDC system..

FFRDCs AT A CROSSROADS: THE EVOLUTION OF THE SYSTEM

The leadership of each FFRDC is charged with maintaining and improving the health and vitality of their respective institutions. Below are suggestions for how the government may increase the value of the FFRDC system.

Encourage diversification for emerging, broadly-defined national security needs. In response to growing national security threats, the FFRDC laboratories have diversified their customer base. FFRDCs attract and retain talent to achieve the highest national impact. The Stimson Task Force, "Leveraging Science for Security," validated this approach,[17] suggesting that in addition to retaining core weapons competencies, the nuclear weapon laboratories should expand their capabilities to address a broader range of 21st century national security needs. This diversification will result in cost savings and allow the best minds to tackle daunting national security challenges.

Recognize the special ability of FFRDCs to work at the public/private interface where some of the nation's most vexing problems develop. The federal government faces a number of problems that are neither fully governmental nor private concerns. For example, cyber threats to U.S. infrastructure, attacks against aviation, and large deep-sea oil leaks require the shared response of government and industry. Whether incorporated within the FFRDC framework or with quasi-governmental organizations that capitalize on FFRDC capabilities, these threats suggest that the nation needs to develop new options for engaging FFRDCs. [see oil spill side bar]

[13] *A History of the Department of Defense Federally Funded Research and Development Centers,"* OTA-BP-ISS-157, U.S. Congress, Office of Technology Assessment, Washington, DC: U.S. Government Printing Office, June 1995.
[14] *Alternative Futures for the Department of Energy National Laboratories*, Secretary of Energy Advisory Board Task Force on Alternative Futures for the Department of Energy National Laboratories, February 1995.
[15] *The Big Picture on the Defense Acquisition Workforce Development Fund,* Defense AT&L: Special Edition 2009, F.J. Anderson, Jr.
[16] Testimony to Defense Acquisition Reform Panel, House Committee on Armed Services, Lawrence P. Farrell, 2009.
[17] *Leveraging Science for Security: A Strategy for the Nuclear Weapons Laboratories in the 21st Century,* Task Force on Leveraging the Nuclear Weapons Laboratories for 21st Century Security, F.F. Townsend, D. Kerrick, and E. Turpen, March 2009.

Maintain program FFRDC core competencies that uniquely serve national needs. The Applied Physics Lab (APL)[18] underwent a self-initiated, multi-year process to determine its critical capabilities and matched those to evolving mission areas. The APL approach could be used as a guide to other FFRDCs as they plan for the future. One key metric is the alignment of each organization's strategic plan to meet agency missions and evolving national needs. Public recognition of "best in class" among the FFRDC would help all institutions to improve.

Develop mechanisms within the agencies with multiple FFRDCs – DoD, DOE, and DHS – to leverage resources. Most federal agencies develop an annual strategic plan that illustrates their direction and the environment in which they are operating. These plans outline current trends but also reflect a longer-term view. Testing each FFRDC's set of capabilities against these agency strategies is a first step to creating a system that is more effective and efficient. Identifying opportunities to pool resources and to jointly plan is another key step in increasing the value of an agency's system of laboratories. For example, the DOE Office of Science capital investment plan[19] is a 20-year outlook for research mission areas, needed facilities, and priorities for capital investments over time. This document has received wide recognition for its vision and for the value of a published long-range plan.

Encourage FFRDCs to form ad hoc collaborations to rapidly mobilize critical technical skills to address emerging problems. The Joint Improvised Explosive Device Defeat Organization (JIEDDO) was established in 2006 to mitigate the threats from Improvised Explosive Devices (IEDs). In the joint office, talent from across the FFRDCs and private companies is pooled and leveraged through coordination and planning of mitigation activities. This continuing JIEDDO effort provides a sustained intellectual base that is well-suited to respond to evolving adversaries and technological threats. JIEDDO is recognized as a model for addressing new security threats. A collaborative effort like JIEDDO could be used to address other pressing problems.

Attempted Bombing on Christmas Day 2009

On Christmas Day 2009, 23-year-old Umar Farouk Abdulmutallab attempted to bomb Northwest Airlines flight 253 from Amsterdam to Detroit. This act of terrorism scared the public and aviation security community – a community still recovering from the events of September 11, 2001.

The Department of Homeland Security (DHS), the U.S. intelligence community, and the Obama administration needed to address the failures in the security system that allowed Abdulmutallab to walk on a plane with explosives hidden in his clothes. Questions included the chemical identity of the explosive carried onto the aircraft and whether it would have crashed the plane. Also, how could the U.S. further improve airport security to prevent another attempt?

The next day, DHS contacted several Department of Energy (DOE) national laboratories. The DOE labs supplied the technical expertise in explosive science and security to identify the technical issues and provide answers.

The White House convened national security leaders to respond to the event. Secretary Chu, recognizing the science, technology, and explosives expertise in his national labs, pledged support to DHS. As a result, the deputy secretaries at DOE and DHS contacted the laboratory directors to organize activities into four categories to make rapid progress: (1) systems analysis, (2) aviation security, (3) "connecting the dots," and (4) emerging technologies.

The national labs mobilized technology teams, a particular challenge because of the holiday recess, and DOE and DHS held daily conferences for two purposes: (1) to determine threats and identify weaknesses in the current security system, and (2) to propose improvements to security. While the DHS/DOE/Lab leadership met, a group of national security laboratory participants convened with the National Counter Terrorism Center to discuss how the labs could help "connect the dots."

The work done by the labs and DOE/DHS teams brought a focus to the resources and organizations that should be included in the effort. Unfortunately, the resources to pursue many of the needs were not immediately available, and ten months later discussions continue but the urgency has faded. Funding to initiate the systems analysis has commenced and multiple DOE labs and DHS FFRDCs are defining needs and future requirements.

The need for a quasi-government body of expertise devoted to national security that is readily accessible to focus on complex problems was clear. The scientific and technical knowledge within the FFRDC system was critical, as was the ability to independently assess problems.

On Christmas Day 2009, an attempted attack on an international air carrier brought together the DOE, DHS, FAA, the intelligence community, and the airline industry to evaluate the threat and to deploy detection and mitigation technologies. While data mining, threat profiling, and detection technologies were already mature, the analysis and recommendations from this collective group accelerated the deployment of new tools and procedures. This resulted in improved confidence in the safety of air travel and increased deterrence to similar attempts in the future. As with the IED task force, the "Christmas Day" effort demonstrated the power embedded in the FFRDC system. The "Christmas Day" project should be documented and analyzed, with the inter-agency process used to stand up the effort codified as a template for future use. [see Christmas Day side bar]

CONCLUDING OBSERVATIONS

Over the past seven decades, the FFRDC system has undergone transitions and endeavored to meet the rise and fall of pressures as national needs and priorities evolved. This evolution has resulted in stronger and more resilient institutions that are valued as the crown jewels of the nation's science and technology enterprise. However, these institutions have largely evolved independently and today their roles and characteristics are not broadly recognized. By highlighting the historical and possible future of FFRDCs, this paper attempts to spark a dialogue that brings about greater understanding and refines their role in the U.S. research, development, and national security enterprise. ■

Acknowledgements

The authors wish to acknowledge informative and open discussions with many leaders and independent thinkers about FFRDCs, UARCs, and other federal research institutes including Miriam John (VP emeritus, Sandia); James Shields and John Dowdle (Draper Labs); Eric Evans and Anthony Sharon (MIT Lincoln Labs); Richard Roca (Johns Hopkins Applied Physics Laboratory); John Hamre (Center for Strategic and International Studies); Ron Townsend, Barbara Kunz, Steve Kelly, Brian Graham, Erik Pearson, Brett Bosley, and Blake Thompson (Battelle Memorial Institute); Steve Proia (Jet Propulsion Laboratory); Lisa Stevens and Genevieve Medley (National Institutes of Health/National Cancer Institute); John Fischer (Office of Secretary of Defense); William Rees (Los Alamos National Laboratory); Parney Albright (Lawrence Livermore National Laboratory); and Robert Knetl, Tom Horton, Rebecca Caravati, and Dennis Crain (Georgia Tech Research Institute). We gratefully acknowledge critical reviews of the manuscript by Harvey Sapolsky and Holly Dockery.

[18] *A View of Future* APL Science and Technology: Guest Editor's Introduction, J.C. Sommerer, Johns Hopkins APL Technical Digest, Vol 26, Number 4 (2005) http://www.jhuapl.edu/techdigest/TD/td2604/index.htm

[19] *U.S. Department of Energy, Office of Science Strategic Plan and Facilities Outlook: Office of Science Strategic Plan,* Feb. 2004; Facilities for the Future of Science--A Twenty Year Outlook Nov. 2003, Interim Report Oct. 2007 http://www.osti.gov/cgi-bin/scsearch/explhcgi?qry1239520167;sc-05184

[20] Master Government List of Federally Funded R&D Centers, http://www.nsf.gov/statistics/ffrdclist/archive_ffrdc.cfm. Accessed 10/19/2010.

Appendix – Current FFRDCs

Aerospace Federally Funded Research and Development Center[20]
Ames Laboratory
Argonne National Laboratory
Arroyo Center
Brookhaven National Laboratory
C3I Federally Funded Research & Development Center
Center for Advanced Aviation System Development
Center for Enterprise Modernization
Center for Naval Analyses
Center for Nuclear Waste Regulatory Analyses
Centers for Communications and Computing
Fermi National Accelerator Laboratory
Homeland Security Studies and Analysis Institute
Homeland Security Systems Engineering and Development Institute
Idaho National Laboratory
Jet Propulsion Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Lincoln Laboratory
Los Alamos National Laboratory
National Astronomy and Ionosphere Center
National Biodefense Analysis and Countermeasures Center
National Cancer Institute at Frederick
National Center for Atmospheric Research
National Defense Research Institute
National Optical Astronomy Observatories
National Radio Astronomy Observatory
National Renewable Energy Laboratory
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Princeton Plasma Physics Laboratory
Project Air Force
SLAC National Accelerator Laboratory
Sandia National Laboratories
Savannah River National Laboratory
Science and Technology Policy Institute
Software Engineering Institute
Studies and Analyses Center
Thomas Jefferson National Accelerator Facility

U.S. - Russia Nuclear Arms Reductions

The Next Round

— BY JAMES E. DOYLE

INTRODUCTION

The signing and implementation of the New Strategic Arms Reduction Treaty (START) reflects the commitment of the United States and the Russian Federation to strengthen their strategic partnership and to seek even greater future reductions in nuclear arms. New START, which entered into force in early February 2011, requires the United States and the Russian Federation to reduce their arsenals of deployed strategic nuclear weapons to 1,550 or fewer warheads by early February 2018.[1]

In the next round of nuclear arms negotiations with Russia, the United States will seek lower limits on non-deployed and non-strategic nuclear weapons in addition to limits on deployed strategic weapons.[2] Limits on non-strategic (also referred to as "tactical") nuclear weapons would be intended to address the numerical disparity between the United States and the Russian Federation's tactical nuclear weapons stockpiles.[3] Continued reduction in overall nuclear weapons inventories and the role they play in U.S. national security strategy are also seen as an important demonstration of the U.S. commitment to its obligations under Article VI of the Nonproliferation Treaty to pursue nuclear disarmament.

For their part, Russian government officials have indicated interest in limiting non-deployed strategic warheads and have called for the relocation of all non-strategic nuclear weapons to centralized storage depots on national territory.[4] Russia's desire for all non-strategic weapons to be located on national territory would require the withdrawal of U.S. nuclear weapons deployed with North Atlantic Treaty Organization (NATO) allies in Europe. Russia may also have an interest in further limits on deployed strategic nuclear delivery vehicles below those imposed by New START, combined with new limits on non-deployed strategic warheads. Such limits would clearly constrain the ability of the United States to rapidly increase the number of deliverable strategic warheads should it break out of New START and any future treaty.

UNCERTAIN TIMELINE FOR NEGOTIATIONS

Despite some areas of mutual interest in convening another round of nuclear arms reduction talks there are also significant issues that cause Russia's enthusiasm for a treaty following New START to be less than that of the United States.[5] Several Russian officials have stated that it is necessary to see how New START is implemented before new talks begin. During the seven-year period for implementation, Russia may view other strategic issues as a higher priority on its U.S. and European agenda. These include the possible continued expansion of NATO,

[1] The formal name of New START is "Measures for the Further Reduction and Limitation of Strategic Offensive Arms." It was signed on April 8, 2010 in Prague and, after ratification, entered into force on February 5, 2011. The New START Treaty: Signed, Posted February 02, 2011, The White House Blog: http://www.whitehouse.gov/blog/2011/02/02/new-start-treaty-signed

[2] These objectives have been articulated in the April 2010 U.S. Nuclear Posture Review and in the Senate Foreign Relations Committee Report providing advice and consent on the New START treaty. See Committee on Foreign Relations, United States Senate, Report on the Treaty with Russia on Measures for Further Reduction and Limitation of Strategic Offensive Arms (The New START Treaty), 111th Congress, 2d Session, Oct. 1, 2010 and The Nuclear Posture Review Report, April 2010 at http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf

[3] Russian inventories of tactical nuclear weapons are estimated to be roughly ten times larger than estimates of U.S. inventories. See Miles Pomper, William Potter, and Nikolai Sokov, "Reducing and Regulating Tactical (Nonstrategic) Nuclear Weapons in Europe," The James Martin Center For Nonproliferation Studies, Monterey Institute of International Studies, Monterey, CA, December 2009, and Robert S. Norris and Hans M. Kristensen, "U.S. Tactical Nuclear Weapons in Europe, 2011," *Bulletin of the Atomic Scientists*, January 2011, http://bos.sagepub.com/content/67/1/64.full

[4] See Madeleine Albright, Strobe Talbott, Igor Ivankin, and Aleksander Dynkin, Next Steps on U.S.-Russian Nuclear Negotiations and Nuclear Non-Proliferation: Recommendations from the June 23, 2010 Meeting, the Brookings Institution, Oct. 2010.

[5] An excellent summary of these is provided by Steven Pifer in "The Next Round: The United States and Nuclear Arms After New START," Brookings Arms Control Series, paper 4, December 2010.

NATO nuclear weapons, ballistic missile defense, and the conventional force balance in Europe.[6] Finally, if the next bilateral treaty limits completely new items such as non-strategic and non-deployed nuclear weapons in addition to lower limits on deployed strategic arms, it may take at least two to three years to negotiate, and possibly longer.

While the duration and outcome of future negotiations is uncertain, there appears to be sufficient interest on both sides to initiate them within the next 12-24 months. Many technical and administrative obstacles to reaching a new agreement have already been identified. The months and years before the talks begin and before potential agreements are reached can be used by both sides to refine their objectives, explore how agreements covering a broader range of nuclear armaments could be implemented and verified, and jointly address obstacles to successful negotiations. While additional bilateral numerical reductions are important, equal emphasis should be placed on seeking opportunities for improving the U.S.-Russian strategic partnership and for providing a model for eventual multilateral efforts at nuclear arms limitations and reductions.

NEW OPPORTUNITIES AMID TOUGH CHALLENGES

One of the greatest challenges and opportunities of the next phase of negotiations is whether the bilateral arms control enterprise can be transformed by both sides into a mechanism that helps achieve a broader range of political and strategic objectives. It is important to continue to adjust the objectives of arms control negotiations to be consistent with changes in the security environment since the end of the Cold War. Objectives should be much less focused on issues of arms race stability, crisis stability or managing a hostile relationship.[7] While these remain important concepts, their salience has been reduced by changes in the nature of the U.S.-Russian relationship and in the global threat environment.

The current security environment warrants greater emphasis on:

- Deepening the strategic partnership
- Increasing transparency regarding nuclear arsenals and infrastructure
- Jointly developing technologies for improved verification and monitoring
- Improving security for nuclear weapons and materials

- Crafting arms reductions to support nonproliferation and counterterrorism objectives
- Establishing models and examples that other states may draw upon if and when they undertake negotiated nuclear arms reductions

To contribute to this set of objectives nuclear arms negotiations may need to become more cooperative and innovative. Formal "rounds" of meetings between negotiating teams will need to be coordinated with ongoing joint technology development, verification experiments, familiarization visits and other transparency activities. Any new agreements on future reductions should still take the form of legally binding treaties. The advantages of this approach include winning political support and commitment to implement the agreement from across a broad base of governments that are party to the agreement. Formal treaties also maintain the precedent that arms reductions agreements and related measures should be matters of domestic and international law and fully enforceable under those laws.

Nevertheless, there is room in the next round of U.S.-RF negotiations for new and innovative means of reaching and verifying agreements. Some existing tools such as on-site inspections and data exchanges through the Nuclear Risk Reduction Centers (NRRC) can be enhanced and used in new ways.[8] Other tools such as intensified military-to-military activities, classified data exchanges and verification measures using trusted third parties could come into play in future agreements.

REDUCING NUCLEAR WARHEADS

As has been clear for decades, one of the greatest technical challenges of the next round of bilateral negotiation will be establishing and reducing actual inventories of nuclear warheads of various categories. Directly accounting for individual nuclear warheads has never been accomplished by previous nuclear arms reduction treaties. Warhead limits, such as the 1,550 deployed strategic warhead limit set by New START are met by counting the number of warheads declared by each side to be carried by strategic nuclear delivery vehicles such as intercontinental ballistic missiles (ICBMs) and strategic bombers.

This does not provide an accurate accounting of nuclear warheads actually possessed by the United States and Russia. For example, New START attributes only one nuclear warhead to each

[6] Other reasons for Russian preference to move slowly with respect to additional nuclear arms negotiation relates to the pace of retirement and modernization occurring within its strategic nuclear forces. Over the next ten years Russia will deploy a new class of ballistic missile submarine with a new class of missiles, retire another class of submarine and upgrade missiles on a third existing class of submarines. Its land-based strategic missile force will also change significantly with new deployments of road-mobile missiles, retirement of most Soviet era SS-18 and SS-19 intercontinental ballistic missiles (ICBMs) and the possible development of a new silo-based, multiple warhead missile. Russia likely wants to delay any new treaty obligations that could impact its strategic modernization programs given a high degree of uncertainty over their successful implementation.

[7] *Arms race stability* is a condition where neither side feels it is at a significant numerical or operational disadvantage in terms of nuclear force structure. Because such disadvantages were seen to be so threatening in the hostile political environment of the Cold War, a real or perceived disadvantage could cause one side to launch a rapid buildup of forces. This, in turn, could be perceived by the other side as displaying hostile intent or seeking a counter-advantage. Without proper communication both sides could get caught in a buildup spiral (arms race) with negative consequences in terms of cost, misperception and distrust.

Crisis stability is a condition where neither side feels compelled to launch its nuclear forces first in a political crisis due to the belief that they are about to be struck by the opponent and will not have sufficient forces to retaliate, or because the residual forces they will retain after absorbing a strike will be insufficient to inflict the necessary level of damage on the opponent to avoid military defeat in the conflict. Maintaining crisis stability requires both sides to retain invulnerable second-strike capabilities.

In both types of stability the assumption during the Cold War was that due to the hostile nature of the U.S.-Soviet relationship both sides would inevitably act to seek and exploit military advantage, and were likely to take decisions motivated by such advantages or perceptions of advantage or disadvantage during crises.

[8] For information on the U.S. NRRC see: http://www.state.gov/t/avc/nrrc/c26278.htm

strategic bomber when in fact they are designed to carry many warheads. Similarly, a large set of nuclear warheads possessed by both sides are kept in storage to supplement the warheads that are mounted atop ICBMs that are kept on alert. Finally, there are the inventories of non-strategic nuclear warheads and retired warheads awaiting dismantlement. In summary, current U.S.-Russian nuclear arms agreements cover only a small fraction of total warheads maintained by both sides. This is illustrated by the fact that as of September 30, 2009, the United States possessed 5,113 nuclear warheads in its military stockpile, of which only 1,550 will be accounted for under New START.[9]

It is difficult to see how the stated objectives of negotiating reductions in non-deployed or non-strategic nuclear weapons could be reached without establishing nuclear warheads as specific items of account. These categories of nuclear warheads are stored separately from their delivery vehicles and, in most cases, can be delivered by a range of different delivery vehicles. A practical approach to accounting for them would be for both sides to periodically exchange data on the number and location of all non-deployed and non-strategic nuclear warheads and allow periodic inspections to confirm the accuracy of the declarations.[10] Data update notifications would be provided when warheads were retired, replaced or temporarily removed for maintenance or training purposes. A similar approach could be followed for retired warheads awaiting dismantlement.

Establishing an agreed method for accounting for all nuclear warheads is an essential tool for moving towards the long-term goal of a world without nuclear weapons. This approach has several benefits. It could establish a legal structure for defining and counting all nuclear warheads. It is more accurate than the arcane counting rules employed in START and New START that obfuscate actual warhead inventories and leave several categories of warheads unaccounted for. A true accounting of all nuclear warheads would provide a greater degree of transparency regarding the size and capabilities of U.S. and Russian nuclear arsenals. The exchange of data on storage locations and periodic maintenance activities would provide more information on nuclear warhead production infrastructures as well.

While the logic and potential benefits of moving to warheads as the primary unit of account in the next treaty are clear, the difficulties of doing so should not be underestimated. Russia has not made a declaration similar to the United States regarding the total number of nuclear weapons in its stockpile. Neither country has disclosed the specific number of non-deployed, non-strategic or retired warheads in its possession. The inventories and locations of these categories of warheads remain classified national security information. Due to the need for dynamic operations such as warhead maintenance, training, and reliability inspections it will be a complex challenge to create treaty protocols and procedures that provide confidence that numbers of stored warheads are being reduced. Moreover, whatever verification and inspection procedures might be proposed for a new treaty limiting warheads, both sides must be confident that they will not compromise classified information or decrease the physical security of the warheads and storage facilities.

A Three-Pronged Approach

To prepare for challenging and potentially long-term negotiations and to create a positive environment for overcoming technical and administrative obstacles to a new agreement the United States and Russia should consider a three-pronged strategy of cooperative activities:

One – Confidence-Building and Transparency Measures

This track could include a sustained set of confidence-building and transparency measures that address enduring concerns and misperceptions in the U.S.-Russian strategic relationship and build cooperation and partnership. The recommendations for activities under this track will concentrate on those most related to nuclear stockpiles, operations and infrastructure but, to be effective, they should be conducted in parallel with similar activities in the areas of missile defense, conventional forces and NATO-Russia relations. Some of the following activities will take several years to plan and implement while others build on previous U.S.-Russian interactions and could be initiated more quickly.

[9] The active stockpile does not include several thousand retired U.S. warheads awaiting dismantlement. See U.S. Department of Defense Fact Sheet, http://www.defense.gov/news/d20100503stockpile.pdf
[10] See Fetter, Steven and Ivan Oelrich, Verifying a Prohibition on Nuclear Weapons, *Elements of a Nuclear Disarmament Treaty: Unblocking the Road to Zero*, edited by Barry Blechman and Alex Bollfrass, pp. 27-56. Washington, DC: Henry L. Stimson Center, 2010.

1) Exchange Current Data and 10-20 Year Plans for Nuclear Forces and Stockpiles

In order to increase trust and reduce the possibility of misperception regarding military capabilities, both sides could periodically exchange 10-20 year plans for their nuclear delivery systems and nuclear stockpiles. From Russia's perspective such data exchanges should include descriptions of planned deployments of ballistic missile defenses and any strategic conventional weapons that could be used in a first strike on its nuclear arsenal. Eventually, Russia is likely to acquire some prompt global strike and improved missile defense capabilities of its own and advance notice of such deployments will be useful to U.S. planners.

Exchanging nuclear weapons information could reduce uncertainties on both sides regarding the future security environment for which they must plan, while simultaneously increasing confidence that neither side was seeking military advantage over the other. For example, official information regarding Russia's general nuclear warhead manufacturing, disassembly, and refurbishment capabilities is not openly available. If the United States knew more about Russia's warhead manufacturing and retirement capabilities over the next decade, it could be less concerned about the need to hedge against the possibility of a Russian "breakout" from a future treaty by retaining large numbers of reserve warheads. Similarly, Russia may be willing to reduce its active warhead stockpile and manufacturing infrastructure if its concerns are eased regarding U.S. capabilities to rapidly upload non-deployed warheads onto strategic missiles or deploy robust missile defenses.

Perhaps the most critical information to exchange in the near term would be total warhead inventories in the following categories:

- Deployed strategic
- Non-deployed strategic
- Non-strategic
- Retired and awaiting dismantlement

These data would facilitate negotiations aimed at further reducing any or all categories of nuclear warheads. It will be essential to first discuss and develop a common method of categorizing nuclear warheads.[11] It may be desirable, but not essential, to declare distinct warhead types within these categories. The same is true for declaring accurate storage or deployment locations. However, if a future treaty required the permanent monitoring or removal from military stocks of an exact number of warheads, their location and life-cycle pathway to elimination will eventually need to be declared and monitored.

There are several advantages to exchanging stockpile data early in what will likely be a long-term effort to reach new agreements. Once information is exchanged, both sides can begin to independently assess their level of confidence in the accuracy of the data. During periodic meetings and exchanges, each side can seek clarification of factual uncertainties or inconsistency. The objective over time is for confidence and transparency to increase, perhaps allowing simplification of verification procedures for future agreements or expanding the range of treaty options that negotiators could consider. For example, if high confidence were established in baseline inventories of total warheads in the deployed, non-deployed, and non-strategic categories, perhaps a future agreement setting a lower limit for a combination of these categories would become more feasible. Such an approach would allow both sides to choose their own mix of warheads under a lower ceiling than has been proposed in the past.[12] Early stockpile data exchanges covering these warhead categories would be a prerequisite to this option.

One development that potentially eases the future exchange of classified or sensitive information is the entry into force on January 12, 2011, of the U.S.-Russian Nuclear Energy Cooperation Agreement. One of the stated objectives of this agreement is to create the conditions for improved cooperation on joint technology development to support arms control and nonproliferation activities.[13] Despite the precedents and potential mechanisms for exchanging classified data, both sides must determine that it is in their interest to share details of their nuclear stockpile.

2) Reciprocal Visits to Nuclear Weapon Storage Facilities

Such visits could serve three purposes. First, they reinforce the idea that neither side is the object of the other's nuclear forces and that both sides have mutual security interests of the highest order. Second, they provide a foundation that can facilitate the joint design of transparency or verification measures and serve as potential models for formal inspections. Third, visits can provide another opportunity to exchange best practices or review the progress of U.S. supported security upgrades because improved security of nuclear weapons is an objective of future agreements. In fact, such reciprocal visits could be integrated with ongoing U.S. Department of Defense (DoD) and National Nuclear Security Administration (NNSA) nuclear weapons security cooperation with Russia. Cooperation could include joint research and development of improved security and accounting technologies, and other activities that become a permanent component of the strategic relationship, providing continued confidence and insight into how each country is managing nuclear security. In this context, the additional possible benefit is potential development of integrated security, accounting and verification technologies.

Any inspections to confirm reductions of non-strategic and non-deployed nuclear warheads will entail declarations of the numbers to be reduced and some method to verify their removal from active stockpiles. Reciprocal visits to the storage facilities for these weapons could take place in the United States and/or NATO nations, and Russia. U.S. and Russian officials have exchanged visits to nuclear storage sites in the past as part of confidence building measures and during joint efforts to improve security of nuclear weapons.[14]

Such visits allow observation of the facilities where on-site inspections or remote warhead storage monitoring might take place, thus facilitating the design of verification instruments or approaches. Factors such as the remoteness of the facility, access procedures, the availability of electric power, and communications infrastructure may affect the feasibility of some verification approaches. Such visits also help establish and exercise administrative procedures for allowing foreign national access to sensitive and classified areas.

[11] Steven Pifer, "The Next Round: The United States and Nuclear Arms Reductions after New START," Brookings Arms Control Series, Paper 4, December 2010.

[12] For example, see Joseph F. Pilat, "Controlling Nonstrategic Nuclear Forces," in Larson, Jeffrey A. and Kurt J. Klingenberger, editors, *Controlling Non-Strategic Nuclear Weapons: Obstacles and Opportunities, United States Air Force, Institute for National Security Studies*, July 2001, p. 243

[13] Fact Sheet: U.S.-Russia 123 Agreement on Nuclear Energy, U.S. Department of States, January 12, 2011: http://www.america.gov/st/texttrans-english/2011/January/20110112112648su0.9979931.html

[14] For example, in June 1998, General Eugene Habiger, then commander of the US Strategic Command visited a Russian SS-19 base at Kozelsk; a national nuclear weapons storage depot in Saratov oblast, the strategic bomber base at Engels; the SS-25 base in Irkutsk; and a naval nuclear weapons storage site near Severomorsk. Habiger previously visited another SS-25 base at Tejkovo and the SS-24 base at Kostroma in October 1997, and a group of senior Russian officers, including Lieutenant General Igor Valynkin, then head of the 12th Main Directorate of the Russian Defense Ministry, which is responsible for the storage of nuclear weapons removed from active service, had toured several American strategic nuclear weapons facilities in March 1998. See Nuclear Threat Initiative (NTI) research library database:

3) Reciprocal Visits to Warhead Assembly/ Disassembly Sites

This activity was proposed as a confidence building measure in the mid-1990s. But an exploratory U.S. proposal for reciprocal visits to dismantlement facilities was not accepted by Russian officials in 1994.[15] However, much has changed in Russia's nuclear warhead production complex since then, and this initiative could be revived.

Reciprocal visits could facilitate the development of monitoring and verification approaches for nuclear warhead reductions. Both sides could exchange basic flow diagrams of how and where the warhead dismantlement process takes place within the facilities. During reciprocal visits each delegation could be given familiarization briefings and tour the storage areas and dismantlement bays and cells. These visits could give both sides a better understanding of all the safety, security, and operational factors that would need to be considered during inspections to confirm warhead elimination.

Because these facilities and their operations deal directly with disassembly and maintenance of nuclear warheads, it will be very difficult to create inspection procedures that do not threaten to compromise classified stockpile information. Reciprocal visits may help both sides identify specific storage areas and certain aspects of the dismantlement process that can be isolated and monitored to help build confidence that reductions have taken place as declared without threatening security. In fact, one of the activities that could be undertaken in relation to the proposed reciprocal visits is for U.S. and Russian specialists to conduct a joint study of managed access at assembly-disassembly plants.

4) Joint Demonstrations of Verification Technologies

Another set of beneficial activities would be periodic, perhaps annual, joint expositions of verification and monitoring technologies under development by U.S. and Russian scientists. The location of these demonstrations could alternate between the countries. One purpose for this collaboration would be for decision makers on both sides to become familiar with current approaches to monitoring and verification for warheads, and to determine the remaining challenges that must be overcome. This activity would be integrated with a program of actual joint technology development and operational field trials that would become the central part of the second prong of bilateral preparations for new negotiations.

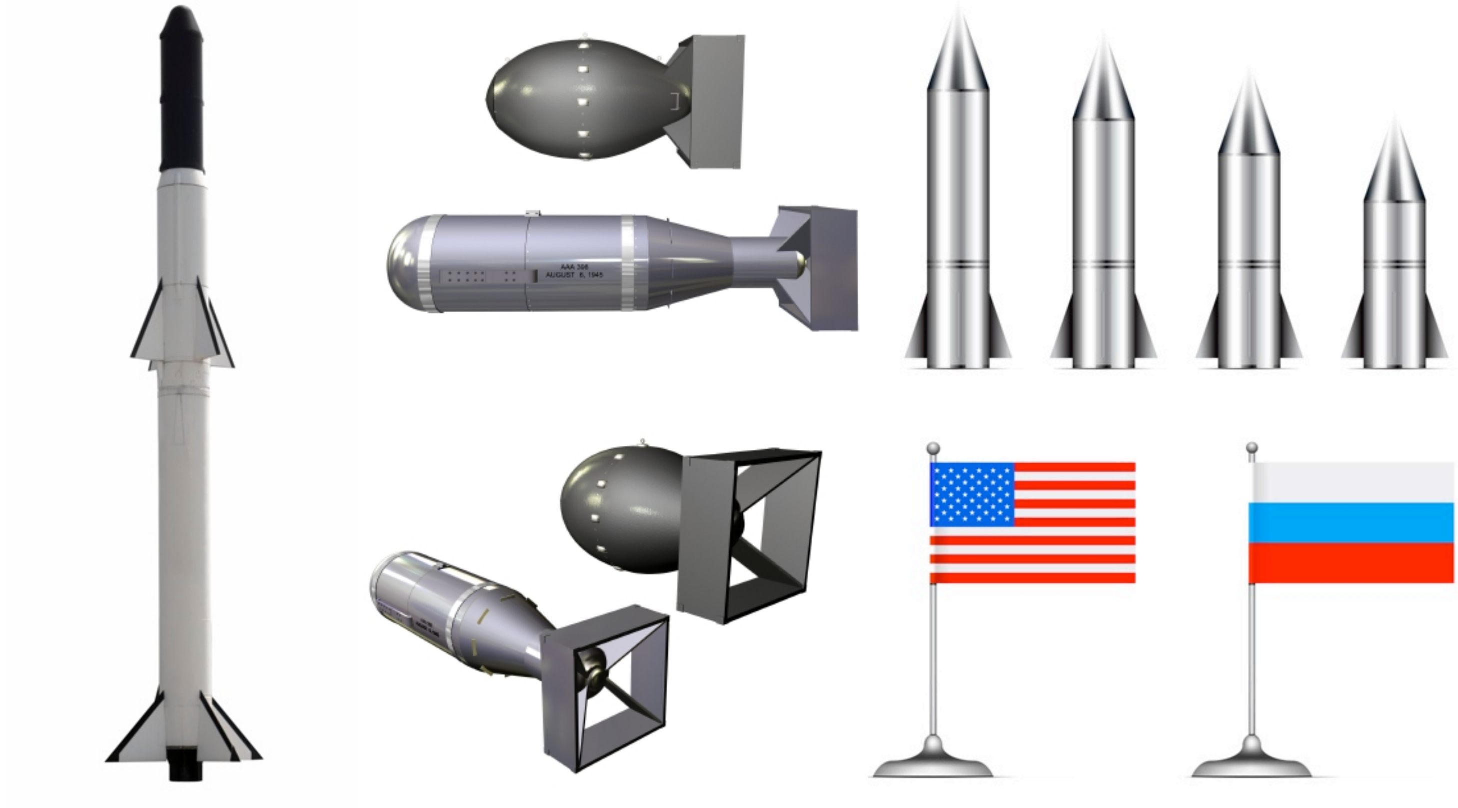
Two - Joint Development and Field Trials of Verification Technology and Procedures

Cooperative development and joint field trials of verification technology and procedures are central to the success of future verified nuclear warhead agreements. These are the most technical and labor-intensive activities, requiring the most financial and administrative resources. Whenever possible, tests and field trials of verification approaches should be conducted in realistic settings at nuclear facilities and use actual nuclear weapons and their storage and transportation containers. The purpose is to investigate how technology can support potential treaty verification activities. Therefore, a series of joint verification experiments could be designed around hypothetical treaty objectives.

Significant precedents exist for this type of joint technical experimentation in the U.S.-Russian relationship, and those experiences provide a foundation for building new cooperation. One precedent was the series of Joint Verification Experiments (JVEs) conducted by U.S. and Russian specialists in 1988 to demonstrate technologies and procedures that were useful for verifying the Threshold Test-Ban Treaty.[16]

[15] See Oleg Bukharin, "The changing Russian and US nuclear weapon complexes: challenges for Transparency," In Zarimpas, Nicholas, ed. *Transparency in Nuclear Warheads and Materials: the Political and Technical Dimensions,* Oxford: Oxford University Press, 2003, pp.203-204.

[16] On August 17, 1988 at the U.S. nuclear test site in Nevada, the United States and the Soviet Union conducted the first phase of the Joint Verification Experiment (JVE). This was the result of a U.S.-Soviet agreement that provides for one underground nuclear explosion experiment at the U.S. test site and for another such experiment at the Soviet test site near Semipalatinsk in September. During the December 1987 Washington summit, the U.S. and Soviet Union agreed to design and conduct the JVE to facilitate an agreement on effective verification measures for the Threshold Test Ban Treaty (TTBT) of 1974 and the Peaceful Nuclear Explosions Treaty (PNET) of 1976. Results of the JVE permitted these two treaties to be ratified. The JVE provided the opportunity to measure the yield of nuclear explosions using techniques proposed by each side. The United States used CORRTEX, a direct hydrodynamic yield measurement system for verification of the TTBT and PNET. Through the JVE, the United States hoped to provide the Soviet Union with the information it needed to accept the routine U.S. use of CORRTEX in the verification of these two treaties. See White House Statement 8/17/1988: http://www.reagan.utexas.edu/archives/speeches/1988/081788a.htm



Another was the series of Mutual Reciprocal Inspections (MRI), involving joint experimental verification measurements of nuclear weapons components that took place in 1994-2000.[17] Both the JVE and MRI activities took place at U.S. and Russian nuclear weapons facilities and involved scientists from the respective national nuclear weapons laboratories. Another objective of these joint activities was to identify verification technologies that would accomplish the intended task and be acceptable to both sides. This remains the challenge for developing technologies and procedures for verifying nuclear warhead reductions in a future treaty.

1) Begin the Preparatory Work Now for Joint R&D on Warhead Verification.

While there are clear benefits to working jointly in the area of verifying nuclear warhead storage or elimination, the sensitivity of this activity will require that each side revive unilateral efforts to identify specific projects they are willing to undertake and prepare for any agreed joint development or experiments. Both sides will have to assess and mitigate the security risks involved with joint R&D and experimentation at their nuclear weapons facilities. The evaluation of candidate verification technologies and procedures that can be proposed to the other side for joint experimentation will also require some unilateral effort. This preparatory work can possibly be conducted by both sides in parallel with bilateral discussions to plan a future set of joint experiments.

2) Propose to Russia the Creation of a Joint Multiyear Warhead Monitoring Experimentation Plan

This plan should include joint experiments to test verification and monitoring approaches that cover a range of possible treaty requirements. Despite the fact that it is unknown at this time what specific new data exchanges, sublimits (for example, limits on the numbers of certain types of deployed warheads) and reductions might be called for under a new treaty, the range of possibilities clearly include the following:

- Reduce deployed strategic warheads, strategic delivery vehicles and launchers below the limits required by New START.[18]
- Reduce non-strategic nuclear warheads.
- Reduce non-deployed strategic warheads.
- Establish a single limit covering all nuclear warheads—providing freedom to mix strategic and non-strategic, deployed and non-deployed—perhaps with one or two sublimits, e.g., a sublimit on deployed strategic warheads.
- Require that some specified number of warheads remain in permanently monitored storage.

All but the first of these five potential treaty objectives would require some exchange of warhead

[17] Andrew Bieniawski "Historical Review," briefing materials, Fissile Material Transparency Technology Demonstration, August 14, 2000, Los Alamos, LA-UR-00-2239.

[18] Because New START already includes inspection procedures for verifying the elimination of nuclear delivery vehicles and launchers, there is no need to conduct joint verification R&D for this purpose. Lower deployed strategic warhead limits could be achieved simply by requiring the elimination of more strategic delivery vehicles and forbidding any increases to the number of warheads carried on remaining vehicles. Under such an agreement the warheads from eliminated delivery vehicles could be stored by either side, requiring no new verification technologies or procedures. However, if the removed warheads were required to remain in permanently monitored storage or be dismantled then new inspection technology and protocols are needed.

stockpile data in one or more of the following categories:

- Non-deployed strategic warheads
- Non-strategic warheads
- Retired warheads in storage awaiting dismantlement

This means that some method for developing confidence in the accuracy of declared stockpile data will have to be agreed to as well. Any future agreed approach is likely to include periodic on-site inspection to confirm declared inventories but may or may not include new inspection technology or instrumentation. Some potentially useful tools in maintaining confidence in stockpile declarations would be systems for the unattended monitoring of warheads in storage and the ability to exchange encrypted stockpile data through the U.S. and Russian Nuclear Risk Reduction Centers.

Any agreed approach is likely to include periodic on-site inspection to confirm declared inventories but may or may not include new inspection technology or instrumentation.

3) Develop Verification Experiment Scenarios

A series of joint experiments could be designed around several treaty monitoring scenarios. Two important challenges that scenarios are likely to include are first, authenticating that a sealed container declared to contain a nuclear warhead or warhead component actually does contain such an item and second, maintaining Chain of Custody (COC) regarding the integrity of authenticated nuclear warheads as they move through various stages of the retirement, storage, and dismantlement life cycle.

The scenarios provided below are illustrations chosen from a wide range of possibilities for joint exercises demonstrating verification technologies and procedures. These exercises can provide valuable feedback both to longer-term R&D efforts for verifying future nuclear arms reductions and to formal treaty negotiations.

Scenario 1: Mock Inspection to Verify Baseline Declaration

A mock inspection could include identification of a nuclear warhead deployment or storage facility, declaration of the type and number of items at the facility and some procedure for confirming the declaration.[19]

An additional step could require unique identifiers or "tags" be placed on individual stored nuclear warheads for later confirmation.

Scenario 2: Removal of Warheads from Operational Strategic Missiles

This scenario could simulate the removal of warheads from any type of strategic ICBM or SLBM, for example, the U.S. Minuteman III ICBM or the Russian SS-18, SS-19, and SS-24 ICBMs. Established treaty procedures already exist in New START for the initial portion of this scenario. Monitoring of the transportation of the missile front section containing warheads on a special truck to a weapon service area will be needed as well as a radiation measurement and final tagging and sealing of the warhead storage or transportation container.[20]

Scenario 3: Continuous Monitoring of Stored Nuclear Warheads

Several approaches to storage monitoring have been tested and/or employed in the past, including manned perimeter-portal monitoring systems, periodic inspections of tagged items, and unattended systems with continuous monitoring of the exterior and interior of storage facilities.[21] Nevertheless, additional testing of prototype systems is necessary. Remote monitoring systems include a variety of sensors including video, motion detection, monitored seals and other technologies that would detect in real time any attempt to enter or remove the contents of a sealed storage weapons magazine.

Scenario 4: Monitored Warhead Dismantlement

Another series of experiments could be aimed at methods and technologies for building confidence that nuclear warheads had been dismantled. For example, the joint development of inspection systems using passive and active radiation measurements to determine the presence or absence of weapons-grade fissile material and high explosives in a sealed container offers one possible element of a procedure for authenticating declared items as nuclear warheads. Other systems that combine tags, seals, and live video could be developed to provide remote monitoring of the actual warhead dismantlement process.[22] Used in combination with observations at warhead deployment sites and methods for monitoring transportation, these measures may provide adequate confidence that warheads had been dismantled in a manner consistent with declarations

Scenario 5: Verification of Weapons Transportation

Current approaches to monitoring items during transportation include the application of tags and seals that are inspected prior to and following transportation. Because, given sufficient time and resources, most tags and seals are vulnerable to defeat, new and more robust approaches are needed to developing confidence that sealed warhead containers have not been tampered with during the significant periods of transportation. One approach could be to provide the inspecting party with live sensor data on the status and integrity of the containers without revealing the precise location of the shipment. (For safeguards and security purposes, the precise location of a warhead transport is kept secret both in the United States and in Russia.)

Scenario 6: Verified Conversion of Weapons-Grade Fissile materials

Key technology challenges for monitoring the conversion of weapons-usable materials into

[19] For more on monitoring declarations see "Verifying a Prohibition on Nuclear Weapons," by Steven Fetter and Ivan Oelrich in *Elements of a Nuclear Disarmament Treaty*, Edited by Barry Blechman and Alex Bollfrass, The Henry L. Stimson Center, 2009.

[20] For a detailed description of this activity at an operation base see Oleg Bukharin and James Doyle, "Transparency and Predictability Measures for U.S. and Russian Strategic Arms Reductions," *The Nonproliferation Review*, vol. 9, no. 2, Summer, 2002, pp. 82-100.

[21] Committee on International Security and Arms Control, U.S. National Academy of Sciences, "Monitoring Nuclear Weapons and Nuclear-Explosive Materials," Washington, DC: National Academy Press, 2005.

[22] For a summary of existing approaches at the time see Office of Nonproliferation Research and Engineering, Arms Control & Nonproliferation Technologies Project. *Technology R&D for Arms Control*, Washington, DC: U.S. Department of Energy, 2001.

non-weapons-usable forms include demonstrating continuity of knowledge during the transition from item accountability to bulk processing and back to item accountability. A joint experiment demonstrating technologies to monitor the conversion of excess warhead components to non-weapon forms could involve the International Atomic Energy Agency (IAEA), which could eventually assume responsibility for monitoring former weapons materials. This scenario matches the objective of the U.S.-Russian–IAEA Trilateral Initiative and joint experiments in this area could be part of an effort to finalize that initiative.[23]

Three - International Outreach Regarding Verification and Transparency Activities

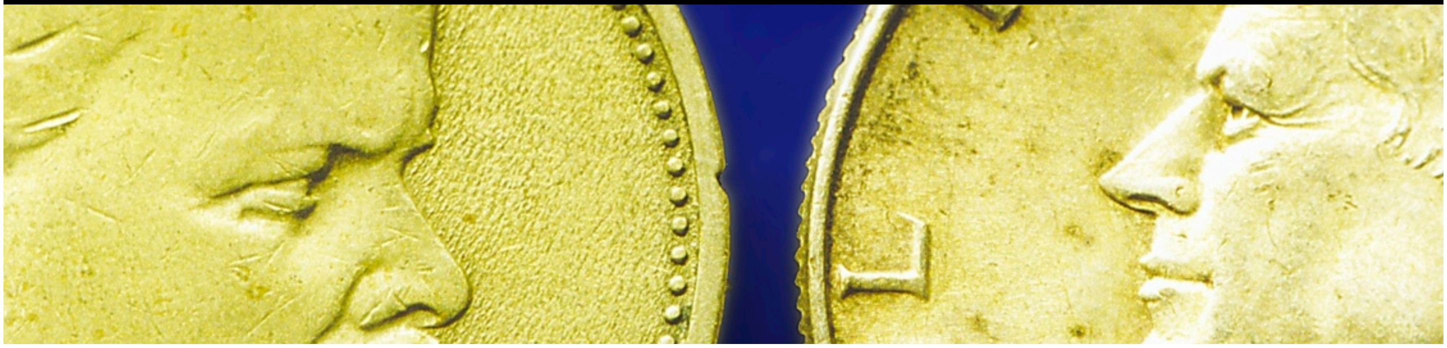
This third effort is the most forward-looking and its objective is to share experiences and approaches to verification developed between the United States and Russia. In essence, it supports the long-term vision of eliminating all nuclear weapons and begins preparing for the phase of nuclear arms reductions that will require the participation of all countries possessing nuclear weapons.

If the United States and Russia develop effective means to verify the elimination of nuclear warheads, they will set a powerful precedent that can be assessed for use by other nations. Several nuclear weapon states and most non-nuclear weapon states have embraced the goal of a world without nuclear weapons. The United Kingdom and Norway have completed a program of mock inspections of warhead elimination. In addition, some Russian officials have stated that any additional bilateral nuclear reductions will have to take into consideration the status of nuclear arsenals in countries such as China, France, and the United Kingdom.

In order to involve these countries in the development of transparency and verification approaches, new political and administrative mechanisms will need to be created. The UK-Norway experiment is one such mechanism that could be expanded to include other states. Another possibility is to involve the IAEA in some aspect of verification and monitoring for nuclear arms elimination.

IAEA participation in nuclear warhead verification or monitoring is limited by the NPT provisions forbidding the transfer of any nuclear weapons information from nuclear weapon states to non-nuclear weapon states. Nevertheless, the IAEA does have the responsibility of verifying the absence of undeclared nuclear weapons activities in the non-nuclear weapons states. Thus, it might participate as an observer in some of the bilateral or multilateral verification experiments. Moreover, the IAEA is an institution that many nuclear security experts believe could be involved in verifying some aspects of nuclear disarmament such as a global ban on the production of fissile materials for nuclear weapons purposes.

[23] Thomas E. Shea, "The Trilateral Initiative: A Model for the Future?" *Arms Control Today*, May 2008. http://www.armscontrol.org/act/2008_05/PersboShea.asp%2523Sidebar1



Many options exist for increasing the participation of other nations in the development of technologies and approaches for verifying the elimination of nuclear warheads. These include but are not limited to the following:

- Periodically invite observers from other countries to verification technology demonstrations suggested under U.S.-Russia Track One activities or joint experiments under Track Two.

- A joint U.S.-Russia team could prepare for and provide verification technology demonstrations in the nuclear institutes or nuclear security centers of China, India, and other states.

- These international demonstrations could include verification technologies developed by the host nation or other regional participants.

- The United States could join the verification R&D efforts of other countries or groups of countries. For example, the United States and the United Kingdom already conduct joint verification R&D. This cooperation could be expanded and joined by other interested states.

- The development of verification approaches for nuclear arms reductions could be included in the agendas of international nuclear security and nonproliferation initiatives such as the Global Initiative to Combat Nuclear Terrorism, the G-8 Global Partnership, and the Nuclear Security Summits.

- Status updates and verification technology demonstrations could be provided every five years at the NPT review conference. This would provide support for implementation of the "thirteen steps" towards nuclear disarmament endorsed at the 2000 NPT Review Conference. The last of these steps is "the further development of the verification capabilities that will be required to provide assurance of compliance with nuclear disarmament agreements for the achievement and maintenance of a nuclear-weapon-free world.[24]

CONCLUSIONS

The United States and Russia have declared their intention to reduce their nuclear arsenals below the levels required by New START. The schedule and objectives of a new round of bilateral negotiations are unknown at this time. However, both countries share an interest in using the time prior to and during the next round of talks to prepare for the negotiations, determine what is desirable and possible in a future treaty, and address the challenges for reaching a new agreement.

These challenges are formidable and span the political, scientific, technical, and financial domains. They cannot be resolved unilaterally. This article has proposed a set of activities that can help address problems specifically associated with making nuclear warheads items of account in future treaties. These activities can help both nations to begin answering critical questions that lie in the way of agreements that reduce nuclear warheads. One of these is to find a mutually acceptable standard for verification of a future treaty. Efforts to jointly develop technologies and approaches can provide a range of confidence levels from transparency to strict verification resulting in a diverse "toolkit" of verification options that could be used as needed for future agreements.

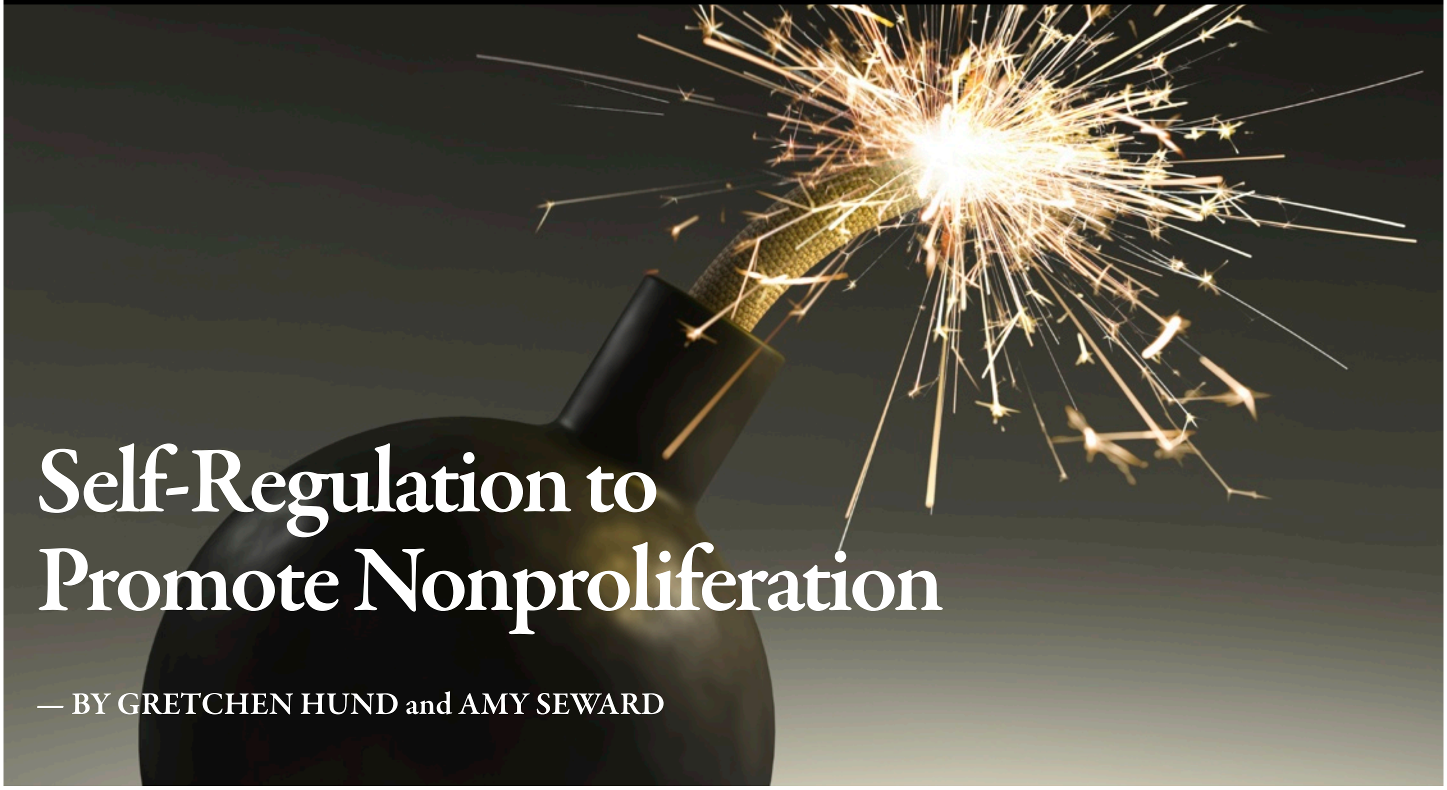
Implementing a strategy similar to the three prong approach suggested above will require a significant increase in effort and resources from the U.S. interagency community as compared to the modest annual investment in arms reduction verification capabilities during the past decade. In addition, new institutional mechanisms are needed to formalize a U.S. interagency verification R&D initiative and build bilateral structures for revitalizing work with Russia's technical community.

Verifying the elimination of nuclear warheads is essential to making a world without nuclear weapons possible. Ultimately this will be a global, not bilateral effort. The international community understands the need for effective verification of nuclear warhead reductions and several states beyond the Unites States and Russia are conducting verification research. It is in the interest of America and Russia to lead this effort and to support the nuclear arms verification activities of other states. The sharing of approaches and technologies can improve the effectiveness of these efforts and increase the likelihood of developing verification methods that are internationally acceptable.

While considering the challenges of verifying warhead reductions, it is useful to keep in mind the security benefits that such reductions can provide. First, such agreements can provide confidence that nuclear warheads have been reduced as opposed to simply placed in storage. This alleviates the perceived need for "hedging" against the possibility of treaty breakout by retaining excess non-deployed warheads. Second, accounting for all categories of warheads provides transparency on the total nuclear weapon stockpiles as opposed to only operationally deployed warheads. Third, reducing and limiting nuclear warheads produces clear progress towards U.S. and Russian NPT Article VI commitments to reduce and eventually eliminate nuclear arms. Fourth, future warhead agreements could provide confidence that the large stocks of Russian non-strategic nuclear weapons have been placed in long-term storage or dismantled, thus reducing the threat of their use or theft. Finally, verified bilateral warhead reduction agreements can help clear some challenges on the path to a future verified multilateral nuclear arms reductions treaty whose goal may be the complete elimination of national nuclear arsenals. ■

James E. Doyle works at Los Alamos National Laboratory. The views expressed are his own.

[24] Deepti Choubey, Are New Nuclear Bargains Attainable? Carnegie Endowment for International Peace Report, November 2008.



Self-Regulation to Promote Nonproliferation

— BY GRETCHEN HUND and AMY SEWARD

INTRODUCTION

The nuclear industry has a unique opportunity to promote the control and security of nuclear material and technologies. The companies involved in the production and trade of nuclear, radiological, and dual-use commodities and technologies are in an ideal position to bolster existing governmental mechanisms to secure these operations and prevent proliferation.

While international agencies, as well as national laws and regulations, are largely in place to prevent access to building or acquiring nuclear or radiological weapons, many countries that are developing nuclear power programs to address their growing energy needs lack the infrastructure to control and secure sensitive materials and technologies. In addition, as the nuclear industry expands, there will be a corresponding increase in the depth, breadth, and velocity of trade in critical commodities. Together, these trends represent a signficant challenge to the nonproliferation regime.

This article discusses research by Pacific Northwest National Laboratory (PNNL) on the need for and means by which an industry, such as the nuclear suppliers, either as a whole or through steps taken by individual companies, can contribute to nonproliferation and nuclear security.

THE INDUSTRY SELF-REGULATION CONCEPT

Since 2005, PNNL has conducted research on the role of private industry in nonproliferation. Specifically, the PNNL team evaluated the concept of industry governance and self-regulation, which over the past several decades has proven to be a powerful tool for improving operational performance in a variety of domains, including environmental protection, occupational and public safety and health, and nuclear safety. Self-regulation can be defined as "A systematic, voluntary program of actions undertaken by an industry or by individual companies to anticipate, implement, or supplement regulatory requirements, generally through the adoption of best practices."[1]

[1] PNNL conducted an initial study by Gretchen Hund and Oksana Elkhamri in October 2005, titled "Industry Self-Regulation as a Means to Promote Nonproliferation," A Pacific Northwest Center for Global Security Publication, PNNL-15355, of four other industries (diamond, fertilizer, cement and chemical) that have undertaken a self-regulation approach to identify potentially detrimental problems early on, and take appropriate steps to avoid damaging consequences to the industry. A subsequent PNNL legal analysis (Frederic Morris and Gretchen Hund. February 2007. "Legal Analysis: Scope for Industry Self-Regulation under Existing Nuclear Export Control and Physical Protection Laws," A Pacific Northwest Center for Global Security Publication, PNNL-16349) assessed the potential contribution of industry self-regulation to prevent proliferation by supporting and reinforcing existing national and international legal and regulatory regimes to prevent access to the means of acquiring nuclear or radiological weapons. This analysis evaluated the systems in place for controlling exports and protecting nuclear, radiological, and dual use commodities in use, storage, and transport. The greatest gaps were identified in (1) dual-use export controls (an adequate model compliance program is needed), (2) security of radiological sources (better guidance is needed), and (3) physical protection guidance for dual use items.

Industries that pursued a self-regulation approach took action in response to a triggering event that was detrimental to a specific company and caused a ripple effect to the whole industry. For instance, following Union Carbide's accident in Bhopal, India, the chemical industry implemented Responsible Care, a program that promotes information sharing among companies and involves a rigorous system of checklists, performance indicators, and verification procedures to improve operations and address concerns about the manufacture, distribution, and use of chemicals. From the perspective of the nuclear, radioactive sources, and dual-use industries, such a trigger could be a terrorist attack using a dirty bomb. Were such an event to occur, it would likely have a crippling effect on the company that supplied the material – knowingly or not – and on the entire industry.

In addition to preventing a trigger event, an industry has many incentives for taking a more proactive role in nonproliferation. An industry could avoid losses in profits and reputation if an incident occurs, preempt the imposition of more restrictive regulations by proactively participating in a voluntary program, and potentially gain expedited clearance of goods. Demonstrating conscientious corporate citizenship could also result in positive gains in corporate ratings and reporting, as well as increased earnings and market share. Another potential benefit is improved relations with regulators and more robust cooperation between industry and government.

Challenges to Industry

PNNL works primarily with dual-use industries to better understand the challenges in meeting existing regulations and in adopting a self-regulation approach.[2] End-user verification is one of the key issues identified by companies in complying with existing regulations. The Department of Commerce implements "catch all controls" with the intent of denying exports to the end-users of the item directly or indirectly related to all aspects of the manufacture of nuclear weapons, reactors and fuel. However, these controls do not adequately address the role of middlemen and front companies, which have been identified as enablers in the diversion or illicit procurement of sensitive goods.

Demonstrating conscientious corporate citizenship could also result in positive gains in corporate ratings and reporting, as well as increased earnings and market share.

Concern about the loss of proprietary information also inhibits the exchange ofinformation on suspected illegitimate end-uses and end-users. A less than collaborative government-industry relationship also limits the degree to which governments receive information that could potentially prevent the spread or diversion of sensitive commodities and technologies.

The private sector can take specific actions to address these challenges. The industry intimately knows the potential uses of sensitive materials and technologies, is familiar with its users, and in many cases has better information than the government on suspected illegitimate end-users.

Actions Individual Companies Can Take

Perhaps the easiest approach is for a company to take steps on its own to support nonproliferation and nuclear security. Most companies already have an Internal Compliance Program (ICP) in place, whose implementation relies on a certain individual or group. What is often missing is for the entire company staff to be aware of the full implications of their actions with respect to nuclear security and nonproliferation and to consider these issues in all of their operations. By doing so, in addition to the ICP there could be a new tenet of the corporate governance structure that includes the control and security of nuclear commodities and technology. Companies could explicitly include this tenet as part of their corporate social responsibility program. These programs traditionally have focused on environmental and social or ethical responsibility. Companies could then preferentially buy goods from the suppliers who adopted similar language in their corporate governance structure, extending the impact of a self-regulation approach throughout the supply chain.

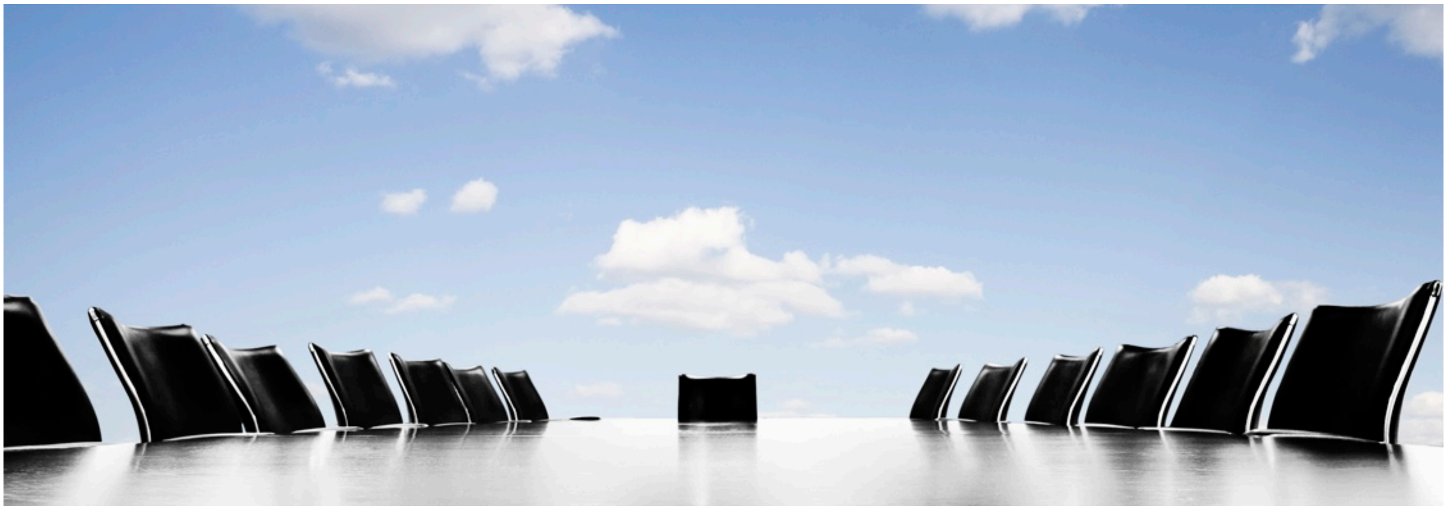
Individual companies would benefit from proactively supporting and strengthening existing governmental mechanisms to prevent proliferation. While a few multi-national companies have taken this approach, there is room for more participation by the industry as a whole.

Actions by an Entire Industry Will Have the Greatest Benefit

An industry can take several steps to support nonproliferation and nuclear security. First, an industry could develop a Code of Conduct and Ethics for model compliance.

Second, it could create a third-party entity to share best practices. Any action to integrate the knowledge of industry activity on nonproliferation grounds will require a resolution of the information sharing concern – between companies (to avoid any appearance of committing anti-trust violations). Similarly, industry has concerns about sharing illicit requests directly with the government out of fear that any company that shares such information will be held responsible for any ostensible wrong-doing. This third-party entity could also facilitate the exchange of information among members. Members could share best practices including how to identify an illicit request. Companies would be encouraged to anonymously share requests for illicit materials, which would alert all members of these requests and suggest that no company fill such an order. The entity could also share these illicit requests with the

[2] PNNL's research has included numerous interviews, primarily with dual-use industry representatives, trade associations, and relevant NGOs to solicit industry's response and potential interest in possible "self-regulation" or "industry governance" approaches. These discussions have enabled better understanding of the challenges industry faces both in meeting existing regulations and in adopting a self-regulation approach.



appropriate U.S. government officials. This third-party concept would augment the overall quality and effectiveness of the existing regulatory infrastructure associated with export control, physical protection, and safeguards of materials throughout the supply chain and at their facilities.

A third step entails working through the International Organization of Standardization (ISO) to develop an ISO standard for compliance with nonproliferation best practices, to be verified by a third-party.

Fourth, an industry could lobby one or more of the international organizations focused on corporate governance, such as the United Nations Global Compact, to include control and security of nuclear commodities and technology as a guiding principle.[3]

Growing Recognition of Industry's Role

The concept of a broader and more proactive role for the private sector in promoting nonproliferation has in recent months attracted growing interest among international nonproliferation entities, the U.S. government, NGOs, academia and industry. PNNL collaborates with other organizations and institutions to analyze and promote an industry role in nonproliferation,[4] and engage industry in dialogue.

Recent discussions with nuclear suppliers indicate that they may have interest in a more proactive role in nonproliferation and nuclear security. AREVA, a major company in nuclear energy services, added nonproliferation as a central principle to its value charter, which suggests a growing recognition of industry's critical role and responsibility in promoting nonproliferation worldwide.[5]

Leadership is needed to move from one company adopting a self-regulation approach to the industry as a whole securing and controlling their goods and services so that they are not diverted for illicit use. PNNL is identifying industry-specific self-regulation approaches by engaging companies in targeted industries. Recent discussions have included the vacuum industry, which is an essential component of uranium enrichment programs.[6] PNNL plans to work with both individual companies and industries to promote this self-regulation concept.

Conclusion

In 2004, the revelation of the illicit trafficking network headed by Pakistani nuclear scientist Abdul Qadeer Khan provided an impetus to strengthen international efforts to prevent nuclear proliferation. Nonetheless, momentum for developing better regulations has slowed perhaps because there has been no overt act of nuclear or radiological terrorism, limiting the pressure for companies or the entire industry to act.

Given the potentially catastrophic impact of a nuclear or radiological terrorist event, the fact that it has not occurred is not a legitimate basis for slowing the development and implementation of a self-regulatory approach. The time is ripe for companies and industries to be proactive in contributing to the control and security of nuclear material and technologies throughout their supply chains. There are direct benefits to companies and industries that choose to adopt such practices as well as to nonproliferation and nuclear security. ■

Gretchen Hund and Amy Seward are senior scientists at Pacific Northwest National Laboratory.

[3] The UNGC is an international framework for economic, ecological, and social sustainability that sets out 10 principles in the areas of human rights, the labor market, environmental protection, and corporate corruption.
[4] Collaboration with organizations includes the Institute of Science and International Security (ISIS), the Stimson Center, the World Institute for Nuclear Security (WINS), Brookings, the American Physical Society, and the American Association for the Advancement of Science. PNNL has also presented research on this topic in several international meetings including the Licensing and Enforcement Experts Meeting (LEEM) at both the Nuclear Suppliers Group (Budapest) and Missile Technology Control Regime (Rio de Janeiro) in 2009. The work has also been presented at several Institute for Nuclear Materials Management (INMM) meetings and at the International Atomic Energy Agency (IAEA).
[5] Keynote speech made by AREVA CEO Anne Lauvergon at the annual Carnegie Endowment International Nonproliferation Conference, 2009.
[6] Vacuum components have application in the uranium enrichment process, in which the concentration of the U-235 isotope is raised to levels where it is usable in civil nuclear power generation, and at higher levels, is potentially usable in a nuclear weapon.

RESEARCH REPORT

New Technology for Detecting Enriched Uranium in Cargo

CHRISTOPHER MORRIS *

INTRODUCTION

The likelihood and consequences of a nuclear detonation in a major U.S. city justifies deploying newly developed technology that can detect shielded enriched uranium (^{235}U) in cargo at border crossings. The doses for both radiography and active interrogation are compared to natural background rates and are shown to be negligible. A system of active and passive charged particle radiography to radiograph all border traffic would cost approximately $6 billion. Research into low dose radiography and detection techniques is warranted.

The terrorist attacks on September 11, 2001, demonstrated that some extremist groups are willing and capable of inflicting massive death and destruction. The tragic consequences of two jet airliners flying into the World Trade Center towers pales in comparison to the number of deaths, the direct economic damage, and the disruption of the world economy that would result from the explosion of even a small atomic weapon in a major urban area.

The explosion of an atomic bomb over Hiroshima at the end of World War II caused about 100,000 immediate deaths.[1] The U.S. government values preventable deaths at approximately $10 million each.[2] Consequently, the direct cost in deaths of a nuclear explosion in a major city would likely reach one trillion dollars. The economic costs would exceed this considerably.

Estimates of the likelihood of such an event[3] range from about 0.01 per year to 0.1 per year. As there has not been such an event in the 65 years since the invention of the atomic bomb, the lower number appears more credible. A simple cost benefit analysis based on these numbers suggests that investing around $10 billion annually to eliminate the likelihood of a terrorist nuclear detonation in a U.S. city is warranted.

There are two classes of nuclear explosives: thermonuclear weapons that comprise the nuclear stockpile of the major nuclear-armed states; and atomic weapons, which are far simpler and less powerful, and are the weapons of the minor nuclear states. The latter poses the terrorist nuclear threat because of the simple and well known principles of their operation.[4]

An atomic explosion is created by injecting fast neutrons to a supercritical mass of a fissile material on a rapid time scale (100s of nanoseconds) so that the fission chain reaction releases a large amount of energy before the energy release causes the supercritical mass of materials to disassemble.The required mass of material that supports a chain reaction is larger than the critical mass of about 10 kg for a bare sphere of ^{239}Pu and 52 kg for ^{235}U. These materials can be made in sufficient amounts to be produced for making atomic bombs. ^{235}U occurs with an abundance of 0.7 percent in natural uranium and is enriched in industrial scale separation facilities. ^{239}Pu does not occur naturally in any significant amount but is made by neutron capture on ^{238}U in the neutron flux in a nuclear reactor, and needs to be chemically separated from

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Large quantities of these materials have been created in the past 65 years. Most are tightly controlled by the major nuclear nations. This is the first line of defense in preventing terrorists from obtaining nuclear explosives. However, the frightening prospect of some material being diverted to terrorists either through theft or intentional release has been the subject of many studies over the past couple of decades.

The higher neutron radiation emitted by some of the plutonium isotopes produced in reactors makes its use in atomic explosions more complicated than uranium. Plutonium requires implosion assembly of a supercritical mass in order to obtain any efficiency in a nuclear explosion because of premature initiation caused by neutrons produced by spontaneous fission. If neutrons are released into the assembly too early, the fission energy released causes the device to disassemble without an explosive yield - a so-called fizzle. The neutrons released by spontaneous fission are difficult to shield and easy to detect. For these reasons uranium is a more attractive material for construction of non-major state atomic bombs.

Detecting highly enriched uranium is difficult using currently deployed technology. An effective border defense can be mounted against the transport of such devices through border crossings. This article describes how this can be accomplished and argues that it is cost effective.

A SIMPLE TEST

A simple experiment with a high purity germanium (HpGe) counter and 20 kg uranium cubes (volume 1 liter) of depleted (DU) and 20 percent enriched (LEU) uranium illustrates the difficulty in detecting shielded highly enriched uranium. Gamma-ray spectra were measured with the detector 3 meters from the center of the targets for 5 configurations: background, bare DU, bare LEU, shielded DU, and shielded LEU. By forming the quantity:

$$\frac{dN}{dE}(^{235}U = \left[\frac{dN}{dE}(LEU) - \frac{dN}{dE}(background)\right] - 0.8\left[\frac{dN}{dE}(DU) - \frac{dN}{dE}(background)\right]$$

For both the bare and shielded configuration, the gamma ray signature due only to the ^{235}U was extracted. The signal would be 5 times larger for highly enriched uranium. The results are shown in Figure 1 for 1000 seconds of counting time. Although there is a clear and strong signal from bare ^{235}U, there is no detectable signal from shielded ^{235}U. Quantities of ^{235}U that can pose a weapon's threat surrounded by 2.5 cm of lead shielding are undetectable with the best practical gamma detection technology[5] in 1000 seconds of counting time.

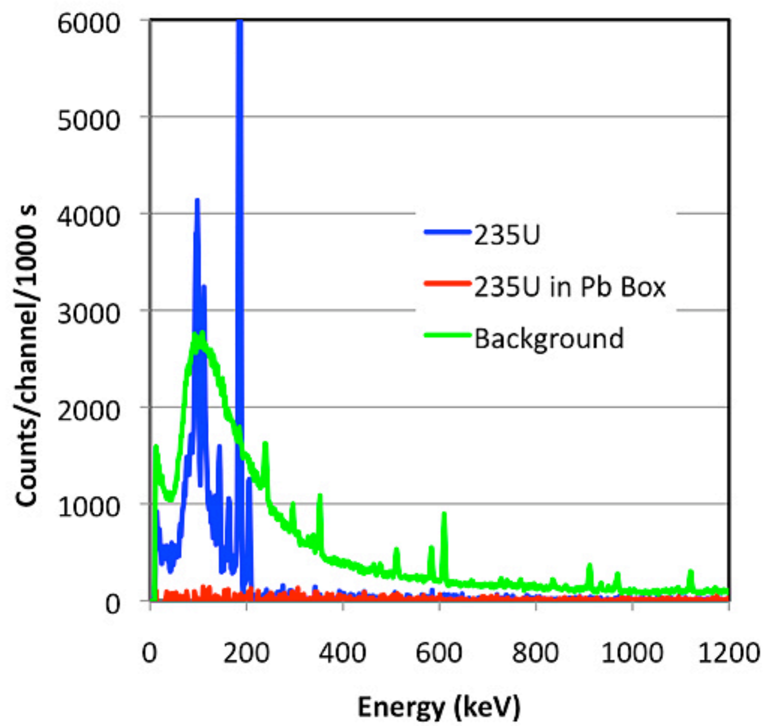

Figure 1. Subtracted signal from an enriched uranium sample showing the gamma ray signal from 235U for a 1000 second counting time. The background signal is also shown.

These objects could be easily transported in a small automobile. The lead shield weighs 17 kg and the uranium weighs 20 kg. Three such shielded packages (3 X 37 kg) would contain enough fissile material to create a Hiroshima-sized explosion, 111 kg - about the weight of a National Football League quarterback.

This experiment demonstrates that radiation monitors cannot be relied upon to detect the threat of a ^{235}U-based fission bomb carried in a light vehicle. The absence of an alarm from a radiation monitor does not prove that ^{235}U is not present--it only proves that no unshielded threat is present. In order to mount a robust border defense, the first level of screening must be based on something other than the passive radiation signal, and it must screen all transport vehicles, including automobiles.

The scale of the problem is daunting. Approximately 20,000,000 shipping containers enter the United States by air, sea, and land annually.[6] In addition, about 100,000,000 personal vehicles enter the country annually from Mexico and Canada.[7] These could be a delivery vehicle for an atomic weapon. Screening the 10^8 personal vehicles in a safe and effective fashion is the most challenging problem in providing a robust border defense.

RADIOGRAPHY AND FIGURE OF MERIT

Radiography has the potential to detect dense objects in complex scenes with high reliability. The most common form of radiography is performed with neutral X-rays. Newly developed forms of radiography use charged particles such as protons or muons; the source of these particles can be natural background, such as cosmic rays, or can be particle accelerators. Although radiography can detect dense objects, it cannot provide a positive identification of fissile materials. Positive radiographic identifications must be checked by direct examination, which may involve unloading the cargo.

A figure of merit for comparing different types of radiography aimed at detecting nuclear threats is the dose required to achieve a given precision. A suitable figure of merit is one that achieves a precision

$$\frac{\Delta l}{l} = 1$$

for a 1 cm^2 10 cm thick uranium object. This dose would provide detection at a 10 standard deviation signal confidence level when averaged over the 100 cm^2 area of the uranium object used for the gamma ray tests. This figure is relevant because 90 percent of border traffic is personal vehicles whose occupants will be exposed to this radiation dose.

There are three forms of radiography with respect to this figure of merit. These are transmission radiography (using X-rays[8]), multiple-scattering radiography[9-11], range radiography[12] , and energy loss radiography[13] (all using charged particles).

ANALYSIS OF VARIOUS METHODS OF RADIOGRAPHY

While conventional *x-radiography* requires a large radiation dose, it can be reduced by optimizing the x-ray energy that is used and by employing collimation to reduce scatter background.

X-ray transmission through an object depends on measuring the attenuation of the incident beam in order to obtain density information. The attenuation is given by Beers law:[14]

$$\frac{N}{N_0} = e^{-\frac{l}{\lambda}},$$

where N is the transmitted flux, N_0 is the incident flux, λ is the mean free path for the incident X-rays, and l is the thickness through the object being radiographed. This can be inverted to obtain:

$$l = -\lambda \ln\left(\frac{N}{N_0}\right).$$

If one assumes mono-energetic x-rays (so that λ is a constant) and perfect counting of the x-rays, the uncertainty is given by the Poisson statistics of the transmitted flux:

$$\Delta l = \frac{\lambda}{\sqrt{N}}.$$

In a simple approximation where the X-ray energy is assumed to be deposited at its interaction point, the dose is given by the energy deposited per unit mass in the beam:

$$D_X = \frac{E_X}{\lambda}.$$

The maximum mean free path of x-rays in uranium is 22 g/cm^2 and it occurs at an x-ray energy near 4 MeV. This long mean free path leads to the best figure of merit for thick object radiography.[15] The dose of 4 MeV x-rays needed to measure a 10 cm thickness of uranium with an uncertainty of 10 cm (1 sigma detection) is about 2 nanoSieverts. If one considers the dose from a bremsstrahlung source (which is not mono-energetic) and detector efficiency, this dose increases this by about a factor of 5. This corresponds to 2.4 minutes of exposure to the natural background radiation illuminating an average person.

Cosmic ray muon radiography (an example is shown in Figure 2) relies on measuring the difference between the trajectories of the incident and outgoing cosmic ray muons passing through a scene (multiple scattering radiography). The uncertainty is given by:[10]

$$\frac{\Delta l}{l} = \frac{1}{\sqrt{2N}}.$$

Because the mean free path of muons is large $N_0 \cong N$, muons lose energy at a nearly constant rate of ~2MeV/(g/cm^2). In this case, the dose needed for the same precision is 0.16 nSv, more than ten times lower than the *idealized* x-ray dose. The disadvantage of muon tomography is the low rate of arrival of cosmic ray muons. This exposure takes ~1 minute, but has the advantage that no external source of radiation is required and no human dose above background results.

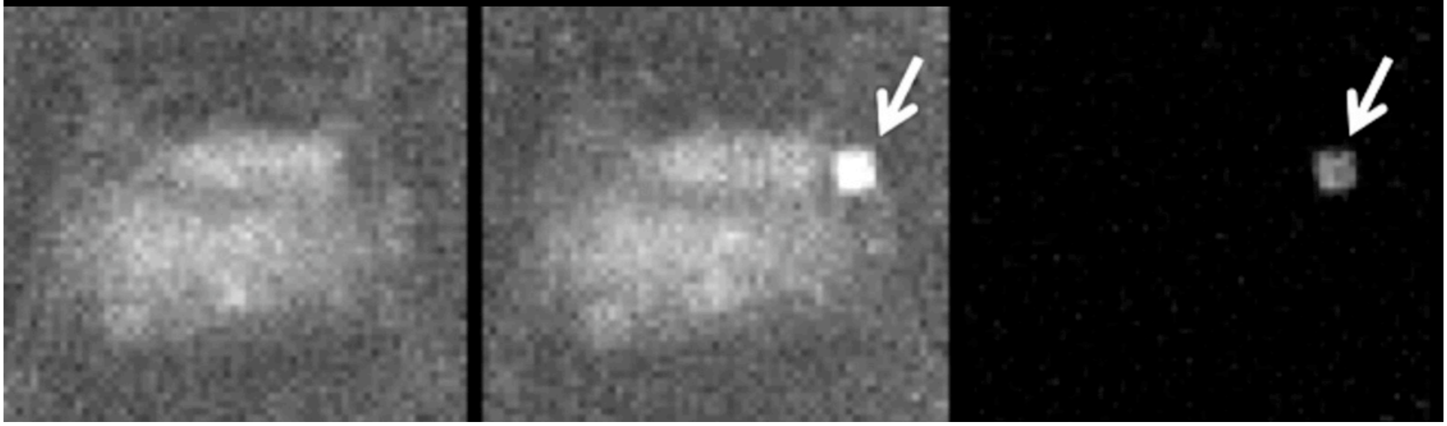

Figure 2. One slice of a cosmic ray muon tomography of an engine (left) an engine with 10x10x10 cm^3 depleted uranium sample (marked with an arrow) above it (middle) and the difference (right). The data are from reference 10.

Multiple scattering radiography is performed using any charged particle with sufficient penetration. The exposure time for charged particle radiography can be reduced by using an artificial source of radiation, i.e., a proton accelerator. In this case the dose needed to obtain a given transmitted flux would be increased because of the nuclear attenuation of protons in the object, and because of the radiation weighting factor for protons which is about 2 compared to 1 for muons and x-rays. [16] This leads to a dose of ~1 nanoSv. A proton energy of 600 MeV would be sufficient to penetrate nearly all cargo containers.

A source of monoenergetic protons can perform *energy loss radiography.*[13] Here the energy loss of protons that have passed through the scene is measured. Since energy loss is approximately linear with material thickness, a single particle provides a measurement of the thickness to a precision of the straggling width. The distribution in the energy loss of charged particles is given by the Landau distribution[17] and its width is only a small fraction of the energy loss. For the thickness of a cargo container, the straggling is typically a few percent of the energy loss. This is illustrated in Figure 3 where calculations [18] of the Landau distribution for 1 GeV protons passing through the amount of iron presented by a cargo container uniformly loaded with iron to its weight limit (green) and the iron plus 10 cm of ^{235}U (red) are shown. The widths of the distributions are several percent. The dose required for energy loss radiography to measure the thickness of 10 cm of ^{235}U is only 4 pSv, 400 times less than x-rays. This is not realistic since it is less than the dose from a single proton, but it does demonstrate the power of energy loss radiography. This is equivalent to 57 ms of average back-ground radiation. Although range radiography would require a similarly small dose, its dynamic range is insufficient for this application. The risk of substantial human exposure to doses of this amount is negligible. Furthermore, with a proton accelerator such a dose can be applied in very short times. This allows the possibility of radiography to detect nuclear threats at highway speed traffic.

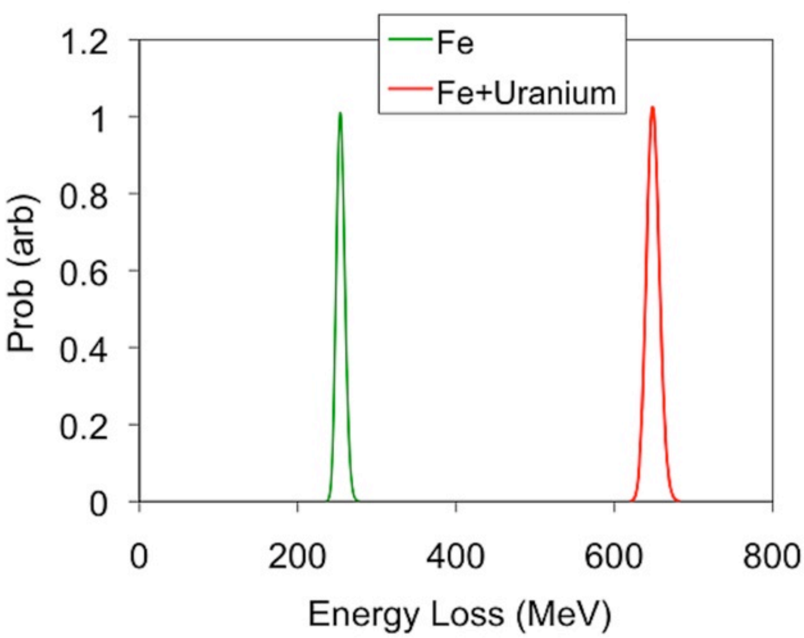

Figure 3. The Landau distribution for 1 GeV protons passing through 149 g/cm^2 of iron (the areal density presented by a cargo container loaded uniformly to its weight limit with iron) and 149 g/cm^2 of iron plus 200 g/cm^2 (10 cm) of ^{235}U. The separation is sufficient so that a single transmitted proton provides detection at a 40 standard deviation confidence level.

ACTIVE INTERROGATION

None of the forms of radiography discussed above can discriminate fissile material from other heavy dense materials, such as gold or tungsten, at low dose. Although radiography can provide primary screening, identification of fissile material requires secondary screening. In personal vehicle traffic at a border crossing, cosmic ray muon tomography could provide primary screening with no added radiation dose while inspection could be used for secondary screening. Where higher screening rates are desirable, one could use accelerator produced proton beams and energy loss radiography for primary screening. The same proton accelerator could be used for targeted active interrogation of any threats that were identified by the radiography.

The long mean free path of protons provides advantages over other probes for active interrogation because the fission cross-sections are large, and protons penetrate materials well and also generate secondary particles. The secondary particles also induce fission on fissile material.[19] In a 20 kg ^{235}U cube, incident protons produce fissions at the rate of about 2 fissions/proton. About 1 percent of fissions produce delayed neutrons 10 sec or more after the irradiating proton pulse. A 20 kg cube of ^{235}U has a k_{eff} (the neutron multiplication factor) of about 0.8. This leads to a neutronic gain of about 5 for both the prompt and delayed neutrons. A single incident neutron produces about 0.5 delayed neutrons. A pulse of 10^4 protons spread over the 100 cm^2 of the target would produce about 10^4 delayed neutrons, a distinctive signature of fissile material. This number of protons per unit area (fluence) corresponds to a dose of 64 nanoSv, the equivalent of 14 minutes of natural background radiation.

ECONOMICS

The cost of a commercially produced cosmic ray muon scanner is about $2 million. Assuming a scan time of 60 seconds, a yearly flow of personal vehicles of 1×10^8, and an efficiency of 10 percent to account for traffic ebbs and peaks, 2000 scanners at a cost of $$4\times10^9$ would cover the borders -- a modest cost when compared to the consequences of a nuclear explosion.

For higher speed scanning, which is essential to avoid disrupting commercial traffic, a very low-power 600 MeV synchrotron accelerator built using conventional technology, beam transport system, and a spectrometer for energy loss radiography would cost approximately $50 million. This system would be capable of 10 times (or more) higher scanning speeds than a cosmic ray muon scanner and could provide integrated active interrogation. If these were used at high traffic ports for cargo scanning perhaps only 40 would be needed at a cost of $2 billion.

These rough cost estimates include neither operating costs nor technological improvements that could come from research. Nevertheless, the actual price of a robust radiography-based border detection system would be below $10 billion, far less than the cost of an unprotected border should there be an attack.

CONCLUSIONS

Existing technology can be deployed to detect enriched uranium in cargo and personal vehicles with high reliability and at low radiation doses. A cost benefit analysis shows that the research and cost of deployment are justified. A solution that employs a mix of cosmic ray radiography and inspection to resolve positive signals or active radiography and active interrogation would be cost effective and provide reliable detection. ■

ACKNOWLEDGMENTS

The author would like to thank his colleagues: Konstantin Borozdin, Greg Canavan, Stephen Greene, Susan Seestrom, Ziehui Wang, and Edward Milner, for many discussions that contributed to this work. This work was performed under the auspices of the U.S. Department of Energy by Los Alamos National Laboratory under Contract DE-AC52-06NA25396.

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DULY NOTED

Nuclear Energy Policy

Democratic Party Nuclear Energy Policy Lurches from Woe to Woe. It Needs to Change.

PETER A. BRADFORD *

Even before the Japanese accident, ten years of strenuous federal subsidy and licensing shortcuts had produced neither a new reactor nor a license to build one. High costs and cheaper alternatives crumpled a 2008 bubble of more than 30 new reactors to four (at two sites) being actively pursued. Those four depend on Congress shifting billions in financial risk from investors to taxpayers through loan guarantees amounting to $100 per American family per project.

Post-Fukushima administration leadership has amounted to Alfred E. Neuman's "What, me worry?" All 104 U.S. reactors will be reviewed in 90 days. More loan guarantees will issue. No reason to delay permits. Nuclear power "can't be taken off the table," whatever that means.

C'mon guys. A series of explosions and other events considered too unlikely to guard against just destroyed one percent of the world's nuclear capacity in four days on nationwide television. Benign winds and the fact that three reactors weren't operating have prevented a far worse calamity.

Dubious spent fuel pool location and protection are likely contributors to the ongoing radiation releases, clearly the worst since Chernobyl. A few years ago, the Nuclear Regulatory Commission refused to enhance U.S. spent fuel pool protections. One of its members leveled insults at the report questioning spent fuel pool safety. The NRC staff was ordered to "produce a hard hitting critique…that sort of undermines the study deeply."

The staff followed orders. But it's not the study that is undermined by those smoldering Japanese spent fuel pools. It's the NRC culture that preferred lashing out at its critics to taking them seriously, especially when doing so would require the nuclear industry to spend money.

Was this an isolated case? Not hardly.

After the NRC delayed closing the Davis Besse plant near Toledo, Ohio, for inspection, the reactor vessel was shown to have a significant rust hole that left only a thin stainless steel liner holding in the cooling water. The NRC Inspector General concluded that the delay "was driven in large part by a desire to lessen the financial impact." The NRC staff official in charge was nominated by the Commissioners for the highest federal bonus.

A couple of years earlier Senator Pete Domenici, an ardent nuclear industry proponent, boasted of persuading the NRC to reverse its "adversarial attitude" by threatening a 33 percent budget cut during a meeting with the chair.

For 20 years now, ideology and campaign finance have weakened public protection of many sorts. President Obama seemed to recognize this when he campaigned against excessive nuclear industry influence at the NRC. His appointees are not implicated in the aforementioned episodes. But what a strange time to keep silent about this unfinished business.

Here are some ingredients of a sensible nuclear policy that reflects the promises of candidate Obama and the concerns of the American people.

Give real priority to learning and applying the lessons of Fukushima. The learning process took 18 months after the lesser accident at Three Mile Island, during which no new licenses were issued. It is likely to take at least as long this time.

Forget further subsidies during this review. Restrict any subsequent subsidies rigorously to "a few first mover reactors" as an MIT study recommended in 2003. A group of no more than six will be plenty to see whether new reactors are capable of producing economically competitive electricity.

Support advanced reactor designs only through research programs until real promise of improved safety and economics is demonstrated.

Acknowledge that new nuclear power has a lot to prove. Stop treating it as if it were a proven success.

If Democratic support for new reactors is to be bait for Republican support for energy efficiency and renewable technologies, stop giving away the store without getting anything back. Every Democratic nuclear moonshine is greeted by further Republican cuts in support for genuinely clean energy. As Casey Stengel said upon taking over the New York Mets, "Can't anyone here play this game?"

** Peter A. Bradford is a former commissioner of the Nuclear Regulatory Commision and chair of the New York and Maine utility regulatory commissions. He teaches at Vermont Law School and is a Board Member of the Union of Concerned Scientists.*

Time to Pursue a Market-based Nuclear Energy Policy

JACK SPENCER *

Though the nuclear crisis in Japan cannot be ignored, it should not deter the United States from moving forward with nuclear energy if it can be done in a safe, clean and economically rational way. Fifty years of domestic operations indicate that it can. 104 reactors operate in the United States, providing 20 percent of the nation's electricity. These reactors produce America's least expensive base load power and have done so very safely. Indeed, no one has died or been injured throughout commercial nuclear power's history.

Despite this success, the American new reactor construction business is largely dead. Each of America's reactors operating today was planned in the 1960s and 1970s. Even those few that have come online in the 1990s and 2000s began construction decades ago. This is because nuclear energy policies in the U.S. stifle nuclear's growth. Though these policies are often portrayed as representing a pro-nuclear versus anti-nuclear debate, the fact is that nuclear energy has enjoyed broad bi-partisan support for some time—at least prior to Japan.

The debate over nuclear energy really lies in how to move the technology forward and what role should the federal government play. Some policymakers support providing subsidies for companies willing to invest in nuclear energy. The problem with this approach is that it undermines motivation to address the underlying policy issues such as inefficient regulations and a dysfunctional waste management policy that have hindered new nuclear construction.

A better approach is to provide market-based reforms that promote innovation, create an efficient and predictable regulatory environment, and that rely on rational economic decision making. It would have the added benefit of allowing the government to focus only on ensuring safe operations through oversight rather than on the actual business of nuclear power.

To achieve this, America's policy makers should consider the following policies.

Reject additional subsidies. The Energy Policy Act (EPACT) of 2005 provides loan guarantees, standby support insurance to protect against government delays, and production tax credits to mitigate the effect of decades of regulatory uncertainty for approximately the first six new nuclear reactors built in the U.S. Unfortunately, this thinking has evolved into subsidy creep. If Congress truly wants nuclear energy to be sustainable, it should allow the industry to succeed on its own.

Enact an efficient permit process for new plants and reactor designs. Creating a permit schedule that at a minimum meets the current four-year timeline or even reduces it would bring regulatory stability to U.S. nuclear policy, which it has lacked for decades. Congressman Devin Nunes (R-CA) recently introduced legislation to help. Establishing a more efficient permit process is not adequate, however. The NRC must also be better prepared to regulate reactor technologies beyond large light-water reactors. This lack of regulatory support is a major barrier to market entry for these technologies that may cost less, be more efficient, be safer or produce easier to manage waste.

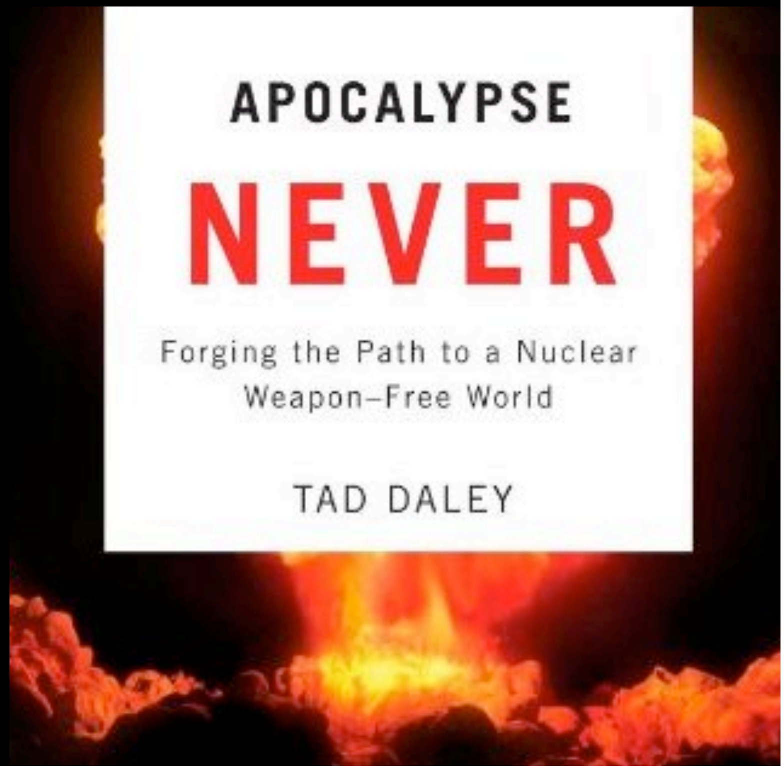
Reform waste-management policy. The federal government's inability to fulfill its legal obligations under the 1982 Nuclear Waste Policy Act has often been cited as a significant obstacle to building additional nuclear power plants. Now is the time to break the impasse over managing spent nuclear fuel. The current system is driven by government programs and politics. There is little connection between used-fuel management programs, economics, and the needs of the nuclear industry. Any successful plan must grow out of the private sector, be driven by sound economics, and provide access to the funds that have been set aside for nuclear-waste management.

Demand that the Nuclear Regulatory Commission (NRC) reach a scientific conclusion on Yucca Mountain. Under any realistic waste-management scenario, there will be a need for long-term geologic storage. Unfortunately, the NRC has discontinued work on the Department of Energy's application to construct a repository at Yucca Mountain. Terminating the Yucca project without a backup plan was premature. At a minimum, the NRC should continue to review the program and determine its viability based on technical and scientific merits. Then the public will be better positioned to debate if the repository should move forward.

The first thing that policy makers must do in the wake of the nuclear crisis in Japan is ensure that regulators and industry have corrected any deficiencies at U.S. plants that were identified from Fukushima. It will be imperative, however, to ensure that the policy response does not result in stifling regulation that impedes the plant level innovation that has kept America's nuclear plants operating safely. Eventually, the discussion will turn to nuclear energy policy. When it does, policy makers must remember that the market works. We should allow it to work for nuclear power. ■

** Jack Spencer specializes in nuclear energy issues as The Heritage Foundation's research fellow in nuclear energy policy.*

BOOK REVIEW



In *Apocalypse Never,* Tad Daley suggests how the world can abolish nuclear weapons and what the world will look like after we do. Daley insists that nuclear materials and technology -- nuclear terror, nuclear accident, a nuclear crisis -- pose an immediate peril to the world.

By CHARLES D. FERGUSON

Even many skeptics of nuclear disarmament would likely grok with the arguments for disarmament made by Tad Daley in his well-written *Apocalypse Never: Forging the Path to a Nuclear Weapon-Free World*. "Grok means to understand so thoroughly that the observer becomes a part of the observed—to merge, blend, intermarry, lose identity in group experience. It means almost everything that we mean by religion, philosophy, and science—and it means as little to us (because of our Earthling assumptions) as color means to a blind man," as defined by Robert Heinlein in *Stranger in a Strange Land*. The writings of Heinlein have influenced Daley as shown by references to the great science fiction writer in *Apocalypse Never*.

While grok connotes an experience that seems otherworldly, Daley endeavors to demonstrate that nuclear disarmament is not science fiction. He wants readers to embrace the sense of grok meant by a compelling and embodying understanding. He does so by laying out a well-organized set of arguments that address the threat of nuclear terrorism, the possibility of accidental nuclear use, the potential mismanagement of nuclear weapons, and the lack of military utility of these weapons (for the United States, but not necessarily for other countries).

Despite the recent killing of Osama bin Laden, who had called on al Qaeda to obtain weapons of mass destruction as a religious duty, nuclear terrorism remains a distinct danger because al Qaeda and certain other terrorist groups still desire to acquire nuclear assets. Deterring terrorists is extremely challenging, if not close to impossible for many terrorists, especially those who are stateless. Deterring nuclear-armed terrorists would likely pose even greater difficulties. Even if terrorists did not detonate the weapons soon after acquisition, they could use these arms as means of extortion. Daley expertly discusses the U.S. strategy to date of securing and reducing weapons-usable nuclear materials. But he argues that this is not sufficient. To drive the risk of nuclear terrorism close to zero, he correctly underscores, "Aspiring nuclear terrorists will not be able to steal a nuclear bomb if there are no nuclear bombs. And they will find it immeasurably more difficult to steal nuclear materials if such materials are placed under the rigorous controls that will necessarily accompany any post-abolition architecture."

Daley next shines a spotlight on hubris and nuclear weapons. He seeks to usher the Greek chorus in by warning us (hopefully not like Cassandra) that we have been very lucky in the past 65 years and that this luck will not hold forever. Not since the atomic bombings in 1945 have nuclear weapons been used in war, but there have been many close calls. A flock of geese, for example, once confused an early warning system. Fortunately, the error was caught in time. Computer errors, however, have prompted nuclear alerts. Of course, humans have programmed these computers and we know that complex systems are not failure free as most recently shown by the Fukushima Daiichi Nuclear Power Plant's accident.

Daley wisely recommends ending "the pointless policy of launch on warning," which is based on the belief that "an adversary will be dissuaded from launching a nuclear first strike on our land-based nuclear missiles if that adversary knows that our missiles will get off the ground before they can be hit." But as Daley points out, U.S. deployed nuclear ballistic missile submarines make launch on warning unnecessary. These submarines guarantee that a retaliatory response will occur and will not have to be carried out promptly. While a means to target and attack these submarines would affect this "insurance," having at least a few submarines deployed would greatly lessen the likelihood of not having at least one of these launching platforms available. Moreover, Daley advises to lengthen the nuclear fuse by removing nosecones and nuclear warheads from ballistic missiles and storing these in separate, secure facilities. This action would increase the number of things that would have to be targeted in a nuclear attack and thus could enhance deterrence.

His next argument for nuclear disarmament addresses the potential for nuclear crisis mismanagement. This chapter begins with a chilling episode that happened during the November 2008 terrorist attacks in Mumbai. Asif Ali Zardari, the president of Pakistan, received a phone call from Pranab Mukherjee, the Foreign Minister of India, who threatened military action in response to the terrorist attacks. As a result of this call, Pakistan put its warplanes on high alert armed with live weapons. But the call was a hoax. This prank may have led to an inadvertent nuclear war. As Daley emphasizes, "political events take on a momentum of their own, and even the instigators may not be able to turn them around."

Daley then tackles the issue of the military utility of nuclear weapons. Because of the U.S. superiority in conventional weapons, the United States would not even have the perceived need to use nuclear weapons in a conventional war. The only remaining purpose for U.S. nuclear weapons is to deter use of others' nuclear weapons, argues Daley while citing the November-December 2008 *Foreign Affairs* article by Ivo Daalder (now the U.S. ambassador to NATO) and Jan Lodal. Consequently, it is clearly in U.S. interests to promote nuclear disarmament because a nuclear-disarmed world would benefit the United States. But conversely, other states that feel threatened by the United States would be at a disadvantage and would have a rationale to obtain nuclear weapons. Thus, Daley uncovers the toughest hurdle for disarmament in "that no state will agree either to abjure or to dismantle nuclear weapons unless it believes that such a course is the best course for its own national security." This observation leads to the fundamental issue of insecurity. Daley quotes former Soviet General Secretary Mikhail Gorbachev to underscore that without addressing "demilitarization of international politics [and] the reduction of military budgets … talking about a nuclear-free world will be just rhetorical."

Daley further is inspired by the concept of "mutual security," as advocated by Gorbachev and Eduard Shevardnadze, who had served as the Foreign Minister of the Soviet Union. That is, by threatening "your adversaries, they will threaten you right back. But if you make your neighbors more secure, you make yourself more secure." This is the challenge and endeavor for all of us to make the world more secure. It is a process that has no definite end, but if the journey leads to greater and greater security, along the way we may wake up one day and realize that nuclear weapons truly serve no beneficial purpose for any state.

Apocalypse Never is definitely worth reading. It is grounded in this world and could still induce a grok-like state that compels readers to work toward a world free of nuclear weapons. ■

Apocalypse Never: Forging the Path to a Nuclear Weapon-Free World (Rutgers University Press, 2010).

Charles D. Ferguson, Ph.D., is the president of the Federation of American Scientists. He is a physicist, nuclear engineer, and author of NUCLEAR ENERGY: What Everyone Needs to Know, available from Oxford University Press.

Tad Daley, J.D., Ph.D., is the author of APOCALYPSE NEVER: Forging the Path to a Nuclear Weapon-Free World, available from Rutgers University Press. He is the writing fellow with International Physicians for the Prevention of Nuclear War, the 1985 Nobel Peace Laureate organization.

FAS MATTERS

FAS NEWS FROM DC HEADQUARTERS

JONATHAN TUCKER JOINS FAS AS THE BIOSECURITY EDUCATION PROJECT MANAGER

Jonathan Tucker worked for nearly 15 years at the James Martin Center for Nonproliferation Studies (CNS) of the Monterey Institute of International Studies, first as the founding director of the Chemical and Biological Weapons Nonproliferation Program and then as a senior fellow in the Washington office. Tucker is the author of *Scourge: The Once and Future Threat of Smallpox* (2001) and *War of Nerves: Chemical Warfare from World War I to Al-Qaeda* (2006). He is the editor of *Synthesizing Security: Reaping the Benefits of Emerging Biological and Chemical Technologies While Preventing Malicious Misuse,* forthcoming in 2012 from MIT Press.

GLOBALIZING BIOSECURITY

The Virtual Biosecurity Center (www.virtualbiosecuritycenter.org) (VBC) launched in March 2011 and is a global multi-organizational initiative spearheaded by FAS. The center counters the threat posed by the development or use of biological weapons and the responsible use of science and technology. The VBC is the "one stop shop" for biosecurity information, education, best practices, and collaboration.

NUCLEAR ENERGY: WHAT EVERYONE NEEDS TO KNOW

FAS President Charles D. Ferguson's new book on nuclear energy is now available from Oxford University Press. This is the only title currently available with an assessment of the nuclear accident at the Fukushima Dai-ichi Nuclear Power Plant in Japan. Ferguson provides an appraisal of the damage to Japan's nuclear reactors, an assessment of the implications for the global nuclear industry, and an in-depth discussion about the pros and cons of nuclear energy. The book is available on Amazon.com and wherever books are sold.

SUMMER ISSUE OF PIR

For Web exclusives, please visit:

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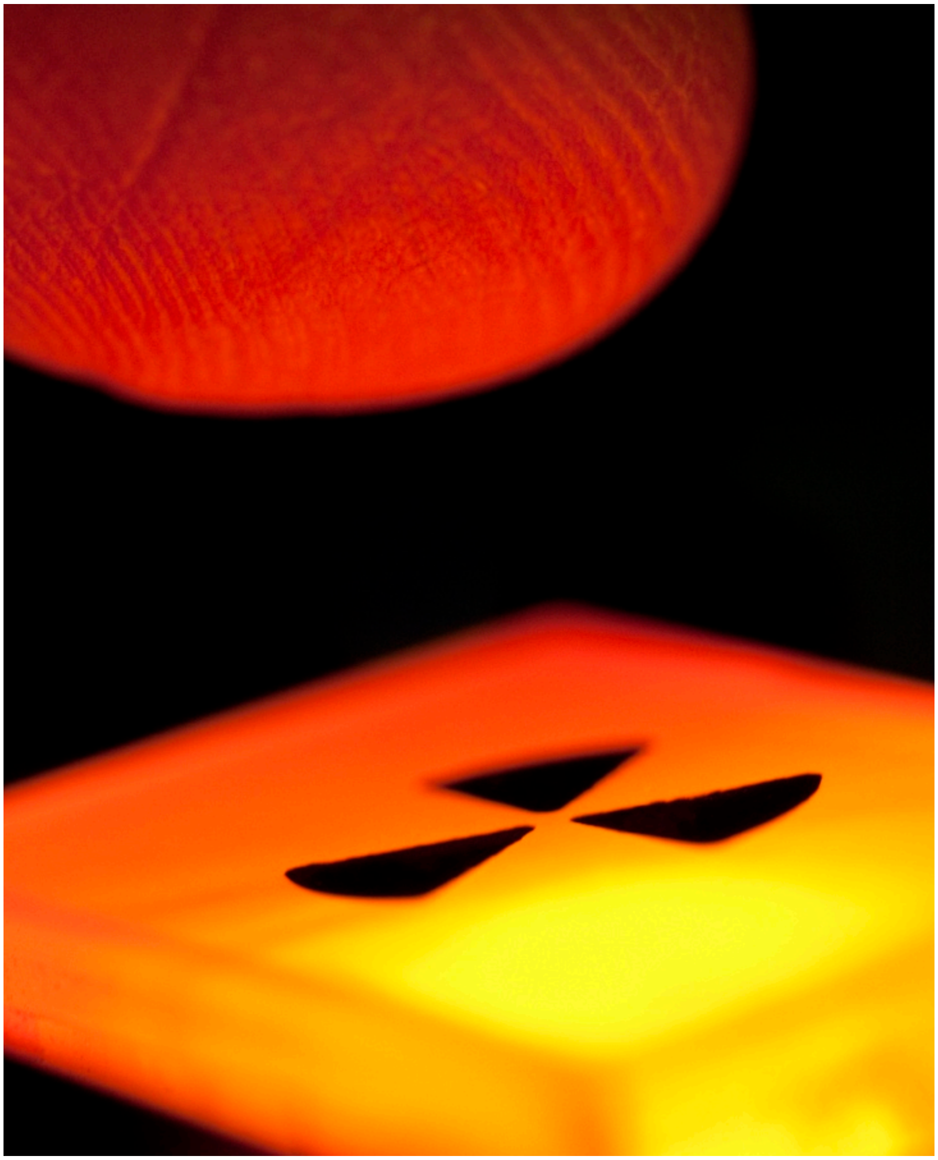
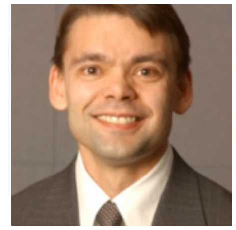
The next issue of the PIR will feature articles on:

- Renewable Energy
- Carbon Sequestration
- Electricity Generation
- Geothermal Energy
- Hydraulic Fracturing
- Natural Gas
- U.S. Energy Policy

The PIR welcomes letters to the editor. Letters should not exceed 300 words and may be edited for length and clarity. The deadline for the summer issue is June 30, 2011. To submit a letter, please email pir@fas.org or fax 202-675-1010.



Gilman Louie is the Chairman of the FAS Board of Directors. He is a leading expert on cyber issues and is leading FAS in an exciting new direction. He is a partner at Alsop Louie Partners, a venture capital fund focused on helping entrepreneurs start companies.



Charles D. Ferguson is President of the Federation of American Scientists. He is a physicist and nuclear engineer. Dr. Ferguson has written on energy policy, missile defense, nuclear arms control, nuclear energy, nuclear proliferation, and nuclear terrorism.

Devabhaktuni Srikrishna is an FAS Board Member and and will introduce a new effort called the "nuclear literacy project." He has written on nuclear detection, quantum computing, wireless mesh networks, and cyber security.

Charles P. Blair is the Director of the Terrorism Analysis Project at FAS. An expert in radiological and nuclear weapons, Blair's work focuses on reducing the risks of nuclear terrorism.

Yousaf Butt is a scientific consultant to FAS. Dr. Richard Garwin has referred to Dr. Butt as "an outstanding scientist." A dual national of the U.S. and Pakistan, he has a Ph.D. in nuclear astrophysics from Yale University.

The Federation of American Scientists is working to prevent the next Fukushima and Hiroshima. Les Dewitt, Martin Hellman, Sri Srikrishna, and Tom Tisch, the Event Host Committee, want the business community to add its voice to these important issues.

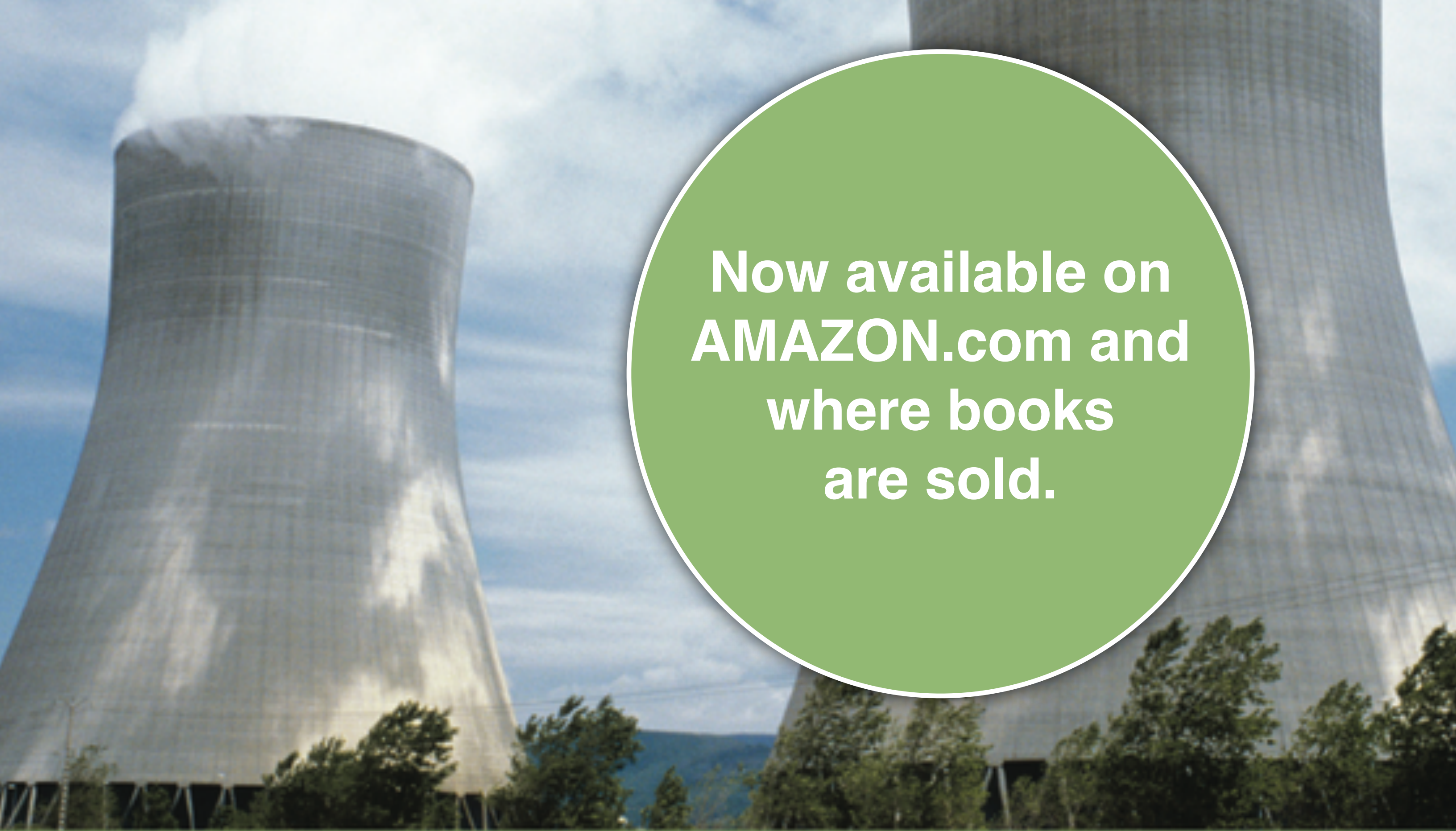
Be part of the conversation and the solution! We will do group brainstorming on the five following scenarios:

- How can sound science improve cyber security?
- The U.S. learns that three terrorists plan to detonate a dirty bomb in a major U.S. city. How should the U.S. neutralize the threat?
- A massive solar flare knocks out communications. What contingency plans should be in place?
- In 2020, the people of Yemen have no access to potable water. What can we do today to alleviate this problem?
- How do we educate and engage policy makers and the public about nuclear security and nuclear energy issues?

Through advice and investment, the business community must play a role to answer these science and security questions.

This event will focus on the next steps needed to create an online "one stop shop" for up-to-date information and analysis.

To learn more, please visit: www.FAS.org/press/events/menlo-circus-club.html.



NUCLEAR ENERGY

WHAT EVERYONE NEEDS TO KNOW

CHARLES D. FERGUSON