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PHYSICS & SOCIETY

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Editor's Comments

This issue contains articles, news, and reviews centered upon the secrecy, security and integrity aspects of the nation's scientific enterprise. All three are different elements of the same foundation pillar of science. Without personal and national security, no science can be done. Since good science often underlies national advantages conducive to security, it is occasionally vital to live with effective secrecy in order to enhance security. Without integrity,including truthfulness and transparency, there can be no science.

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IN THIS ISSUE

Note to Librarians and readers: *You will note two tables of contents in this issue: one for this issue - January 2003, one for the previous issue - October 2002 - which appeared only on the Web* (at www.aps.org/units/fps/oct02.html). *As previously announced to our readership, this journal will only be published in hard copy in the January and July issues; the April and October issues will only be Web-published. For the convenience of those non-subscribers who only see us in libraries, the web-issue tables of contents will also appear in the following hard-copy issues.*

IN THE JAN. 2003 ISSUE

IN THE OCTOBER 2002 ISSUE

Physics and Society is the quarterly of the Forum on Physics and Society, a division of the American Physical Society. It presents letters, commentary, book reviews and reviewed articles on the relations of physics and the physics community to government and society. It also carries news of the Forum and provides a medium for Forum members to exchange ideas. Opinions expressed are those of the authors alone and do not necessarily reflect the views of the APS or of the Forum. Contributed articles (up to 2500 words, technicalities are encouraged), letters (500 words), commentary (1000 words), reviews (1000 words) and brief news articles are welcome. Send them to the relevant editor by e-mail (preferred) or regular mail.

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EDITOR'S COMMENTS continued..

As long as human beings do science, there will always be erroneous "discoveries". The realization of the ever-present possibility of error lies at the foundation of the process of science. From this concern have evolved techniques to be carried out by the discovering scientist and his colleagues to minimize such possibility of error. *Fraud is a different matter*. Perhaps because of the growth of science as a livelihood rather than a "calling", perhaps because there are growing numbers of scientists competing for a relatively diminishing pool of open positions, perhaps because of the increasing awareness, by the public, of science and the glamour of discovery, perhaps because of the increasing number of awards and models for the successful "discoverer", the occurrence of scientific fraud seems to be more common today than in the past. And because more science is currently done – and reported - by large teams rather than individual researchers, one of the major techniques for preventing the dissemination of error- the independent, *unprejuidiced*, reviewer- has been subverted.

Under ideal circumstances, the reviewer, of a scientific article submitted to a professional journal for dissemination into the world of science, is completely independent of the article's author(s) and focuses exclusively on the article's substance, not on the identity of its creator(s). In that way, the novice would have as good a chance as the well-established scientist to get new ideas and results published.

In reality, of course, the established scientist often gets a pass. His/her name and reputation, known to the reviewer, usually eases any doubts that may arise in the latter's mind. And this reality is not that bad- after all, the established name has earned his/her reputation; has done the work, and stands behind it. Or has s/he?

If that "Distinguished Name"(DN) is on the paper just because the work was done in DN's lab –by some striving novice, the paper will get the same "pass" as if DN was actually responsible for the work. ("Responsibility" here does not necessarily imply conceiving and/or doing the work. It does imply being thoroughly familiar with all aspects of the work, all arguments leading to the conclusions, and the foundations upon which the validity of these arguments rest.) This "pass" seems to be what happened in the recent frauds at Bell Labs and at Lawrence Berkeley.

The two young perpetuators of these frauds were soon identified and fired.Warnings have been issued by APS panels (who describe these events merely as "misconduct"), that teams of coauthors should be more alert to the activities – honest or otherwise - of their colleagues. But the question remains: if it was so easy (as apparently it was) to identify, within the groups, the specific individuals who committed the fraud, why is it not equally as easy to limit the list of authors of the research in question to those who really count? It should be possible to find other ways to reward the lab directors, the creators of the hard- and software used, and others who aided the research but were not fundamentally involved.

The affect of fraudulent science negatively impacts all of us – scientists and citizens. We would welcome short comments and suggestions from all our readers about how to deal with this issue for our next letter page.

Continuing with my theme of scientific integrity and its relationship to the well-being of society, our readers should be aware of the recent announcement by the Administration, that the missile defense facilities in Alaska and California, which had been requested and procured as research and development (R&D) facilities, are now to be considered as actively functioning components of our national defense system. R&D and deployment, hitherto regarded as separate activities and concepts, each with their own requirements – often contradictory to each other - are now to be considered as one. Instead of "try before you buy" it will now be "buy before you try". It's hard for me to accept that procuring and relying upon a new, very complex, technological system before its parameters, behavior and efficacy are understood, is any different than publishing a paper claiming the discovery of a new element before any of the relevant data has been taken and understood.

Again, I welcome comments from our readers on the science – not the politics – of these developments in the field of defense against long-range ballistic missiles.

Turning to more pleasant matters, I am happy to announce that we again have a News Editor and thus, as seen in this issue, a News Section! Jeff Marque was our News Editor several years ago, but pulled out for family reasons. The News Section continued successfully for a number of years under the guidance of others, but has been absent since Marc Sher had to leave. Happily we welcome Jeff back: from Marque to Marc to Marque.

And I know that he would welcome news items from our readers!

CANDIDATE STATEMENTS

FOR CHAIR-ELECT

Allan Hoffman

Background: Dr. Hoffman is currently on detail from the U.S. Department of Energy, to serve as Senior Advisor to Winrock International's Clean Energy Group. His responsibilities include serving as advisor on a broad range of emerging energy technologies, with special responsibility for developing a water-energy program for Winrock, an organization focused on helping communities in developing countries achieve sustainable economic development. Earlier positions include Deputy Assistant Secretary for Utility Technologies/U.S. DOE, Executive Director, Committee on Science, Engineering & Public Policy/National Academy of Sciences, Director, Advanced Energy Systems Policy Division/U.S. DOE, and Assistant Professor of Physics/University of Massachusetts, Amherst. In 1974 he received an APS Congressional Fellowship and served until 1978 as Staff Scientist with the U.S. Senate Committee on Commerce, Science & Transportation. In this position he played a leading role in developing the Corporate Average Fuel Economy (CAFE) standards for passenger vehicles and in creating the White House Office of Science & Technology Policy (OSTP).

Statement: The Forum on Physics & Society, established in 1972 as the American Physical Society's first Forum, continues to serve a unique and critical role in the physics community. That role must be protected and enhanced. Many of today's critical public issues involve science and technology, and physicists at all levels of training have much to contribute to the understanding of these issues, and to the identification of options for addressing them. The Forum offers a vehicle for discussion within the physics community of these issues, and for effective outreach to other communities, including decision makers at all levels of government. It is also a focal point for physicists, student and otherwise, interested in pursuing careers at the science-public policy interface. As the APS moves into its 2d century, the role of scientists in both academic and non-academic pursuits will be critical to society's decision-making and progress. This first became clear during World War II, and today is exemplified in the large number of professional society Fellows serving on Congressional and Executive Branch staffs. The Forum must continue to stress and demonstrate the importance of this role, and help nurture a new generation of public service-oriented physicists. As Chair-Elect I would provide strong support for and guidance to these efforts.

Mark Sakitt

Background: Dr. Sakitt obtained a B.E.E. from the Polytechnic Institute of Brooklyn and a Ph.D. in Physics from the University of Maryland. He joined the Physics Department of the Brookhaven National Laboratory where he has worked on experimental high energy physics for 30 years. In 1990 he became Assistant Director for Policy and Planning at the lab and was responsible, at various times in strategic planning, technology programs, educational programs and technology transfer. He is currently the Director of a new program at the lab, the Center for International Security Studies, and he is also a Senior Scientist in the Physics Department where he continues to do research in high energy physics. Dr. Sakitt has worked on arms control problems, US Naval strategy and nonproliferation issues. He was a Carnegie Fellow at the Stanford's Center for International Security and Arms Control where he wrote a monograph on naval defense issues. He is a fellow of the APS, a member of the AAAS, the Arms Control Association and has served on the APS Panel on Public Affairs.

Statement: In the near future we will continue to face decreasing resources for research, decreasing prospects for younger scientists in their traditional fields and decreasing public appreciation for the benefits of basic and applied research, but *increasing* reliance on science and technology to address critical national problems, both for understanding and for eventual solutions. Within that challenging picture the American Physical Society's Forum can play a significant role by being involved in those issues for which it has the relevant expertise and resources. The standard for APS studies has been excellent and it must be maintained. The Forum should explore augmenting the effectiveness of those larger studies with smaller narrowly focused mini-studies that would not take the same level of funding. We should be considering other options that can reach out to the public and the people responsible for making key decisions affecting the well-being of science in our nation. The Forum can consider working with other parts of the American Physical Society, and also with other similar societies, to organize special symposia to focus attention on selected key issues. In general we need to generate additional inventive communication vehicles beyond the existing excellent major studies program.

FOR VICE CHAIR

Mark Goodman

Background: Dr. Goodman is a Physical Scientist in the Office of Multilateral Nuclear Affairs at the Department of State, working on nuclear nonproliferation at State and ACDA since 1995. He manages the State Department-funded program of research and development to support the International Atomic Energy Agency in implementing safeguards to verify that states are not diverting nuclear materials or misusing nuclear facilities to produce fissile material for nuclear weapons. He also supports negotiations and policy formulation on IAEA verification of excess fissile material in the U.S. and Russia under the Plutonium Management and Disposition Agreement, and on a prospective Fissile Material Cutoff Treaty. After receiving his Ph.D. in theoretical particle physics at Princeton University in 1986, Goodman held postdoctoral research positions at the Institute for Theoretical Physics at University of California-Santa Barbara and Rutgers University. His work at Harvard's Center for Science and International Affairs formed part of a 1991 book with recommendations on U.S. nuclear weapon policy after the Cold War. As an AIP Congressional Science Fellow in 1992-93, Goodman worked for Senator Kent Conrad (D-ND) on science, technology, energy, environment, and defense issues. He contributed to reports by the Office of Technology Assessment on civilian satellite remote sensing, and the reports of the Advisory Committee on Human Radiation Experiments.

Statement: The Forum on Physics and Society provides a mechanism for APS members to learn about, exchange views on, and otherwise engage in societal issues where physics plays an important role. Since coming to Washington I have also worked on nuclear arms control, energy and climate, international scientific cooperation, and public mistrust of science. Recent events and ongoing changes in U.S. policy have brought many of these issues back into the fore, but in a changed context that requires careful reexamination. I had the good fortune to work for two of the finest organizations that brought scientific and technical expertise to bear on public policy issues – the Arms Control and Disarmament Agency (which was merged into the Department of State) and the Office of Technology Assessment (which was eliminated). The unfortunate demise of these institutions has made it harder for decision makers in the Executive and Legislative Branches to obtain balanced technical advice on many important issues. One of the key challenges facing the scientific community in general, and one I hope to address as Vice Chair of the Forum, is how to strengthen the institutional mechanisms for interaction between scientists and government.

Tina Kaarsberg

Background: Dr. Kaarsberg is a Professional Staff member (Majority) for U.S. House of Representatives Committee on Science, in the Subcommittee on Energy. She was previously at the U.S. Department of Energy, where she led the Power Technologies Analysis Collaborative for the Office of Energy Efficiency and Renewable Energy. Prior to joining DOE, Dr. Kaarsberg was the Northeast-Midwest Institute's senior scientist. She also worked for Sandia National Laboratories' Strategic Technologies group. In 1992, she was an APS Congressional Science Fellow in the office of Senator Pete Domenici (R-NM). In 1990, Dr. Kaarsberg moved from a UCLA physics department faculty position to the APS Washington Office to staff the Panel on Public Affairs and the newly-formed Physics Planning Committee. She received a Bachelor of Arts degree with distinction in physics from Yale University and master's and doctoral degrees in physics from the State University of New York at Stony Brook. She is active in both the APS and the AAAS and has served on numerous public policy committees in both organizations, including helping to create an endowment for the Leo Szilard Award.

Statement: The events of the past few years have strengthened my longtime belief that physicists could be key players in addressing many of the security, economic and environmental problems now facing society. The Forum on Physics and Society has a long and distinguished record of catalyzing physicist involvement in issues ranging from nuclear weapons policy to global climate change. More recently, the FPS also has partnered with other APS Fora on issues of workforce (with the Forum on Education) and economic development (with the Forum on Industrial and Applied Physics). Starting as a graduate student, going to November 11th committee meetings at Cornell, and especially since 1990, I have worked in many of these areas. I believe I have the experience (or can recruit others who have the experience) to guide FPS efforts on a wide range of societal challenges. For example, in my current position working for Congress, I am especially well positioned to encourage increased communication between physicists and policymakers. In the past year I have worked on the role of science and technology in homeland security and in energy and climate policy. Specifically, as Vice chair, I would try to (a) expand the readership of the Forum newsletter; (b) increase the number of Forum-sponsored or co-sponsored sessions at APS meetings; (c) involve our distinguished past and current prize winners in these and other activities.

For Executive Committee:

Kai-Henrik Barth

Background: Dr. Barth is currently a Visiting Assistant Professor in the Security Studies Program at Georgetown University's School of Foreign Service, where he teaches classes on science, technology, and security. His research focuses on the role of scientists in international affairs, in particular in arms control negotiations. He studied physics at the University of Hamburg, Germany, and worked in the ZEUS detector group at DESY. In the early 1990s he moved to the United States to pursue a PhD in history of science and technology at the University of Minnesota with a dissertation on nuclear test ban negotiations and seismic detection of underground nuclear explosions. In 1999 he interned at the National Academy's Committee on International Security and Arms Control and was an analyst for the Congressional Research Service. While an NSF Postdoctoral Fellow at Georgetown University's program in Science, Technology, and International Affairs, he began a book manuscript entitled "Experts in International Affairs: Scientists and the Making of the Comprehensive Test Ban Treaty."

Statement: The Forum on Physics and Society fulfills important functions for the physics community, since it connects the professionals with larger societal concerns and reflects our social responsibility. Physicists contribute to many of today's most significant debates, ranging from security and energy to environmental issues. Most prominently, physicists will continue to play a role in nonproliferation efforts, missile defense debates, and in the critical evaluation of energy scenarios. I propose to bring my enthusiasm and background as a physicist, historian of science and technology, and security analyst to the Forum's activities and to use my multidisciplinary background to reach out to groups beyond the scientific community. As a long-time APS member I have always enjoyed the Forum on Physics and Society, in particular the Forum's newsletter. It deserves a broader distribution. I volunteer to seek opportunities to transform the newsletter into a full-fledged journal for physicists and other scientists as well as interested policy analysts, policymakers, historians of physics, and political scientists.

Barry Berman

Background: Dr. Berman is the Columbian Professor of the Natural and Mathematical Sciences, Department of Physics, The George Washington University, Washington, DC, 1985-. Experimental Physics Division, Lawrence Livermore National Laboratory, 1963-86. Visiting scientist at Yale, Toronto, Frankfurt, S‹o Paulo, Melbourne, Saclay, MIT, LBNL, LANL, Jefferson Lab. Harvard BA '57; Illinois MS '59, PhD '63. Consultant to Los Alamos and Sandia National Labs, book and media publishers, industrial companies, U.S. Departments of Energy, Defense, and State, World Bank, foreign governments. Berman's principal field is experimental nuclear physics of photonuclear reactions, few-body nuclei, meson and baryon photoproduction, electron and pion scattering, relativistic heavy ions, neutron physics, nuclear fission, nuclear astrophysics. In addition, he works on applied physics of channeling and other coherent radiation, crystal properties, microlithography, medical imaging, radiation damage to DNA, cancer therapy, substance identification, explosives detection, and lunar geology.

Statement: I would like to see the Forum on Physics and Society continue its role as a clearing house for opinions that are based on real science on issues affecting society at large and as a promoter of in-depth scientific studies of such issues. Current important subjects that come to mind are nuclear energy, global warming, missile defense, air and water pollution, and most important of all right now, detection and control of weapons of mass destruction. I also would like to see the Forum continue and expand its campaign against pseudoscience and other such irrational and/or anti-intellectual pursuits, whether in the form of astrology, alternative medicine, space aliens, parapsychology, or most insidious, creationism.

Charles Ferguson

Background: Dr. Ferguson is the Scientist-in-Residence based in the (CNS), Monterey Institute of International Studies. For the last several months, he has been the scientific director of a CNS study assessing all major aspects of nuclear and radiological terrorism. Previously, he worked on nuclear reactor safety issues in the Bureau of Nonproliferation, U.S. Department of State. Prior to that, as a Senior Research Analyst and Director of the Nuclear Policy Project at the Federation of American Scientists, he analyzed nuclear arms control and global security issues. He did postdoctoral work in nonlinear dynamics and statistical mechanics at the University of Maryland. He has also researched computational fluid dynamics problems at the Los Alamos National Laboratory. After achieving a B.S. degree with distinction in physics from the United States Naval Academy in 1987, he graduated from the Naval Nuclear Power School and the Submarine Officers School and served as an officer on a fleet ballistic missile submarine. Upon leaving the U.S. Navy, he earned an M.A. in 1994 and a Ph.D. in 1996 in physics from Boston University.

Statement: Leo Szilard lamented that during World War II scientists were "on tap, but not on top." Today, society more than ever needs physicists who are both on tap and on top as researchers working to solve society's problems and as leaders shaping public policy. As a member of the Executive Committee, I would encourage more physicists to apply their analytic skills to public policy. One of physicists' most valuable strengths is the ability to analyze complex dynamic problems. These are precisely the problems that frequently arise in public policy. Two critical examples, among many, are global warming and nuclear nonproliferation. Because many political leaders do not fully understand the feedback mechanisms and unintended consequences inherent to public policy decisions, the physics community should lead in exploring and explaining these dynamics by providing informed technical advice to policymakers at the beginning of the decision process. Therefore, I would support FPS sessions on examining how to further develop system dynamics skills in the framework of public policy. In a related area, as someone who has applied innovate teaching techniques to the classroom, I am deeply interested in encouraging physicists to become better science educators. I believe that physicists should broaden their educational activities beyond the classroom. To this end, I would support FPS sessions on how to effectively educate political leaders and the public.

Susan Ginsberg

Background: Dr. Ginsberg is currently finishing up her Senior Science Policy Fellowship in the Office of Public Affairs at the American Physical Society. While at APS, Ginsberg has focused on science education issues and increasing basic science research funding at the National Science Foundation, the Department of Energy's Office of Science and the Department of Defense. Before her Fellowship at APS, she was a AAAS Congressional Science Fellow in the office of Congressman Howard Berman (CA-26th), where she acted as minority counsel for the House Judiciary Subcommittee on Courts, the Internet and Intellectual Property. She received a BA in geology from Amherst College (1994), a MS from the University of Minnesota in geophysics (1997) and a PhD from the University of Minnesota in materials sciences (2000).

Statement: The Forum on Physics and Society has long established itself as a group that produces excellent discussions and presentations at APS meetings as well as a first-rate newsletter. The vast technical backgrounds along with the wide-varying interests of FPS members – as well as their connection with the APS Panel on Public Affairs – have made the Forum stand out within the American Physical Society. I believe that the Forum on Physics and Society can and should continue to look beyond their meeting sessions, both inside and outside APS. Inside the Society, the Forum on Physics and Society should coordinate with other policy committees that are forming, notably the DPF Government Liaison Subcommittee and the APS Task Force on Countering Terrorism. I believe that bringing together representatives from these various groups at FPS sessions, through newsletter exchanges and even special meetings can ensure that APS has a full-dimensional view of science policy issues. Having spent the last year working with the leadership of DPF and serving as the liaison to the Task Force on Countering Terrorism, I would be able to assist the FPS in establishing these relationships. Outside of the APS, I would like to see FPS take a more active role in Washington, D.C. The APS Office of Public Affairs (OPA) focuses on facilitating communication between physicists, the public, and government on scientific issues of concern to APS members and to the nation as a whole. The Forum is perfectly situated to help the OPA adopt a more proactive approach by offering well-conceived and concrete suggestions for influencing critical policy decisions in Washington and working with the other APS divisions and fora. As a natural liaison between FPS and OPA, I believe that I can facilitate this strengthened relationship.

ARTICLES

Russian Early-Warning System and Danger of Inadvertent Launch

Pavel Podvig

The status of the Russian early-warning system has always attracted considerable attention, especially after the end of the cold war, which brought into focus the dangers of accidental or inadvertent launch that could result from a human or technical error. Since consequences of an error of this kind would be truly catastrophic, it is understandable that the reports about the problems that Russia has been having in its attempts to operate the strategic forces in a safe manner are among the causes of serious concern.

The Soviet Union was one of the two countries (the other being the United States) that developed and deployed a system that would allow it to detect a missile attack before missiles hit their targets. According to the logic of the cold war, this effort was necessary to achieve the launch-on-warning capability which is the ability to promptly launch missiles to escape an attack. This, it was argued, was a way to strengthen deterrence, for it made a first nuclear strike virtually ineffective. Although this may have been true, the price for strengthening deterrence was rather high, since a launch-on-warning posture required keeping missiles on constant hair-trigger alert, ready to be launched on a moment notice.

Since the end of the cold war, neither Russia nor the United States has officially excluded launch-on-warning from their set of options. It is known that both countries have technical capability to launch their missiles within minutes. This certainly raises concerns about the status of all systems that could be involved in a decision to launch on warning.

Since an early-warning system is the key component of the launch-on-warning mechanism, reports about deterioration of the Russian early warning system, which have been appearing in recent years, quite naturally raise questions about dangers of inadvertent missile launch that may result from it. In this article I present a short overview of the Russian early warning network and argue that although the Russian early-warning system is in serious decline, it poses no serious threat of an inadvertent launch (although, certainly, no problem even remotely linked to nuclear forces is too small to discount).

The Soviet Union began its work on early-warning in the early 1960s. This work, however, was not in any way connected to attempts to acquire launch-on-warning capability. Rather, the first early-warning radars were supposed to support operations of the Moscow missile defense system, which was under development at that time. Besides, the Soviet Union did not have strategic forces that would allow it to implement a launch-on-warning posture until well into the 1970s.

The decision to begin development of an integrated early-warning system came only after 1972. The plan, presented at that time, called for deployment of a two-layered network that would consist of satellites and over-the-horizon radars that would detect U.S. missiles shortly after launch and above-the-horizon radars deployed around the territory of the country that would see ballistic missiles and warheads as they approach their targets. The work on all components of the proposed system began shortly afterwards and had been largely completed by the end of the decade.

It may seem that the large-scale effort to deploy an early-warning system, initiated by the Soviet Union in the 1970s, indicated that the military had made their choice in favor of launch-on-warning as the primary option in Soviet strategic posture. This view has been further reinforced by the fact that the Soviet Union in the 1970s invested a disproportionately large effort into deployment of land-based missiles with multiple warheads. These missiles were very vulnerable to an attack and it was therefore universally assumed that they would be used either in a first strike or in a launch-on-warning scenario. When in the late 1970s–early 1980s the Soviet Union completed deployment of its early warning system, almost all observers in the West concluded that launch-on-warning was one of the main, or even the primary, option in the Soviet arsenal of war scenarios.

This notion has persisted to the current day and it is fairly widely believed that the Russian strategic forces are kept on hair-trigger alert, ready to be launched within minutes from a signal from the early-warning system if it indicates that an attack against Russia is underway. It is therefore perfectly understandable that the status of the Russian early-warning system causes serious concerns, for a malfunction of this system, such as a false alarm, might have catastrophic consequences. The fact that the Russian early-warning system has seriously deteriorated since the Soviet times, only adds to these concerns.

In reality, the situation is not as serious as it may seem. Although the Russian early-warning system is indeed only a shadow of its former self, it is highly unlikely that its decline has increased probability of inadvertent launch of Russian strategic forces. The reason for that is that, contrary to the outward appearance, the Soviet Union never considered launch-on-warning as its primary war option. Besides, the Soviet early-warning system was never intended to provide genuine launch-on-warning capability.

The first Soviet early-warning system, developed in accordance with the 1972 plan and put in place by the and of the 1970s, consisted of two layers. The first one was formed by the radar network. Hen House-class radars were deployed at six sites around the periphery of the Soviet Union—in Olenegorsk (Kola Peninsula, Russia), Skrunda (Latvia), Mukachevo (Ukraine), Sevastopol (Ukraine), Balkhash (Kazakhstan), and Mishelevka (near Irkutsk, Russia). These radars were complemented by radars of the Moscow missile defense system. The second early-warning layer was provided by satellites of the US-KS system (also known as Oko), deployed on highly-elliptical orbits (known as Molniya orbits). Another proposed component of the early-warning system—a set of over-the-horizon radars that were supposed to detect launches from the U.S. territory, failed to materialize because of technical difficulties.

Although the Soviet Union had spent considerable effort building that system, it did not provide coverage necessary for launch-on-warning, since both its layers had significant gaps. The radar network did not cover approaches from north and north-west. The constellation of early-warning satellites was designed to detect launches of land-based missiles from the U.S. territory, but could not see launches of sea-based missiles from submarine patrol areas.

The limited capabilities of the early-warning system reflected the role that it played in operations of the strategic forces. The primary mission of the system was to detect a *massive* missile attack against the Soviet Union, which had to involve land-based missiles and could not have avoided detection by at least some of the radars. The system, therefore, could not deal with a small-scale attack or an isolated launch. This capability, however, was not considered necessary, for the Soviet military were apparently confident that the forces that would remain after a small-scale attack would be sufficient for retaliation and, therefore, for deterrence.

Another important feature of the Soviet military doctrine, which also contributed to the limited role of early-warning, was the concept of "period of tensions", that was believed to precede any use of nuclear forces. The Soviet military firmly believed that in a case of a crisis they would have enough time—from hours to days—to raise the alert level of the strategic forces and ensure their survivability. This did (and still does) contradict the approach taken by the United States, which relies on highly survivable basing of its strategic forces and sees launch-on-warning as the only way to ensure survivability of its land-based missile forces. It is therefore no surprise that the Soviet strategic posture was very difficult to interpret and it may have appeared rather threatening.

Although the role of the early-warning system was limited, the Soviet Union constantly worked on expanding its capabilities. This was done by the introduction of new-generation radars and satellites to replace the ones deployed before the beginning of the 1980s, as well as by improving coverage and detection capabilities of the system. As part of this plan, the Soviet Union initiated a program of development of new-generation large-phased array radars, known as Daryal in Russia and Pechora-class in the West. The program called for construction of seven new radars of this type at sites at Pechora (Komi region, Russia), Gabala (Azerbaijan), Balkhash (Kazakhstan), Skrunda (Latvia), Mishelevka (near Irkutsk, Russia), Mukachevo (Ukraine), and Krasnoyarsk (Russia).

The program, however, did not go beyond construction of the first two radars in Pechora and Gabala, which were completed in 1985. Construction of a radar in Krasnoyarsk had to be stopped because of the U.S. protests about violation of the ABM Treaty. Construction at other sites was interrupted by the breakup of the Soviet Union in 1991. Radars in Mukachevo, Balkhash, and Mishelevka were left unfinished. The radar building in Skrunda was demolished shortly after Latvia took control over the site in 1994.

As a result, for early-warning coverage Russia still has to rely on the outdated Hen House radars, which were built in the 1970s and will soon reach the end of their operational lives. Another serious problem for the radar network emerged in 1998, after closure of the base in Skrunda, in Latvia, which hosted one of the Hen House radars. The closure opened a gap in radar coverage, which can not be closed by any of the existing radars.

If Russia would ever want to complete construction of the early-warning radar network, it will have to replace the aging Hen House radars and complete construction of Pechora radars in Mishelevka and Balkhash. In addition, Russia will have to find way to close the gap in radar coverage that was supposed to be filled by the Krasnoyarsk radar. A program of this kind would be prohibitively expensive and it is difficult to imagine the circumstances that would justify it. It is therefore safe to assume that Russia will never have a radar network that would provide it with early warning of an incoming missile attack.

The situation with the space-based early-warning system is hardly better. The constellation of early-warning satellites that the Soviet Union deployed in the late 1970s–early 1980s is in decline and Russia has not demonstrated the ability to keep it fully operational. As in the case of the radar network, the evolutionary upgrade of the system, which was supposed to improve its capabilities, was interrupted by the breakup of the Soviet Union.

As was noted above, the original constellation of early-warning satellites included satellites on highly-elliptical orbits (HEO). Later, the system was augmented by a satellite placed on geostationary orbit. When the constellation is complete, the system is capable of providing 24-hour coverage of launch sites on the U.S. territory. This requires as many as nine HEO satellites and one GEO satellite, although the system could provide some coverage with as few as four HEO satellite or with one or two HEO satellites augmented by a geostationary one.

The detectors of these satellites detect missiles against the background of space, so the coverage provided by the system is limited to the U.S. territory. To extend it, the system was supposed to be replaced by a new one, which would rely on satellites that can detect ballistic missiles against the Earth background and therefore could provide almost global coverage. In order to achieve that, satellites would be placed at points on geostationary orbits. The new system was supposed to be brought into operation in the early 1990s, but its development was delayed by the breakup of the Soviet Union and it still seems to be undergoing testing and has not reached operational status yet.

Russia had managed to keep the early-warning satellite systems in operation until 1996, maintaining the number of satellites in orbit at the level of eight or nine satellites. After that the system began to deteriorate and by the beginning of 2001 the constellation consisted of just four HEO satellites.

In May 2001 the whole system was damaged almost beyond repair when a fire at the control center near Moscow destroyed cables and other ground equipment. As a result of the fire, the control center lost communication with all four satellites that were operational at that time. Three of these satellites were eventually lost, and only one was brought back into operation in September 2001. This means that for almost four months of summer 2001 Russia had no space-based early-warning at all.

After the May 2001 fire, the Russian military space forces undertook efforts to restore the constellation. A new geostationary satellite was launched in August 2001 and a new HEO satellite in April 2002. The HEO satellite, however, failed to reach the operational orbit, so, as of the time of this writing (December 2002), Russia has only two operational early-warning satellites—Cosmos-2368 on highly-elliptical orbit and Cosmos-2379 on geostationary orbit.

The quality of the coverage provided by these two satellites is probably not very high as they cannot guarantee sufficiently high probability of detection all 24 hours a day. The future of the constellation is also very uncertain. Although the Russian military are very optimistic about the prospects for deployment of the new system, it is extremely unlikely that Russia could find the necessary resources.

As we can see, the Russian early-warning network is indeed in a serious decline and cannot provide the Russian strategic forces with the support necessary to exercise the launch-on-warning option. In fact, there is virtually no chance that the system will ever recover to be of any use for launch-on-warning. What is important to note is that the system has been constantly losing its capabilities for quite some time now and the Russian military are very well aware of this fact. Given that the Soviet and Russian military have never relied on the early warning system to begin with, it should not have been difficult for them to adjust operations of the strategic forces to completely exclude the deteriorating system from the decision-making process. Further degradation of the early-warning system will only diminish its role and is very unlikely to increase the danger of inadvertent launch.

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Risk-Based Security at the National Labs: A Report of The Commission on Science and Security

Anne Witkowsky

Tension between science and security is not new, and it is not new at the Department of Energy laboratories. But, the turbulence that these laboratories experienced over the last several years, in the wake of the Wen Ho Lee investigation and the missing disk drives have put at risk the vitality of some of the nation's most valuable assets.

With the high-profile allegations and security violations at Los Alamos as a backdrop, Energy Secretary Bill Richardson chartered the Commission on Science and Security in October 2000 to assess the challenges facing DOE and the newly created National Nuclear Security Administration (NNSA) inside the DOE. Its charge was to examine how to maintain excellence in the conduct of science in the national laboratories while protecting and enhancing national security. The commission was asked to examine all DOE national laboratories (not just the three large nuclear weapons labs where classified work is most concentrated) in order to address the Department's broad range of classified and unclassified activities and information. That was because many of the newer security and counterintelligence measures deeply affected unclassified work and open science laboratories. The commission was comprised of 19 distinguished members from the scientific, defense, intelligence, law enforcement and academic communities. John Hamre, President and CEO of the Center for Strategic and International Studies (CSIS), chaired the commission and CSIS provided support to the Commission. In May 2002, the commission presented a final report to Secretary Abraham, who had re-chartered the commission after he took office.

The commission found that the context for its work was an environment where over the past two decades, the conduct of science and the security landscape have changed considerably. Some problems are long-standing in the structure and culture of the Department. At their core, they reflect the difficulties that the Department has had in making the transition from a world in which our national security laboratories were fairly insulated from the outside to one in which they have — and need – much greater scientific interaction with other laboratories, institutions and industry. The nature of open science, in turn, has become much more international, collaborative, and networked. And these interactions are taking place in an environment in which the threats to our security have become more complex, multifaceted, and sophisticated, as our nation grapples with the war on terrorism and preventing weapons of mass destruction from falling into the wrong hands. Accordingly, providing for both excellence in science and security requires increased vigilance and threat awareness on the part of the national laboratories, within a risk-based security system that will allow open, unclassified scientific interaction to flourish.

The commission felt that the controversies following the Wen Ho Lee investigation and the investigation of the missing hard drives exacerbated many of the Department's existing problems. Well-intentioned, but poorly engineered, security procedures imposed in the wake of the security scandals were found to be undermining an atmosphere of creativity and innovation. This legacy deeply affects the open science community at the laboratories and ultimately will undercut not only DOE's science programs, but also our national security.

Summary of Analysis

The commission concluded that new approaches to improve security and counterintelligence must be developed, in a way that is complementary to the practice of science in the laboratories. Its report provides recommendations in five key areas that, if implemented, will provide a long-term strategy to help the Department of

Energy meet its science and security goals. The commission's overarching finding was that the DOE's current policies and practices risk undermining its security and compromising its science and technology programs. In support of this finding, the commission identified five fundamental problems:

First, the commission found that the Department's continuing management dysfunction impairs its ability to carry out its science and security missions. Even the best security policies and sound processes for their development will not be effective if strong leadership and effective management are lacking. Many well-intentioned reform efforts, piled on top of a structure that traces back to the early days of the Manhattan Project, have created an organization with muddy lines of authority. The relationship between the Washington and regional offices of the Department, and the contractor-owned laboratories, create a complicated layered structure in which assigning accountability is difficult. Multiple constituencies mean that internal Department battles consume an inordinate amount of time and can be fought over and over repeatedly. As a consequence, the development and management of security policy lack clarity, consistency, and broad strategic planning.

Second, collaboration between the science community and security and counterintelligence elements has been badly damaged. The commission found no one from the scientific community who thought it was unimportant to protect national security information. Neither did it find anyone from the security community who felt laboratory scientists did not need to interact with outside peers. The commission did find widely differing views on what constitutes a significant risk to national security and how best to minimize those risks. There are deeply held differences dividing the communities over what requires protection, how much protection is needed, and by what means that protection should be provided.

Third, the commission found that DOE does not have an effective system for risk-based security management that encompasses the entire DOE complex. The Department lacks an approach for assessing risks to its assets that takes into account the entire DOE system. Thus, it does not have a means of comprehensively determining priorities for the protection of those assets. DOE also lacks a budget process that could support security decisions based on establishing risk and priorities. Therefore, spending on security overall is missing an underlying rationale, and cannot take into account the opportunity costs to science of implementing security measures. Additionally, the Department does not have the needed counterintelligence analytical capabilities to support and shape risk-based security management.

Fourth, the Department's investments in new tools and technologies for its security and counterintelligence programs are woefully inadequate. In the last few years, security and counterintelligence have received significant funding increases, but the commission found that virtually no resources were being devoted to develop systems that move beyond the Department's labor-intensive, paper-based security system. This lack of automation and integration creates missed opportunities to significantly improve the monitoring of processes, facilities, and databases, and bogs down management and scientists under unnecessary administrative burdens.

Finally, the commission found that cyber security lacks sufficient priority in the Department. Management of DOE networks needs significant improvement. More than any other area, cyber security demands strong, smoothly functioning processes to ensure that the laboratories can protect themselves against cyber threats in a manner that is risk-based.

Summary of Recommendations

To make the necessary changes, the commission argued that the Department must establish a security and counterintelligence program that is sustainable for the long term—one that is risk-based and tailored to the missions and activities of the laboratories. Its report suggests five overarching sets of recommendations, summarized below.

1. Clarify Lines of Responsibility and Authority. First, if reforms in security and counterintelligence programs are to succeed, the Secretary and the Administrator of the National Nuclear Security Administration (NNSA) must address basic organizational problems at DOE, most significantly confusion over "line" and "staff" responsibilities. The commission recommends clarification of the chain of command between the Secretary and the laboratory directors; most important, that responsibility for security, like safety, or any other operational matter, must rest with line management. Together with a more clearly defined chain of command, DOE needs to reduce excess layers of management and staff that have built up within since the late 1980's. To support a more disciplined decision-making process on all matters, including security, the commission recommends that the Department install a rigorous multiyear budget process, modelled on the Planning, Programming, Budgeting, and System (PPBS) at the Department of Defense (DOD). Related to this point, the commission said that the idea of a separate security budget, administered by someone other than the laboratory director as the line manager, is a flawed concept, and recommended that line managers control the resources required to execute their missions.

2. Integrate Science and Security. DOE leadership must ensure that science and security at DOE is an integrated enterprise – collaborative and complementary. First, the commission underscored the importance of ensuring that laboratory directors have full responsibility and authority for science and security, and of holding them strictly accountable. The laboratory director must be chief scientist and chief security officer. Scientists and engineers throughout each laboratory must be invested in carrying out their missions securely, but this will only happen if laboratory directors themselves take a strong leadership role. Contracts, directives, and other guidance to the laboratories must reflect this philosophy; they must be performance-based so that laboratory directors have the capacity to implement them in a manner that is consistent with the work at their sites. At the same time, DOE oversight must be rigorous and DOE leadership must demand – and reward - accountability. To improve collaboration, the commission also recommended the creation of a high-level, Department-wide laboratory security council for the development of security policies. Its representation should include security, counterintelligence, the field offices, laboratory personnel, and others for whom security policy decisions will have a significant effect. The commission further recommended that laboratory directors establish comparable groups to integrate security decision-making and implementation at the site level. Together with these integration improvements, the commission said that DOE leadership must restore a climate of trust within the Department, between managers at all levels, and between managers and employees.

3. Develop and Practice Risk-Based Security. Third, the Department must develop and practice risk-based security management. Risk-based security management is based on the premise that sensitive activities are not uniformly distributed throughout an organization and that assets representing a higher risk to national security require greater protection. A risk-based system should provide for the ability to make decisions about the marginal value (in an economist's definition, i.e., additional) of increasing investments in a given aspect of security, and the tradeoffs between security alternatives, as well as the tradeoffs between security and the science (programmatic) mission. The commission underscored that a modern security system must find a way to balance resources, which are limited, and risk, which can never be eliminated.

Specifically, the commission recommended the establishment of a risk-based systems approach to the development, analysis, and implementation of security policies throughout the DOE complex. A key to the success of this approach will be clear guidance for the laboratories about the Department's priorities for protecting its assets. That guidance can only be developed with the participation of national security, intelligence, and law enforcement agencies outside DOE. It also will require a greatly improved threat assessment process. The commission recommended that risk-based management plans be developed annually across security functions at each site. Specifically, in parallel with the fiscal budget, the Secretary and the NNSA Administrator should issue a single DOE-wide integrated safeguards and security plan that reflects the comprehensive plans agreed between the sites and federal managers.

To support this risk-based model, the commission found that the Department needs to strengthen, refocus and revalidate its counterintelligence program. It is crucial that DOE leadership expand the Department's counterintelligence analytical capabilities in order to conduct pattern analysis, monitor trends, and provide the threat assessments that are necessary for a security system that is properly oriented around risk. The commission recommended that the program broaden its cooperation and information access across agency boundaries, and, as discussed under "New Tools and Techniques," below, invest in new technologies. The counterintelligence program should assist in shaping security measures, but leave the responsibility for decisions regarding security to line management; its primary function should be collection, investigation, and analysis. In this respect, the commission recommended that the counterintelligence program strengthen cooperation with the scientific community for information collection purposes; DOE leadership must ensure that counterintelligence officers have access to available information at all laboratories, including the unclassified, open science laboratories. At the same time, the commission recommended removing unproductive security burdens associated with collecting that information, specifically on unclassified foreign scientific collaboration.

The commission also made specific recommendations for clarification or amendment to a number of specific security policies. For example, the commission recommended amending the practices for controlling the confusing area of so-called sensitive unclassified information. The current lack of management discipline around this type of information both hinders the scientific enterprise and reduces the ability of security professionals to control this information where necessary. In the commission's view, if information requires protection, it must be classified or protected by proper administrative controls that are based in statute and have clear definitions for use.

4. Adopt New Tools and Techniques. Fourth, the commission recommended that DOE augment its capabilities for security and counterintelligence with significant investment in new tools and techniques. Specifically, DOE must develop and invest in state-of-the-art technologies for personnel authentication, access control to cyber systems and facilities, and data fusion and analysis techniques. The Department should invest in biometric and other systems that would help make authentication and access control processes more robust and less intrusive. By employing new technologies, DOE could strengthen positive identification of employees and visitors and significantly reduce cumbersome physical and cyber access requirements. In parallel, the commission recommended that DOE invest in databases, information systems, and analytical tools to perform data cross-correlation, data mining, and analysis for security and counterintelligence purposes. Such tools are badly needed in order to strengthen the analytical capacity of the counterintelligence program.

5. Strengthen Cyber Security. Finally, the commission recommended that DOE devote priority attention to strengthening cyber security; it is both the strength and the Achilles heel of the scientific enterprise. Other parts of the commission's report contain recommendations that would improve cyber security, but the commission also made several additional recommendations that are specific to cyber security. First, the role of the Chief Information Officer (CIO) in DOE and NNSA should be strengthened by ensuring that he/she has responsibility for cyber security, so that development of cyber security policies are integrated with information technology systems policy. The commission also recommended that DOE establish a cyber security advisory panel that utilizes the knowledge and experience of outside experts, to bring cutting edge solutions to the DOE cyber enterprise. Finally, the commission underscored that DOE must place a higher priority on timely implementation of cyber security solutions that are already developed, and do more to evaluate emerging technologies being developed by other agencies and the private sector.

Conclusion

When the Department released the commission's report in June 2002, it said that it had implemented, or was in the process of implementing, many of the commission's recommendations, in part as a result of dialogue with the commission as work was underway. It is still early, however, to be able measure any results. The commission has offered its services to assist in any follow-up that the Secretary may request in these implementation efforts. As the commission noted in its report, DOE is at a critical crossroads. The future strength of the national laboratories is imperiled. The commission hopes that the DOE leadership recognizes its options: The Department can continue to muddle through with security and counterintelligence procedures that are out of date and undermine the health of the national laboratories. Or it can seize the opportunity to lead the way in the federal government with development of a modern, risk based security model.

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Nuclear Power, Nuclear Proliferation, and Global Warming[1]

H.A. Feiveson

Introduction

I address here the nuclear weapons proliferation risks that will be posed by a robust expansion of civilian nuclear power worldwide. By robust, I will take as a benchmark, a global nuclear capacity of 3000 gigawatts-electric (GW) – an eight-fold increase from today's worldwide capacity of 350 GW.

An increase of at least this magnitude will be necessary for nuclear power to make a dent in global warming. For example, under the central business-as-usual projection of the Intergovernmental Program on Climate Change (IPCC), if nuclear power grew to 3000 GW in 2075 (50% of world electricity then projected), and then 6500 GW in 2100 (75% of world electricity), the total carbon emissions avoided cumulatively would be approximately 290 billion tons through 2100 – only about one-fourth the projected cumulative carbon emissions to 2100 projected by the IPCC.

The management of a nuclear system of 3000 GW would be truly challenging. If based on a once-through fuel cycle using light water reactors, such a system would generate roughly 600 tons of plutonium annually, and would require on the order of one-half million tons of natural uranium annually. If based on liquid-metal plutonium breeder reactors, it would involve the fabrication into fresh fuel annually of over four thousand tons of plutonium (though the cumulative inventory of plutonium would be much less than for a system based on light water reactors). Is a nuclear future of such magnitude thinkable?

The proliferation risks I have in mind are two-fold:

·That countries or terrorist groups could divert fissile materials directly from the civilian nuclear fuel cycle into nuclear explosives;

·That countries aspiring to obtain nuclear weapons could use civilian nuclear facilities (power reactors, research reactors, reprocessing plants, uranium-enrichment plants, etc.) and trained cadres of nuclear scientists, engineers, and technicians as a cover and/or training ground for the dedicated acquisition of fissile material for nuclear weapons.

A third sort of risk — that terrorists could use civilian spent fuel or high level wastes for a so-called "dirty" bomb or radiological weapon, or could release substantial amounts of radioactivity through attacks on reactors, spent fuel pools, dry-store casks, transportation casks, or the like – raises a different class of questions and I do not consider these here.

So let's consider how a nuclear system of 3000 GW would look, and the specific proliferation risks it would pose.

Implications of a Robust Future for Nuclear Power

What countries will have nuclear power?

Nuclear power today is overwhelmingly located in a relatively few industrialized democracies, a few countries in Eastern Europe, Ukraine, Lithuania, and Russia. Of the 350 GW installed capacity worldwide, less than 10 GW are in developing countries. This includes 2.3 GW in India, 2.1 GW in China, 0.9 GW in North Korea, 0.4 GW in Pakistan, and 2.7 GW in South America. For the most part, the countries with nuclear power programs are either already nuclear weapon states or countries which for whatever reason do not aspire to become nuclear weapon states.

An exuberant nuclear future will present a different picture. It is widely recognized that the scene of significant nuclear growth over the next half century will have to be largely in the developing countries. This is where by far the greatest increase in electricity production is projected. The table below shows the top 25 countries by population projected for 2050 by the U.N. I then arbitrarily assumed a 1 kW per capita (1 kW/c) electricity capacity for each country shown, and equally arbitrarily assumed a nuclear penetration of 33 percent. In an article last year in Physics Today, Ernie Moniz and Melanie Kenderline note that the knee of a curve plotting the U.N. human welfare index against per-capita electricity consumption is at about 4000 kWh/y.[2] This would correspond to a 1 kW capacity at slightly less than a 50 percent capacity factor.

This list includes several countries which today have essentially no or a negligible amount of nuclear power: Indonesia, Nigeria, Pakistan, Bangladesh, Ethiopia, Congo, Philippines, Vietnam Egypt, Iran, Saudi Arabia, Tanzania, Turkey, Sudan, Uganda, Yemen, and Thailand. No doubt, several of these countries (and

Rank Order World Population in 2050

Country	Population (millions)	GW at 1 kW/c	GW nuclear at 33%
India	1620	1620	540
China	1470	1470	490
United States	403	403	134
Indonesia	337	337	112
Nigeria	303	303	101
Pakistan	267	267	89
Brazil	206	206	68
Bangladesh	205	205	68
Ethiopia	187	187	62
Congo	181	181	60
Philippines	153	153	51
Mexico	153	153	51
Vietnam	119	119	40
Russia	118	118	40
Egypt	113	113	37
Japan	101	101	37
Iran	100	100	33
Saudi Arabia	91	91	30
Tanzania	88	88	29
Turkey	86	86	29
Sudan	84	84	28
Uganda	84	84	28
Germany	79	79	26
Yemen	71	71	23
Thailand	70	70	23

many others down the list) will, in the event, not actually develop nuclear power on a large scale. And, of course, it is a real question how these countries will obtain the capital and technical expertise required. But let's not kid ourselves. If, as we are positing here, nuclear power comes to play a substantial role in the world energy economy, it will have to be located in many of these countries – and on a substantial scale. After all, in the illustration shown, nuclear represents just one-third of electricity posited, and electricity overall is likely to be no more than about one-third of total energy consumption. Thus, even in this exuberant extrapolation, nuclear represents a relatively small fraction of total energy – on a lesser scale, it would make little dent in the greenhouse problem.

This immediately provokes several concerns.

States of Concern. Today, Iran and, in a somewhat different category, North Korea, raise special problems. These countries are parties to the NPT, and in the case of Iran at least have accepted full IAEA safeguards. But both countries are suspected of harboring nuclear weapon programs (in the case of North Korea admitted) and raise vexing issues for the international community. As the table above suggests, in the future, there are likely to be several countries whose nonproliferation credentials will be suspect, and some of these may be tied to terrorists. Because of this, there will be temptation for the international community to indulge in a two-class system of nuclear power, with certain technologies and fuel cycles denied to one class of countries, while permitted in "safe" countries. It seems unlikely that such a system could be maintained over decades.

Latent Proliferation. Whereas today it is fair simply to demand that civilian nuclear power remain a less attractive route to acquisition of weapons-usable material than a dedicated route, that is not the way to think about a robust nuclear future. For in this case, we are talking about scores of countries which do not today have any substantial nuclear power program at all obtaining both nuclear facilities and the infrastructure in technology and expertise under the guise of a civilian purpose that would eventually allow a dedicated weapons program. Today, we have to be realistic in admitting that in many countries the nuclear technology genie is well out of the bottle; but this does not in itself justify letting genies everywhere out of the bottle.

There would be a large expansion of safeguards. If safeguards' efforts are calibrated roughly by the number of facilities in non-nuclear-weapon states, the nuclear future envisioned would involve a many-fold increase in numbers of inspections and in the inspection budget as compared to today.

What happens today if a state withdraws from the NPT? While its NPT International Atomic Energy Safeguards (IAEA) agreement would then also expire, in many – in fact, in most – cases other obligations would remain in place from pre-existing safeguards agreements that were suspended when the NPT came into force, or from back-up safeguards demanded by nuclear suppliers at the time of the export. The legal situation is somewhat murky and has to be examined country by country; but it appears that facilities and materials produced indigenously might not carry back-up safeguards obligations. This could be troubling in a robust nuclear future where over time one imagines an increasing number of countries will be able to develop nuclear power independently of outside suppliers.

Pressures for reprocessing and recycling of plutonium

Nuclear power today is operated predominantly on once-through fuel cycles in which the fuel for the reactors is either natural uranium or low-enriched uranium which cannot be used for weapons, and the spent fuel discharged from the reactors is not reprocessed – that is, where the plutonium contained in the spent fuel is not separated from the highly-radioactive fission products. Thus, the once-through fuel cycles are reasonably proliferation resistant. A country could, of course, seek to enrich low-enriched uranium fuel to weapons levels (from 4-5% U-235 to over 90% U-235), or alternatively to build a quick and dirty reprocessing plant to recover plutonium. But in general safeguards should be adequate to discover such activities so that any attempt at diversion could not be done clandestinely. Still more important, such enrichment or reprocessing appears out of reach for sub-national groups.

However, even today not all nuclear power is operated on once-through fuel cycles, the UK, France, Russia, and to a lesser degree Japan are reprocessing spent fuel. Large commercial plants in the UK and France are reprocessing both their own spent fuel and spent fuel from other countries, notably Japan and Germany. At present, about one third of the spent fuel discharged from reactors each year worldwide is being reprocessed. The plutonium separation is currently roughly 20-24 tons per year, though this may decrease some during the next few years. Most of the plutonium that has been separated remains stored at the reprocessing plants.

Some of the separated plutonium is being fabricated into mixed-oxide fuel (MOX) at four plants in Europe. In 2000, these plants produced somewhat less than 200 tons of MOX, incorporating 10-12 tons of plutonium, with the MOX production capacity expected roughly to double in the next few years. The MOX is being burned in approximately 32 light water reactors (LWRs) in France, Germany, Belgium, and Switzerland. Another 18 have been licensed to use MOX. Japan is planning to use MOX in one-third of its reactors by 2010. In almost all these cases, MOX is being used or is planned on being used in one-third of cores.

The proliferation risks of reprocessing and recycling are clear. First of all, the reprocessing has generated a tremendous quantity of separated plutonium which has to be very carefully accounted for and guarded. Much of the separated plutonium – in the form of plutonium oxide – is in France and the UK, and reasonably secure one believes. But a large quantity is in Russia under less certain security, and there are appreciable quantities in Japan. Second, the use of MOX in reactors means that there will be supplies of fresh plutonium fuel at MOX fabrication plants, at reactor sites, and in transport from reprocessing plants to fabrication plants to reactors.

For a time, many in the nuclear industry maintained the belief (or unexamined hope) that the plutonium being separated and recycled could not be used for nuclear weapons. They believed this because the plutonium recovered from civilian spent fuel – so-called "reactor-grade plutonium" — has a relatively high fraction of the isotope Pu-240, around 25% for plutonium from LWR spent fuel, compared to less than 6% for weapons-grade plutonium. Pu-240 fissions spontaneously, emitting large amounts of neutrons, leading to the possibility that one of the neutrons could initiate a chain reaction before the bomb assembly reaches its maximum super critical state and thus creating a fizzle yield. Indeed, the prospect of such pre-detonation rules out the use of gun-type designs employing even weapon-grade plutonium. Unfortunately, it is now clear that reactor grade plutonium can be used for weapons. The issue was addressed in a 1994 in a National Academy of Sciences study and later described in a January 1997 U.S. Department of Energy Release[3]:

"virtually any combination of plutonium isotopes … can be used to make a nuclear weapon. … In short, reactor-grade plutonium is weapons-usable, whether by unsophisticated proliferators or by advanced nuclear weapon states. Theft of separated plutonium, whether weapons-grade or reactor-grade, would pose a grave security risk."

So, in short, reprocessing and recycling already present risks. However, with the recycling activities so far restricted to Europe, the standards of security and safeguards applied to the MOX are probably high. But this cannot be counted on in a vastly expanded nuclear industry worldwide. Whatever the risks today, they will be multiplied if ever a real market develops for MOX, with middlemen and agents arranging for the purchase and sale of MOX.

And in the robust future envisioned, there will be marked pressures on countries to reprocess and recycle. First of all, the uranium demand for nuclear power relying mostly on a once-through fuel cycle will be enormous. It will be on the order of 600,000 tons of natural uranium per year. Even if eventually hundreds of millions of tons of uranium could be obtained from so far unexplored terrestrial sources and/or from seawater, there will exist strong incentives for countries to use uranium resources more efficiently.

Perhaps even more significant will be the pressure put on spent fuel disposal. If repositories are limited by heat output at time of the closure of the repositories, reprocessing could increase effective repository space by a factor of 3 or so if only plutonium and uranium are separated, and ten-fold or more if the separation includes Americium and the lesser actinides. It seems unwise to base our fuel cycle choices on repository availability given the high costs of reprocessing and transmutation that would be involved – and especially so if the difficulties of finding repositories is due more to politics than science. But concerns with spent fuel disposal will certainly give strong support to those who wish to reprocess and recycle, and in fact are already doing so.

No plutonium recycling–continued reliance on once–through fuel cycles

Let us say, nevertheless, that the world can keep to once through fuel cycles. How proliferation resistant would such a world be?

For sake of specificity, let's assume a 3000 GW nuclear capacity comprised half by pebble-bed high temperature gas reactors of the kind now under study in the U.S. and South Africa, each of 100 MW, and half by light water reactors (LWRs), each of 1 GW. In such a world there would be 15,000 pebble-bed reactors and 1500 LWRs, and an enrichment capacity worldwide of about 400 million SWUs per year. If one takes 2 million SWUs per year as a nominal capacity of one enrichment plant – about the size of a URENCO plant – 200 such plants would be required. A 2-million SWU plant could make about 600 bombs per year starting with natural uranium. It could make 3500 bombs per year starting with 8% uranium, the fuel enrichment of the gas-reactor fuel.

Although arguably enrichment plants could be highly centralized with capacities much greater that 2-million SWU, the wish of countries to diversify and not to put too many eggs in one basket will place some limits on centralization. And in any case, a nuclear system based on a once-through fuel cycle will involve massive flows of natural and low-enriched uranium, lots of separation plants, and lots of incentive for innovation to make isotope separation cheaper and quicker. This is especially of concern in that terrorist groups could far more readily make a nuclear weapon from highly enriched uranium than from separated plutonium.

But plutonium will also be a matter of concern in this ostensibly once-through nuclear world. Consider the scope of the spent fuel (and contained plutonium) that will be generated in such a once-through world. The spent fuel would be on the order of 50,000-70,000 tons of heavy metal per year, approximately the capacity that has been planned for Yucca Mountain (70,000 tons). So nominally we can imagine one "Yucca Mountain" being constructed every year worldwide. And each one will have to be guarded indefinitely, since after several decades, the radioactivity surrounding the plutonium will decay substantially making the spent fuel repositories prospective "plutonium mines."[4] Each repository (using the Yucca Mountain scale) would contain some 1400 tons of plutonium-239.

Proliferation Resistance of New Generation Reactors and Fuel Cycles

Advanced nuclear technologies and fuel cycles under study could in principle improve the proliferation resistance of nuclear power, but whether they could do so to the extent necessary under an exuberant nuclear future must be doubted.

The concepts being examined by nuclear engineers and scientists in the U.S. and abroad include: reactor-types and/or new fuels which allow very high burn-up and produce less plutonium than do current reactors (such as, for example, the pebble-bed high temperature gas-cooled reactor); breeder or particle-accelerator driven reactors that, to the extent possible, co-locate sensitive processes (such as reprocessing) with the reactor, and do not separate the plutonium from other actinides; and schemes that restrict nuclear power to large, international energy parks that would then export to individual countries, electricity, hydrogen, or small, sealed reactors. The reactors envisioned in this last scheme would be say 40 or 50 MW and would be fueled at some central nuclear park and then sealed and sent out to client countries. The reactors would have lifetime cores, not requiring re-fueling, and at the end of the core life (say 15-20 years) would be sent back to the central facility unopened. Let's call this a hub-spoke configuration.

All these ventures are worthy of study. However, so far none of the concepts appears altogether satisfactory. The high-burn-up reactors require higher enriched fuels than light water reactors, and as indicated above, if deployed on a grand scale, would lead to vast flows of uranium and a great expansion of enrichment activities. And it is also questionable that such reactors maintained in a once-through mode could sustain a nuclear capacity of 3000 GW. The breeder and closed fuel cycle concepts generally imagine a world where the breeder reactors are restricted to "safe" countries while off limits to much of the developing world. As noted earlier, I am skeptical that such a two-tier nuclear world can long be sustained.

The third concept of large, centralized international parks appears to me the most attractive of the new proliferation resistant ideas being examined. But are international energy parks realistic alternatives on political and economic grounds? Politically, international energy parks run against the strong wish of many countries to become energy independent. Countries will also be wary of concentrating too much of their energy future in a few places, with their attendant risks of common-mode failures, disruption of transmission lines or shipping, etc.

Conclusion

All in all, it may be that nuclear power can limp along for years, maybe decades, at roughly current levels and with almost all nuclear power located in a relatively small number of highly industrialized countries, with tolerable proliferation resistance. And this possibility would be further enhanced if new-generation reactors can be deployed in the next twenty years or so. Certainly, in the margin, a few more or a few less reactors in the nuclear weapon states, in Japan, and in Europe would hardly seem to matter at all. But, in this case, we have to ask the question whether such a limited nuclear future is really worth all the attendant aggravations and real (albeit contained) risks. If not, perhaps the time has come for many countries to begin plotting a determined phase out of nuclear power!

In my view, the risks associated with a robust nuclear future are essentially irreducible even if some of the so-called "proliferation-resistant" concepts now being explored by the international community are implemented. The concept under study that holds the most promise is the development of a hub-spoke arrangement where all sensitive activities are performed at a central, perhaps international, facility with sealed nuclear reactors, electricity, or hydrogen then sent out from the central facility to the "client" states. But such a strategy faces enormous political and practical obstacles. And all the more so does the extreme of this strategy – to place all nuclear power under international control. A nuclear power system worldwide of a scope to address global warming will pose unacceptable risks of nuclear proliferation without a drastic lessening of national control either over nuclear energy or over nuclear weapons.

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(Footnotes)

[1] This paper is based on a longer paper presented at the University of Michigan Workshop on the Future of Nuclear Energy, October 2-4, 2002; and on "The Search for Proliferation-Resistant Nuclear Power," Public Interest Report Federation of American Scientists, September/October 2001.

[2] Ernest Moniz and Melanie Kenderline, "Meeting Energy Challenges: Technology and Policy," Physics Today, April 2002. The current average worldwide per capita electricity consumption is about 2300 kwh/y. The idea of using population projections to 2050 was suggested to me by Moniz, private communication.

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Sniffer Plane Secrets and Political Courage

Alan J. Scott

In the book *Voodoo Science*[1] Robert Parks describes the "Sniffer Plane" incident by the French government in 1976. This government spent $200 million for a secret instrument claimed to be able to spot mineral and oil reserves from the air by measuring a new particle. French president Valery Giscard d'Estaing ordered tight secrecy on the program to keep the technological advantage. Officials didn't even get close to the device because of dangerous radiation warnings that were issued.

Getting suspicious, the French had a prominent physicist examine the device. It was found to be an elaborate hoax that was able to survive 3 years under the cloak of secrecy and national security. After the government had determined it was a fake, they shut the operation down but kept its existence secret because of political embarrassment. In 1981 a new government took over and stumbled across the cover-up.

This story exemplifies the process I shall dub *Sniffer Plane Secrecy*. *It applies when governments keep things secret, not necessarily for national security, but for political expediency and to prevent public scrutiny.*

National Missile Defense as Sniffer Plane Genre

The United States is not immune to this type of secrecy and the instances of it appear to be rising. There are numerous multi-billion dollar programs that the United States is undertaking that have a striking resemblance to the *Sniffer Plane*. Consider George W. Bush's plan to build a national missile defense shield (NMD). The missile defense program has spent 70.7 billion dollars from 1984 to 1994 without any deployable system or technological advancement.[2] Billions of dollars are being spent each year for the program. Many missile interceptor tests have required a homing beacon to be placed into the target missile and - even with this beacon - many of the tests fail to intercept the target.[3]

The Union of Concerned Scientists clearly state that the program is "unworkable" and "counterproductive."[4] The Defense Department has recently moved to restrict access to information about future tests and costs.[5] Thereby removing it from public scrutiny and turning it into a *Sniffer Plane Secret*.

Ted Postol, physicist and MIT Professor – formerly a U.S. Navy scientist, has been so bold as to declare the NMD a "fraud" and that a cover-up was happening.[6,7] In the past, Postol declared the Patriot Missiles almost a complete failure when the Pentagon was declaring them 90% effective. It has been determined the Patriot's were a lot less effective than the Pentagon indicated.

Aurora as Sniffer Plane

Another such secret is the Aurora plane. It is (maybe) a classified plane that the U.S. government will neither confirm or deny exists. The secrecy is almost laughable since a model airplane company has sold kits for its construction.[8] Carl Sagan discusses this plane in his book *The Demon Haunted World*.[9]

The plane is estimated to have a speed of greater than Mach 4 and can fly at an altitude of 200,000 ft (38 miles). It is a successor to the SR-71 Blackbird spy plane. The Federation of American Scientist (FAS) web pages at <http://www.fas.org/irp/mystery/aurora.htm> estimate the plane's development cost to be between 4.4 and 8 billion dollars. Building 24 Aurora planes is expected to cost about 10 and 24 billion dollars. *An intelligent debate about the costs verses benefits is stifled under the cloak of secrecy.* With spy satellites and the notion that any capable U.S. foe has probably developed effective counter-measures to the plane, it is hard to fathom why it is kept secret other than to protect a giant boondoggle.

Political Sniffer Planes

In 1997 a congressional commission[10] reported *"Excessive secrecy has significant consequences for the national interest when, as a result, policymakers are not fully informed, government is not held accountable for its actions, and the public cannot engage in informed debate… The classification system, for example, is used too often to deny the public an understanding of the policymaking process, rather than for the necessary protection of intelligence activities and other highly sensitive matters*." President George W. Bush issued an executive order[11] in November, 2001, to limit the disclosure of presidential records just as information about President Reagan and Vice President George H.W. Bush was to be made public. It is easy to see how conspiracy and cover-up theories flourish in this age of secrecy.

President Nixon argued not to release Whitehouse tapes because it wouldn't be in the *national interest*. These tapes revealed crimes against our nation perpetrated by the president. They also revealed the potential truth about conspiracies. Shortly after Arthur Bremer tried to assassinate George Wallace in 1972, Nixon decided to concoct a scheme to blame the event on supporters of Democrats George McGovern and Edward Kennedy. The tapes revealed Nixon saying "*Just say he (the shooter) was a supporter of McGovern and Kennedy…Now, just put that out!…Just say you have it on unmistakable evidence*."[12] One can only imagine what crime was recorded on the erased sections of the Nixon tapes. More recently and a bit less egregious, we have President Bill Clinton attempting to circumnavigate justice by declaring he did not have a sexual relationship with Monica Lewinsky.

The U.S. has a wide variety of "Intelligence" agencies. Two of the most prominent are the National Security Agency and the Central Intelligence Agency. Their budgets are not disclosed but the total intelligence budget is estimated at about $27 billion dollars annually.[13] Cost effectiveness of these agencies is as much a mystery as their activities. Much of what is known about these agencies comes from books published in the popular media. These include *Body of Secrets* by James Bamford,[14] *Veil: The Secret Wars of the CIA* by Bob Woodward,[15] *and The U.S. Intelligence Community* by Jeffrey Richelson.[16] These agencies do have some merit but, as indicated in these books, many abuses have occurred under the cloak of secrecy for national interest.

Sniffer Plane Secrets as an Affront to Science and Society

Secrecy does have a role for protecting the national interest. For example, the security plan for protecting Vice President Cheney on his visit to the 2002 Winter Olympics should be kept secret. (Such plans were accidentally left in a souvenir shop by a secret service agent.[17]) But secrecy can tear apart the very fabric of society and science. The U.S. government has withdrawn[18] over 6,000 documents from shelves and web pages pertaining to or even remotely connected to germ and chemical weapons. Ronald M. Atlas, the president-elect of the American Society of Microbiology, was quoted as saying "(it) *takes apart the whole foundation of science...I think it undermines science*." In the wake of September 11, the Pentagon tried to establish the Office of Strategic Influence. Its purpose was to influence public sentiment in foreign countries by providing news items – possibly false news items or propaganda![19] About two weeks after the office was established, the Bush Administration closed the office due to public criticism. This leads one to ask how many other governments around the world have such an office which is kept secret and out of the reach of public scrutiny. Truth and openness is vital for healthy governance and strong science.[20] As Mark Twain has stated "Truth is the most valuable thing we have, let us economize it."

Solutions to Sniffer Plane Secrecies

The world needs an antidote to cynicism the consequence of *Sniffer Plane Secrets*. Producing workable solutions is formidable. The most important solution is to encourage our political leaders to be honest and open. Our nation needs to recognize and reward such courage. The recent book *Profiles in Courage for Our Time*[21] edited and introduced by Carolyn Kennedy, acknowledges those that have labored admirably in the political arena. One essay in this book is about Russell Feingold and John McCain for their courageous efforts to reform campaign financing. It chronicles the strategic maneuvering by special interest to keep their hold on American politics and stifle the McCain-Feingold reform effort. A total of 160 million dollars were given to political campaigns in 2001 to advance the agendas of special interests.[22] The biggest special interests include Securities and Investments, Telecommunications, Labor, Insurance, Lawyers, and Pharmaceuticals.[23] The people of the United States can be proud of McCain and Feingold for their principled determination on this issue!

There exists another surprising way in which to rout out *Sniffer Plane Secrets*. When government officials see classified documents that are blatant abuses of power, it can be argued that exposing the abuses by leaking the information to the press is a patriotic act. Robert Parks (which brings us back to the author of Voodoo Science) discusses this issue by stating "…but conscientious government employees who are willing to risk their careers by leaking classified documents may be the only check on government excesses carried out behind the screen of national security."[24]

As our nation rallies to fight terrorism, it is important to recognize the acts of bravery and sacrifice of soldiers on the battlefield. It is also important to recognize acts of courage from our political leaders because it is these acts that make our nation and its institutions worthy of wartime sacrifices.

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COMMENTARY
The Physics of Religion

John T. A. Ely

Physicists have a duty to clarify for society extremely urgent issues (i.e., those having great peril) in which we have both unique understanding and a freedom to speak out without penalty. As an example, this essay concerns religion as a principal cause of wars and the population pressures that have driven them for circa a millennium since the Crusades. The essay presents a straightforward (and, I believe, irrefutable) logical argument that world peace cannot occur until all major powers have separated Church and State. It might reasonably be interpreted to imply that the US (whose leaders appear to have been illadvised) should set an example in this matter by joining other nations who have already separated Church and State.

Prelude. Today, in all branches of Physics, scholars are in basic agreement on its laws worldwide, regardless of their nationalities. Thus, there is only one Physics! It has been created by, and is a description of, Nature. Most true scientists do not try to assign human intelligence to some supreme being as the creator of the universe. However, long before any Physics was known, such ideas arose naturally from our human fears and ignorance, giving rise to many religions that have persisted since the earliest recorded times.

Science and religion. Age-old questions are still asked regarding comparisons between science and religion. In essence, science is questioning (i.e., open-minded to change), but religion is assertive (i.e., dogmatic and intolerant of questions). Those who make assertions regarding the existence or nature of a divine being or creator (i.e., "God") are dogmatists. They, like many of us, fail to grasp even the fundamental principle that the intensity of one's convictions is no criterion of their validity. Since there has never been a recantation, they risk being considered ideological descendants of those who executed "witches" at Salem or ran the Spanish Inquisition, sometimes burning 100 people a day in a carnival atmosphere

Different religions. In the past few millennia as human cultures developed widely separated on the sparsely populated earth, virtually all of them developed distinctive beliefs. The differences were usually of minor or no logical consequence (such as the name assigned to the creator who had often been conceived in man's image). As the populations grew, contacts also multiplied at their boundaries. The perceived differences in religions produced hatred and wars. These sectarian conflicts have been possibly the largest cause of death, destruction, wasted effort and obstacles to progress in human history since the Crusades. True separation of Church and State would prevent the religious differences from causing conflicts between governments.

Physics and religion. Although its acceptance will be slowed by dogmatists (religionists) themselves, the solution is simple: each human must be educated to realize that the entire universe and its laws are the laws of Nature. Thus, if scientifically uneducated persons derive comfort, sense of security, moral strength, etc. from the belief that the universe has a creator that can be deified and wish to become closer to that creator (i.e., "God"), such people should be required to study the laws of Nature in the K-12 curricula of all countries. The laws of Nature are the "Laws of Physics". Therefore, the soul-searcher should study the physical laws at least enough to realize that these are absolutely the same for everyone (since there is only one Physics). Then, there can at most be only one creator (i.e., one "God"), and at most one religion that is exactly the same for everyone! Thus, there are only imagined differences in religion. In the past, most people searching for basic truth may have been intellectually capable of this reasoning but failed for lack of scientific knowledge. Before the 20th Century, enough Physics was not known to assert the uniqueness of this fundamental canon.

In summary. Thus, the long tragic litany of human slaughter in wars was forced on the world by mistakenly perceived differences in religions. This can be ended by separation of Church and State in the US, as in other countries (i.e., UK, Germany, etc.). This is a necessary, although of course not a sufficient condition, to end wars via population control, freedom of choice, etc., that have been opposed by religionists in the US throughout its history.

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NEWS

Earl Callen, our first Chair

As good friends of Earl Callen, the first chair of the Forum on Physics and Society, we mourn his recent passing. The Forum was born in the tumultuous 1960's and 70's. The issues of that era—the Vietnam War, the debate over the Anti-Ballistic Missile system, the energy crisis, the start of the environmental movement, the civil/human rights revolution—impelled that generation of physicists to consider their professional responsibilities. Many felt that the APS should have a division or forum in which appropriate science and society issues would be debated by informed participants before the APS membership.

Every group needs a George Washington as its founder, and Earl Callen was ours. Although his particular interest was the international human rights of scientists, the major emphases of Callen's term were building membership, developing a reputation within the APS membership for quality and objectivity, and establishing an effective working relationship with the APS Council. In its early days, the APS leadership looked upon the Forum with suspicion, fearing that the Forum would move issues too far and too fast. But, they were never embarrassed by the new group. An example of Callen's leadership is what he did when Robert March proposed an amendment to the APS Constitution. The amendment would have required the APS to "shun activities which contributed harmfully to the welfare of mankind." It was very difficult to obtain a speaker against the March amendment at an April 1972 FPS session. The first Forum Chair, Earl Callen, stepped forward and filled that role (in which he believed), which helped to defeat the March amendment.

But most of all, we cherish our personal memories of Earl. In the old days we used to meet at an Indian restaurant near the Shoreham Hotel in Washington. In those days, Leo Szilard's wife Trude used to attend to help present the Szilard Award. We can still remember the lively banter led by Earl. We miss him very much.

Expressions of sympathy in his memory can be made to the Dr. Earl Robert Callen Scholarship Fund, c/o The Physics Dept., The American University, 4400 Massachusetts NW, Washington, DC 20016.

David Hafemeister, 1985-86 Chair
Martin Perl, 1973-74 Chair

Good News for NSF; According to the AIP's FYI #128, authored by Richard M. Jones, there is very good news for the National Science Foundation. In mid-November 2002, Congress passed the bill H.R. 4664 which will lead to a doubling of funding for the NSF by the year 2007. President Bush is expected to sign the bill.

The idea of doubling funding for NSF has been in the works for at least five years. According to Jones' article, some of the representatives who played key roles during these years in bringing this vision to reality included Senator Phil Gramm (TX), Senator Bill Frist (TN), Representative Sherwood Boehlert (NY),Senator Christopher Bond (MO), Senator Barbara Mikulski (MD), Representative Eddie Bernice Johnson (TX), Representative Nick Smith (MI), and Senator Ted Kennedy (MA).

This event occurs in the context of the Bush Administration's original proposal to grow the NIH budget at a much higher rate than that of the NSF. In response, the American Physical Society led organized letter writing campaigns to both the Congress and the White House expressing the need for a more balanced approach to science funding. Senator Mikulski is quoted as having once said, "I remain fully committed to the doubling of the budget for NSF over the next five years, but without the support of the administration, the authorizing committees, and the Budget Committees, the appropriators cannot do it alone." Perhaps we can now add "support of APS scientists" to list of ingredients that were needed for success in this venture.

Bad News for Physics-Research Misconduct: In the Search and Discovery section of the November 2002 issue of Physics Today, Barbara Goss Levi gives many of the details surrounding a case of scientific misconduct which, earlier this year, shook Bell Labs at Lucent Technologies. The case involved some spectacular claims regarding the coaxing of organic materials into acting as superconductors, lasers, single-molecule transistors, and more. In her article, Levi even enumerates prior issues of Physics Today(5/00, 9/00, 1/01, 10/01) in which these spectacular claims were described and discussed.

Whistles starting blowing when physicists inside and outside of Bell Labs noticed that several figures, published in different papers, were suspiciously similar to each other. Levi showed an example of substitution of data, in which one experimental curve on a plot was numerically identical to another curve over a large domain except for a scaling factor.

This case follows on the heels of another sensational case of misconduct, related to claims of heavy element creation by a group at Lawrence Berkeley Laboratories. In both cases, the charge of deliberate fraud was made against a single investigator within a group. And both cases have raised the issue of collective responsibility within a group of authors for the content of publications. As Levi quoted a committee established to investigate the Bell Labs case, there are "no widely accepted standards of behavior [regarding co-authors' responsibilities]", and the committee called on the community to establish some.

Bad News About Science Students - they are missing: After a decade of decreasing enrollments by American students in undergraduate and graduate programs in science and engineering (S&E), a summit was organized in November 2002 by over 40 scientific and engineering societies, think tanks, and governmental agencies to discuss the health and training of the S&E workforce in the United States. Many of those who attended did so out of concern for the continuing contraction of American citizens' enrollments in S&E training programs and for the continued dependence of the American economy on foreign S&E workers. The meeting was reported by Audrey T. Leath in FYI #135 of the American Institute of Physics. This article is derived from Ms. Leath's FYI.

Almost two decades after "A Nation at Risk" was published, more than a decade after former President Bush declared that students in American public schools would be #1 in the world in math and science achievement by the year 2000, and several years after America's disappointing showing in TIMS (Third International Math & Science Test) , the summit last month seemed to agree that K-12 science, technology, engineering, and math (STEM) education must be improved. In addition the summit, sponsored by the National Academies' Government-University-Industry Research Roundtable, focused its attention on conditions within S&E careers. "Those who are concerned about whether the production of U.S. scientists and engineers is sufficient for national needs must pay serious attention to whether careers in science and engineering are attractive relative to other career opportunities available to U.S. students." was the warning from one of the participants at the summit.

Representatives from federal agencies described difficulties in finding qualified S&E workers, and one participant estimated that more than half of federal S&E workers might retire during the next decade, thus exacerbating the shortage of qualified manpower.

Other subjects discussed at the summit included the need for more data related to S&E labor in the U.S., the need for more precise and consistent definitions of S&E shortages, improvement of training for STEM teachers, making S&E undergraduate programs more attractive, and increasing the participation of women and minorities in S&E careers.

Readers interested in learning more about the summit can go to http://www7.nationalacademies.org/guirr PanOrganizational_Summit.html

Bad News at Los Alamos: As part of a series of events that might augur the end of University of California's management of the Los Alamos National Laboratory, Keay Davidson reported in the January 3, 2003 issue of the San Francisco Chronicle that "The future of the University of California's management of the nation's first nuclear weapons lab may be in jeopardy after the resignation of its top administrator amid scandal." Davidson was referring to the resignation of John Browne after a frank discussion between Browne and UC President Richard Atkinson during the latter part of December 2002.

Browne's resignation, on December 23, 2002, followed several months of controversy regarding, among other things, the loss of over 250 laboratory computers since 1999 as well as other lab property valued at a total of about $2.7 million. The losses were reported by Steven Doran and Glenn Walp, two investigators hired by Los Alamos and subsequently fired after they accused the lab of a cover-up surrounding the equipment losses. Secretary of Energy Spencer Abraham wrote a letter on December 24, 2002 to Atkinson in which the firings were described as part of "systemic management failure" at Los Alamos. The letter also warned that "these problems have called into question the University of California's ability to run the Los National Laboratory" and hinted that Abraham might try to end UC's role in the lab management prior to the expiration in 2006 of UC's contract

REVIEWS

Common Sense on Climate Change: Practical Solutions to Global Warming

by the Union of Concerned Scientists, 2002, pp. 14

The Union of Concerned Scientist (UCS) is a nonprofit organization that was founded in 1969 by faculty and students at the Massachusetts Institute of Technology. It has since grown to over 50,000 people and is primarily focused on utilizing rigorous scientific evidence to solve social and environmental problems. These problems include sustainable agriculture, nuclear arm reduction, and global warming. The topic of this review is a short booklet released by the UCS that is written to provide practical political and consumer solutions to reducing carbon dioxide emissions and thus alleviate global warming.

This booklet begins by outlining the major sources of U.S. carbon dioxide emission as electricity generation, transportation, and industry. It then outlines five "common sense" solutions that can be implemented at both the individual and nationwide levels:

1. Produce and purchase more fuel-efficient vehicles.
2. Modernize electricity generation to include renewable resources (wind, geothermal, solar, and biomass).
3. Increase energy efficiency in both homes and businesses.
4. Protect threatened tropical rainforests by purchasing sustainably harvested timber and planting trees.
5. Support research and development efforts to produce renewable energy sources and improve energy efficiency (e.g. hydrogen fuel cells).

The final portion of the booklet suggests practicing sustainable farming and working to get international cooperation to reduce other key greenhouse gases like methane and nitrous oxides. The report concludes with a one-page overview of the greenhouse effect, the resultant global warming, and possible impacts of this temperature increase.

Although this report provides many key facts concerning the sources of U.S. carbon dioxide emissions and possible methods of reducing such sources, it tends to be overly simplistic in citing its "practical" solutions. The prospect of increasing energy conservation and increasing funding for alternative energy resource programs is highly appealing, but the prospects of producing hybrid vehicles, switching to renewable energy sources, and protecting threatened forests need to be further addressed. For example, despite the recent decrease in renewable energy costs they are still considerably more expensive than fossil fuels. What will be the projected impact on the U.S. economy of switching to 20% renewable energy sources by the year 2020 as suggested by the UCS? How can we convince developing countries to switch to more expensive energy sources and stop deforestation? Likewise, one of the chief concerns many people harbor when deciding whether or not to purchase a lightweight hybrid vehicle or a large SUV is safety. Is there any evidence that light, fuel-efficient vehicles are comparably safe? There are very strong responses to all of these queries supporting the suggestions put forth by the UCS and they should have been mentioned in this report. Despite this criticism, I would highly recommend reading this brief release.

As a parting thought, one should note that this report is not intended to justify the belief that global warming is occurring or that human activity is directly responsible for it. Fortunately, the UCS has other brief brochures that clarify these points and address many of the key criticisms, at http://www.ucsusa.org/environment/0warming.html .

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Making the Nation Safer; the Role of Science and Technology in Countering Terrorism.

National Academy Press, Washington D.C., 415 pages. Prepublication copy reviewed at http://books.nap.edu/html/stct/index.html

The terrorist attacks of 9/11 shocked a nation grown accustomed to being invulnerable to military action by foreign powers; not since Pearl Harbor has the United States been attacked on its home territory. The Pacific and Atlantic oceans had, throughout U.S. history, been a nearly perfect Maginot Line, protecting the country from attack.

It therefore is not a surprise that all sectors of the United States have been asked to respond and prepare for future possible attacks on U.S. soil. The scientific community, through the National Academy of Sciences (NAS), was asked to formulate recommendations to better prepare the nation against future terrorist attack. Making the Nation Safer; the Role of Science and Technology in Countering Terrorism is the result of 1.5 years of work by the NAS and is a compendium of 146 specific recommendations for the executive and legislative branches of government.

The book takes its cue from the greatest marriage of national security and science in the United States during WWII, the Manhattan Project. However, a more apt metaphor for the place of science in the "war on terrorism" may be found in the Cold War. The role of science in the Cold War was far more ambiguous than its role in creating the atomic bomb. The Cold War was not just a matter of discovering and applying physics — it was also a political and economic struggle.

This book suffers from its rushed nature. The chapters are uneven in style and content. Chapter 2 ("Nuclear and Radiological Threats") provides little statistical background for its recommendations, while chapter 3 ("Human and Agricultural Health Systems") is far better at providing some statistics that lend context to the committee's recommendations. Chapter 6 is particularly repetitive in its discussion of Supervisory Control and Data Acquisition (SCADA) systems, managing to reiterate 9 times that commands to remote pipeline and electrical distribution systems are transmitted in the clear—without encryption—over the Internet. And one can only marvel at the statement that "the purpose of terrorism, of course, is to terrorize" that begins "The Response of People to Terrorism" (Chapter 9).

The unfortunate effect of the stylistic problems is to balkanize the book. Each chapter reads better as a memo to a specific government agency rather than a holistic look at the problems of defending a nation against terrorist acts.

Moreover, some of the chapters strike this reader as pseudo-scientific. For example in "Complex and Interdependent Systems" (Chapter 10), the argument is presented that the methodology of systems engineering can help delineate costs and risks associated with terrorist attacks. Yet the models that are presented, even if simplified, greatly trouble me. There is no discussion of how to verify the models of terrorist behavior that would be used in any risk assessment. Policy makers, at best, will fool themselves that this 'scientific' approach has given them an optimized set of parameters. At worst, the risk assessments will simply be pure delusion based on ad hoc models of 'terrorist' behavior.

The book properly notes that there is no magic bullet in the war against terrorists: "Overall, the committee believes that it has identified scientific and technological means by which the nation may reduce, but not eliminate, the vulnerabilities of society to catastrophic terrorist acts." One maxim of war is that "he who defends everything defends nothing." Many of the book's chapters repeatedly point out that an economy as vast and as large as the U.S. has many points of vulnerability.

Another consistent thread of the recommendations is that attribution of sources of all weapons (nuclear, biological, etc.) be made a priority. Nation states can be deterred against aiding or abetting a terrorist attack if there is a high probability of determining the source of the materials used by the attacker. On September 17, 2002, Secretary of Defense Donald Rumsfeld acknowledged this problem in an interview on the "Jim Lehrer News Hour." He said that we would have "no return address" if terrorists detonated a chemical or biological weapon on U.S. soil. Of course Mr. Rumsfeld did not mention that if nation states cooperate and share information, the problem of attribution can be solved to a great degree.

In contrast, the report is blunt that deterrence will not work against many terrorist groups. The financial and material support of nation states is no longer required to build any of a range of weapons of mass destruction (WMD). Repeatedly, the book points to the widespread dissemination of knowledge and that the dual use of many technologies in the nuclear, biological, chemical, or information sciences allow relatively small groups of motivated people to produce a WMD. The Tokyo subway attack by Aum Shinriikyo is cited as an example of this problem.

That the book calls for increased investment and research in a variety of fields is certainly expected. There is a very good case that fields such as vaccines, radiological detectors, and computer security are all seriously underfunded if the nation is serious about improving its ability to detect, defend and recover from a terrorist attack. The recommendations on improving inter-agency coordination are mother's milk. Increasing coordination and cooperation between agencies will, of course, increase the efficiency of the plans developed to fight terrorists.

All in all, if policy makers reading this book are sobered by the task at hand, this book will have served its purpose. Yet, even if all of the recommendations are accepted, our security would only be marginally improved. As Ellen Goodman argues in an article reprinted September 12 in the San Francisco Chronicle: "the pledge of absolute security now rings hollow." My overall impression is that the book does not spend enough time deflecting our policy makers to more fruitful discussions on how, just like the Cold War, political and economic policies put forward by the U.S. are more likely to achieve a positive benefit than any equivalent effort expended by the scientific community.

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Cut along dotted line.

FORUM ON PHYSICS AND SOCIETY
2003 ELECTION BALLOT

This is your election ballot.
(You can also vote via a Web Ballot at: http://physics.wm.edu/ballot.html)
Information on the candidates appears in this issue of *Physics and Society*, paper and Web.

The ballot below will decide the next Chair-elect, the next Vice-Chair and two members of the Executive Board. The reason it covers two Chair positions is that Michael Rosenthal resigned his position of Vice-Chair as he has accepted a position at the International Atomic Energy Agency in Vienna. The primary responsibility of the Chair-Elect is to arrange the Forum sessions at APS meetings, while the Vice-Chair coordinates nominations for Forum APS fellows.

Put an X next to the name of the candidates of your choice:

Chair-Elect (vote for one):

_____ Allan Hoffman

_____Mark Sakitt

____________________ (space for write-in candidate)

Vice-Chair (vote for one):

_____ Mark Goodman

_____Tina Kaarsberg

____________________ (space for write-in candidate)

Members of the Executive Committee (vote for two):

_____ Kai-Henrik Barth

_____ Barry Berman

_____ Charles Ferguson

_____ Susan Ginsberg

____________________ (space for write-in candidate)

Please fold and tape this self-mailing ballot, place a stamp on it, and return it to
Andrew Post Zwicker
so that he receives it no later than March 1, 2003.

Fold Here and Seal with Tape (No staples please)

(Fold Here)

Place Stamp Here

Signature

Andrew Post Zwicker, Secretary/Treasurer
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