October 2003

IN THIS ISSUE

Reviews

A Serious but not Ponderous book About Nuclear Energy, by Walter Scheider, reviewed by *John Ahearne*

Risk and Reason: Safety Law and the Environment, by Cass Sunstein, reviewed by *Peter Schroeder*

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.

Editor Comments for October 2003 Issue of P&S

This issue of P&S contains the first installment of a series of articles on the dangers of nuclear weapons after the Cold War. JM brought the idea of a P&S multi-issue publication project to Professor Wolfgang Panofsky in his office at SLAC. He suggested a series on nuclear weapons dangers post Cold War, along with the names of several possible contributors to such a series. We found his suggestion to be attractive because several of the foreign policy stances of the Bush Administration (e.g., the proposal to use nuclear weapons for destroying underground caches of biological weapons), as well as recent news events, make the publication of a series on the subject of nuclear dangers to be timely: Shortly before the writing of this comment, North Korea announced to the world that it was going to test a nuclear weapon.

We are pleased to publish, in this issue of P&S, two articles by Professor Panofsky. The first is a kickoff/summary article for the series on nuclear weapons danger following the Cold War. The second, itself part of the series, discusses a proposed method by the Bush administration to handle the nuclear threat against the U.S.A. via ballistic missile defense. Suggestions for alternative nuclear weapon postures are given here by Professor Michael May, now at Stanford but formerly at Lawrence Radiation Laboratory at Livermore. The threat of nuclear weapons in the hands of "rogue" states is addressed by Phil Coyle, formally Director of Operational Test and Evaluation in the Dept. of Defense. Charles Ferguson extends our interest from nuclear explosives to more general nuclear threats. We expect that a near-future issue of P&S will feature an article concerning the smuggling of fissile materials. We are also seeking out expert authors for articles on the dangers of command and control failure, as well as the broad issue of nuclear proliferation. We wish to take this opportunity to thank Professor Panofsky for his catalytic role in getting this series started.

Also in this issue are several reactions from readers, and a response from one of the concerned parties, to the issues raised, in the previous *Physics and Society*, about the role of physics as a profession in dealing with their country's military and foreign policies.

Jeffrey Marque and Al Saperstein

ANNOUNCEMENTS AND COMMENTARY

FPS Discussion Board Opens for Business

The FPS recently announced the opening of the Forum on Physics and Society Discussion Board at www.fpsboard.org <http://www.fpsboard.org>. The Discussion Board's purpose is to support ongoing discussions of physics and society topics as raised by members of the physics community, and in doing so to facilitate active interactions among participants on issues of mutual interest. The board can even arrange private forms on particular topics, for registered users who wish that capability, although forums will ordinarily be available to all participants

A major activity of the Discussion Board will be to organize discussions on topics of special topical interest, and the Board has opened with forums on the APS study group report on "Boost-Phase Intercept Systems for National Missile Defense," released on July 15. The Board includes a subsite with extracts from the APS report and other information. For the fall, the Board plans to add summaries, and to support ensuing discussion, of the invited talks that took place at the April FPS Awards Session, whose abstracts should now be available via the site. Finally, note that one forum on the Discussion Board is devoted to a *continuation* of topics begun in *Physics and Society*.

Anthony Nero

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Forum Election Results

The Forum on Physics and Society election is completed. The winners are:

Vice-Chair: Joel Primack

Secretary-Treasurer: Andrew Post-Zwicker

Forum Councilor: Bo Hammer

Members at Large: Maureen Mellody and Rob Nelson

There were over 740 votes cast, which is much higher than our usual turnout (which is around 500). The closest election was Councilor, which was decided by about 4%. The various methods of dealing with duplicate votes (drop the first, drop the second, drop them both) would not have changed anything by more than 3 votes--but in case we have a Floridian election, this should be resolved by next year. A perl script could be written to check in real time if someone has voted, but I don't have the ability to that.

Best wishes to all.

Marc.Sher

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Energy for Society from Space

A constant underlying theme in "Physics and Society" is our future energy supply - in the July issue both book reviews and a news item on US participation in ITER reflect this theme; the April issue's letters in favor of nuclear power, a January article on nuclear power and a review on climate change, and many more relevant articles going back over the years. Even the commentary concerning the Iraq war is arguably tied to US concerns about energy supply.

Fossil fuels, bio-fuels, hydroelectric power and wind energy all derive indirectly from the most powerful energy source in our solar system - the Sun. Even our fuel for fission derives from fusion in ancient stars, as does the radioactive heating that drives geo-thermal power. Tidal power has a rather separate, but also space-based origin. Only fusion itself, still not technically or commercially viable as a power source, is independent of the stars (and Moon) above us.

But all the discussion of energy supply in recent years seems completely blinded to what, to any physicist, should be the most obvious solution of all - capturing more of the Sun's energy directly. The energy from the Sun that passes just through the region between Earth and Moon is measured in ZettaWatts - billions of TeraWatts. In fact, this option has not been completely ignored; the Department of Energy and NASA funded some studies in the late 1970's on space solar power options; that ended abruptly with some cuts in President Carter's DOE budget. But a rather minimal level of funding ($5 to $10 million/year) returned for the space solar power program at NASA under President Clinton in the late 1990's. A review by the National Research Council in 2000/2001(1) indicated the program was underfunded relative to the research needs and should be strengthened. Rather than strengthen it, all funding for the program ceased under the new administration, and the concepts for solar power from space are back in limbo (there is some very minimal research continuing outside of NASA).

A frequently recognized pre-requisite for commercially viable space solar power is less expensive commercial launch capacity. Whether built directly from Earth components or using industrial capacity installed on the Moon, the cost to first power, and the capital investment required before profitable power production, depend heavily on costs for launch from Earth. However, there is a bit of a chicken-and-egg problem here: a frequently recognized pre-requisite for reducing the cost of launch from Earth is a bigger launch market. Several commercial reusable launch vehicles were under development in the late 1990s that could have greatly reduced launch costs if the expected market for communications satellites had materialized. The failure of the Iridium system and subsequent telecommunications company financial troubles has put all those projects at least on hold. Plans for large-scale space infrastructure to capture solar power would very likely bring these low cost launchers back into play; other low cost launch options will likely also appear as materials and aerospace technology continues to improve.

There are a number of myths about space solar power that seem hard to dispel. The intuition that solar power on Earth is a better prospect than in space is false - the day/night cycle, sun angle, weathering, cloud cover, long-distance transmission, and environmental impact from covering large parts of the Earth's surface with solar cells make collection from a space platform far more efficient and environmentally friendly. The most important question is how power would be returned to Earth - directed microwave power is a simple extension of communications satellite technology, the main downside of which is the need to reserve spectrum for power transmission applications. The other downside of microwave transmission is the need for relatively large platforms for reasonable efficiency - below a critical size (for a given microwave frequency and antenna geometry), received power levels vary as the third power of the construction cost.

Compared to fusion power, and even fission reactors, solar power from space presents few challenges for physicists: it is primarily an engineering and economic problem at this point. But to anybody interested in real solutions to our energy supply problems, it should seem strange that an energy technology so close to usability has received essentially no government funding for two decades, while the still-impractical fusion gets close to $1 billion/year (between the magnetic and inertial confinement programs). The ITER project is currently estimated at $5 billion for a research reactor that will produce only thermal power (500 MW) -in contrast the 1995 "Fresh look" (2) study for space solar power found some systems with an estimated cost of $6 to $8 billion, producing 250 MW electric available for commercial sale, readily expandable to several GW and a profitable return on investment. With some further research those numbers can likely be improved upon, but the funding has again dried up.

We already have an immense fusion reactor working for us in our solar system, and stellar fusion is responsible for all our current energy choices; all we really need to do is make better use of it by tapping into it more directly.

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1. "Laying the Foundation for Space Solar Power: An Assessment of NASA's Space Solar Power Investment Strategy" (2001) - National Research Council; see http://www.nap.edu/execsumm/0309075971.html

2. ."A Fresh Look at Space Solar Power: New Architectures, Concepts and Technologies", John C. Mankins, 38th International Astronautical Federation conference (1997); see http://spacefuture.com/

ARTICLES

The Risks from Nuclear Weapons after the Cold War

WKH Panofsky

Physics and Society will publish a series of essays on the risks of nuclear weapons remaining after the end of the Cold War. Those risks have by no means disappeared and, in fact, may have grown. In an unfortunate and misleading categorization, nuclear weapons have been grouped together with biological and chemical weapons as *weapons of mass destruction.* However, each of these weapon types has its own distinctive character. Nuclear weapons have increased the amount of destructive power which can be carried by a delivery vehicle of given size and weight by a factor of a million or even somewhat more as compared with conventional explosive weapons. Delivery of nuclear weapons is very difficult to prevent in an effective manner, and the destructive effects – blast, heat, prompt radiation, and delayed radiation are difficult to mitigate. Chemical weapons, however horrendous their perceived effects, have not increased the lethality of munitions of given size and weight relative to conventional explosives by a significant amount. Biological weapons have fortunately not been used in warfare to any significant extent, but their lethality could become comparable to that of nuclear weapons. Their means of delivery remains to some extent unreliable and unpredictable, and defenses ranging from public health measures to protective gear can be effective. Note that the effects of biological weapons are delayed while most of those by nuclear weapons are prompt.

We consider remaining nuclear risks in the following five scenarios:

1. The Risk of Revival of Hostility with Russia.

While the United States is striving for partnership with Russia and while there are no longer ideological conflicts with Russia, it is at least conceivable that the relationship might turn hostile again at some future time. Since the inventory of nuclear weapons in Russia is still near the 20000 mark, the use of only a small fraction of their inventory could endanger the survival of the United States as a civilization.

2. Accidental Release of Nuclear Weapons, through error or failure of command and control.

With the end of the Cold War the early warning systems of Russia have become much less capable than those of the former Soviet Union, and the discipline inherent in Russian command and control systems has slackened. While such systems are considerably more robust in the case of the United States there have been instances of "near misses" on both sides where some, but happily not all, of the various safeguards against accidental delivery were breached.

3. Proliferation of Nuclear weapons to "states of concern"

The current regime to limit proliferation of nuclear weapons is centered on the Non- Proliferation Treaty of 1970 and has been remarkably successful. All states in the world other than India, Pakistan, Israel and now, North Korea are parties to the NPT. That treaty divides its signatories into nuclear weapon states and non-nuclear weapon states. The peaceful nuclear energy facilities of non nuclear weapon states are subject to an inspection regime negotiated with the International Atomic Agency (IAA). However, the non proliferation regime is under stress due to the failure of the nuclear weapon states, and in particular the US, to reduce their reliance on nuclear weapons in international relations and due to the clandestine nuclear weapons programs which may be pursued by non nuclear weapons states which are parties to the NPT.

4. Acquisition of Nuclear Weapons by Terrorists

A new threatening possibility is that sub-state actors may acquire nuclear weapons. September 11th has reminded us that the destructive power which terrorists will wield is only limited by the tools at their disposal. Nuclear weapons require the availability of highly enriched uranium or plutonium. Highly enriched uranium (HEU) might be the material of choice for terrorists since bomb manufacture using HEU is well understood and does not require elaborate technology. It is noteworthy that the stockpiles of HEU and plutonium now in the hands of Russia, and to a lesser extent of the United States, are well in excess of the amounts required to fashion 100000 weapons. Thus safeguarding and reducing these inventories is a matter of paramount importance. While progress along these lines has been made a great deal more remains to be done, and obstacles to further progress have arisen.

5. Regional Conflict Using Nuclear Weapons

Nuclear weapons have not been used in war since two weapons were detonated in 1945 by the United States over Hiroshima and Nagasaki. This tradition of non-use has persisted for 58 years despite the fact that the US and the USSR collectively accumulated over 70000 nuclear weapons during the Cold War. The US and the SU, in fact, avoided direct hostile engagements during this entire period. However, the situation may become different in respect to countries in conflict, such as India and Pakistan, which share a common border.

Risk is a product of the probability of an adverse event times its consequences. While the maximum consequences of a nuclear weapons release have diminished since the end of the Cold War, the probability that one of the five disastrous scenarios listed above could occur has probably increased. In the interest of human civilization, therefore, efforts must be intensified to decrease these risks. The newsletter of the Forum on Physics and Society will dedicate a series of articles outlining the promises on the one hand and difficulties on the other of these efforts.

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An Alternative Nuclear Posture

Michael May

President Bush's 2002 nuclear posture differs sharply from its predecessors and is relevant to the President's recently repeated assertion that he will strike first against any country that might pose a threat of using weapons of mass destruction.

The main new trend in the posture is that the US will be prepared to use nuclear weapons in a much wider range of circumstances than before. Such an emphasis has not been seen since the days of "flexible response" forty or so years ago, when tactical nuclear weapons were deployed in Europe and elsewhere.

Yet, nuclear weapons don't help much with the kinds of missions the US prepares for, including the ones noted in the posture, such as digging out deep underground facilities that might contain bio-warfare agents. Deep underground facilities are difficult or impossible to destroy without large nuclear explosions that create large amounts of fallout. Nuclear weapons are more suited for use against shallow-buried facilities (of the order of ten meters deep) but even in those cases, Hiroshima-type yields are needed, and complete destruction of the bio-agents cannot be guaranteed. Other uses mentioned to justify the posture are even more marginal in their feasibility.

Given the overwhelming US conventional advantage and the relative invulnerability of the US to all but nuclear weapons, the US nuclear posture should aim at minimizing the chances of nuclear weapons spread rather than seeking marginal gains with tactical nuclear weapons. Nuclear weapons are equalizers. Why bring them back into the forefront of regional problems, whether in the Middle East or anywhere else?

Increasing the US nuclear threat will increase the motivation of adversaries, big or small, to improve and extend their own nuclear force, or to get one if they don't already have one. The US cannot subsequently be confident that it will be the only power to use or threaten to use nuclear weapons. There are now several demonstrations of the relative ease with which states can acquire nuclear weapons. North Korea, a poor nation of 17 million people, made and separated with little help enough plutonium for perhaps one or more weapons. South Africa made at least six weapons with essentially no help. Other cases tell the same tale.

The nuclear genie is long out of the bottle and the relative stability that characterized the Cold War is also gone. Instead, the US has been pursuing an aggressive strategy of military expansion around the world and ever closer to other states' vital interests. Quite apart from the wisdom of that strategy, is it wise to couple it with an increased nuclear threat to possible adversaries, as the posture does?

In the past, the existence of a real or putative nuclear threat has been a serious motivation for states to improve and extend their own nuclear force, or to get one if they didn’t already have it. That was true of the US, USSR, China, and others. The US, as the world's strongest and least vulnerable major power, should pursue a strategy that minimizes the most serious risk rather than increase it for marginal, and questionable, benefits. The posture implies a strategy that does the opposite.

A nuclear posture better suited to our times would recognize these changes. It would lay the policy basis for the following difficult, long-term, but necessary steps:

1. *Minimizing the demand for nuclear weapons, focusing on Asia.* Asia contains most of the world's population and might, in a few decades, have most of its wealth. Three states there (four if Israel is included) have nuclear weapons; several more could readily have them. The US nuclear posture should provide US initiatives toward a more stable security order there, one in which peaceful states will not be threatened by nuclear or potentially nuclear rivals. The Non-Proliferation Treaty provides a basis -the only existing basis- for such an order, but it needs to be updated with more inducements in the way of technical cooperation and reassurance, and more clearly defined internationally agreed sanctions if the treaty is disregarded. The US nuclear posture in essence forswears the lead in this endeavor.

2. *A pattern for nuclear arms reductions that would include eventually limitations on all arsenals.* Openness here is as important as numbers. The US and Russia have most of the weapons but, after the first hundred or so survivable weapons, it matters less and less how many a state has. An internationally recognized framework is needed that can be applied to the regions of the world where nuclear rivalries threaten. Instead, the US has gone the other way, with a sketchy US-Russia agreement that delays the time scale for reductions and does not provide any precedent for international agreements on inspections.

3. *A strategy for addressing the problem of nuclear terrorism.* The most serious dimension of that problem - the possibility of a terrorist nuclear weapon - is closely related to the proliferation of nuclear weapons and capabilities. Any strategy to avoid that has an important international dimension. Hundreds of tons of weapons-grade uranium and plutonium, most of it surplus in the US and former Soviet Union from the Cold War, need to be better secured and accounted for. A solution to the problem of keeping nuclear weapons and materials out of the tens of millions of shipping containers that crisscross the world requires international cooperation on standards, procedures, cost sharing, and inspections. A good start has been made toward these goals, mainly through the Nunn-Lugar programs, but more money and agreements are needed. A modern nuclear posture should establish the policy basis for securing those resources and agreements. There is at present no comprehensive global strategy for securing such vital agreements and establishing the institutions to enforce them. Consistent, high-priority US participation is vital to secure other countries’ participation.

4. *A strategy for reducing the risks of accidental nuclear launch while at the same time maintaining invulnerability of the reduced deployments.* The nuclear posture briefly mentions the "rigorous

safeguards" on US weapons systems and proposes to deal with the problem of accidental or unauthorized launch of "certain foreign forces" via nuclear missile defense. That is at best a partial and certainly a distant remedy. Maintaining the human and financial infrastructure for nuclear weapons system will become more difficult in the US as well as elsewhere. Given the relationship among nuclear deterrent forces, the problem cannot be solved unilaterally. A program that would use US technical leadership to improve warning and control for *all* states threatened by nuclear weapons is also needed. It is needed now in South Asia. Later, it could help limit crises with or among Russia and China, and help prevent proliferation in the Middle East. President Reagan, with a portion of Star Wars, and, before him, President Eisenhower, with Open Skies, had something of the kind in mind. It is time to begin thinking about how this would look in modern form.

In summary, a nuclear posture for a world with more dispersed power centers and more widely available nuclear technology should have more, not less, emphasis on international agreements. President Eisenhower stated fifty years ago that “Only chaos will result from our abandonment of collective international security.” That is even truer in today’s world than it was then. The present administration seems to have a bias against such agreements, which are slow to bear fruit and do not win votes. That is shown in the posture itself, which states that arms control measures will not stand in the way of nuclear weapons development.

Yet these and other agreements are essential to deal with the dangers of proliferation to unstable states, with the possible use of international trade for terrorism, and with the risk of accidents and unauthorized launch. Nuclear deterrence continues to be needed, but the last thing a modern posture should do is to bring nuclear weapons back into the forefront of regional deterrence.

Ironically, when it has committed itself to the task, the US has used international agreements more effectively than any other nation. The Cold War - better called a Cold Peace perhaps, since the military lines of demarcation never changed while the safeguarding of Western values and collapse of the Soviet Union were brought about mainly by economic and political instruments - saw a rise in US power and influence in good part through the use of US-led international agreements in the areas of trade and security, areas that are necessarily related. Now is not the time to give up that approach, especially not in matters relating to nuclear weapons.

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Weapons of Mass Destruction in Iraq, North Korea and Iran:

Hype, Hope or Hysteria?

Philip E. Coyle, III

Since Sept. 11, 2001, public debate in the United States and at the United Nations has combined and often confused the notions of fighting terrorism with the pursuit and production of weapons designated as weapons of mass destruction (WMD). The actions of al Qaeda on Sept. 11 and the subsequent, unsolved anthrax infections and deaths after October 2001 lead to a reactive lumping of biological, chemical and other conventional weapons into the WMD category, which was previously limited to nuclear weapons.

Since the Cold War and until 9/11, WMD meant only nuclear weapons: something that could produce truly mass destruction, that is, hundreds of thousands or even millions of deaths. Since 9/11, WMD has been redefined as something that could cause a few thousand deaths, or even a few hundred, or less. Last September, the State of California passed a law that would define an ordinary school bus as a weapon of mass destruction if used for terrorism. These revisions to the definition have added additional layers of complexity to determining when or how to deal with issues of global terrorism.

Defining WMD

Among the general populace, a weapon of mass destruction is thought to be either a nuclear bomb, or chemical, biological or radioactive materials dispersed by a bomb or by some other apparatus. In the following section, I evaluate each kind of weapon and whether the label "WMD" is applicable.

When radioactive materials are dispersed it's called a "dirty bomb," - a bomb that scatters radioactive materials but without producing any nuclear explosive force. Let's examine the meaning of the term "dirty bomb" Some people think a "dirty bomb" is worse than a full scale nuclear explosion, just somehow "dirtier." Let us deconstruct the dirty bomb's impact and its potential as a WMD by discussing the following example:

Suppose some aberrant person stole a radiation source from a hospital, a radiation source that is used to save lives, not take them, such as radioactive isotopes used to treat cancer or used in x-ray machines. Suppose that same person wraps the radioactive source in dynamite, or just throws it into a fire, to create a "dirty bomb." Such a bomb might kill no one, or at least no more than might have been killed by the dynamite alone, but because of the hype of WMD such an incident would scare everyone to death. The cleanup afterwards would likely close an area the size of downtown Washington, D.C., but the detonation wouldn't produce **mass** destruction. The cleanup would certainly be expensive, and would disrupt and distract people living and working nearby, but it would not produce mass destruction, only mass disruption and mass distraction.

Like the dirty bomb, chemical and biological weapons do not fit the Cold War definition of WMD either. Both toxic chemicals and biological agents can certainly produce horrible deaths, but they make lousy weapons of mass destruction. Wind, rain and temperature can weaken the effects of chemical agents. It is difficult to disperse chemicals in lethal doses over a large population and the effects are so immediate that everyone who could would flee. Anyone who has ever whiffed a chlorine spill or industrial chemical spill knows how quickly our senses tell us to move.

As with chemical weapons, biological weapons do not distinguish friend from foe. Biological weapons also take too long to act on the battlefield. Some biological agents, such as anthrax, can be treated successfully with antibiotics, and others can be treated with anti-toxins or vaccines. The anthrax attacks in the mail in October 2001 did not kill many people, as tragic as those few deaths were. There are worries that tomorrow's biotechnology might be able to invent 'superbugs' that would act with more speed and virulence. It is certainly true that we have already been able to take genetic information from a database and translate it into DNA and then an actual polio virus. This kind of technology is still at the cutting edge and, while we can reconstitute existing organisms, enhancing their performance, for good or ill, is a fundamental research question. Furthermore, 'weaponizing' any biological system is not easy. Finally, it is also the case that modern biology is proving equally adept at countering biological threats. For example, within a month of the first SARS break out, scientists in Canada, and soon thereafter at the U.S. Centers for Disease Control, had succeeded in deciphering the DNA of the virus that causes SARS.

Why is it that the United States, Russia, and other countries willingly gave up chemical and biological weapons decades ago, but still cling to nuclear weapons? It's because it is difficult to make an <u>effective</u> chemical or biological weapon that doesn't end up killing your own troops or allies. Saddam Hussein learned this in his war with Iran. Nuclear weapons, on the other hand, can create destruction on a scale of no other weapon known to mankind.

So, for all practical purposes, there are no weapons - <u>plural</u> - of mass destruction that can be effectively delivered by terrorists; there's still only one: a nuclear weapon. Does that mean that someone couldn't make a horrible mess and kill many people with hazardous chemicals or with anthrax, of course they could. With this information in mind, we can be less hysterical about these threats.

This fear of WMD is what is causing the security perimeter around the White House, around the U.S. Capitol, and around airports to be expanded, even though - and think about this - the number of international terrorist attacks in the mid 1980s was about 600 a year; whereas in 2001, the year of 9/11, it was just 350. And here's another comparison: at the height of World War II, a time of high alert in the United States when enemy ships and planes were being sighted off U.S. shores, people ate their lunches on the lawn between the Treasury building and the White House. Today, security is tight around the White House perimeter and tours are suspended.

Defining WMD: Impact on the Current Developments in Iraq

This expanded notion of WMD is driving us to distraction and disrupting our daily lives. The fear of WMD was used to market the war in Iraq. Many people, who otherwise would have been against war in Iraq, supported it because they genuinely feared the WMD that Iraq was said to have, and believed those weapons could reach the United States.

We knew for certain that Saddam Hussein, as leader of Iraq, was pursuing nuclear technology until UN inspectors stopped him a few years ago. We also knew that he had used chemical agents on both his Iranian foes and his own Kurdish people, and we suspected that he was developing biological weapons. As either an enemy to his neighbors or as a sponsor of state terrorism, his ruthless pursuit of any weapons forbidden by international conventions has been a deep concern for the last decade and more.

Before the war with Iraq, the UN inspectors told us that Saddam Hussein did not have a nuclear weapons capability and had never used biological weapons - if he ever had them - either in his war with Iran or against his own Kurdish people, as he had with chemical weapons. Before the war with Iraq, the

UN inspectors had not found any WMD and proposed tripling or quadrupling the number of inspectors from 250 to 1,000. The administration of President George W. Bush mocked that proposal, saying that more inspectors would not help.

Now, after the war in Iraq, recent documents indicate Saddam Hussein may not have nuclear or biological weapons capability and effective or deployable chemical weapons. This does not mean that we may not find caches of chemicals or other evidence of his attempts to develop such weapons, but the reality of Saddam Hussein's WMD has not lived up to the pre-war claims. Now, after the war, the administration is building a team of 1,000 or even 1,500 U.S. inspectors to go into Iraq in defiance of the United Nations, and is actively opposing letting UN inspectors back in.

During the fighting in Iraq, television news reporters repeatedly stated that they ***hoped*** we would find WMDs in Iraq, as otherwise the justification for the war would be questionable. Why one would <u>hope</u> for such a thing, other than to justify the government's decision, is puzzling. From the administration's repeated assertions it is clear that WMD will be found in Iraq.

The fear of WMD also is driving the administration's justification for preemptive action and confrontation against Iran, North Korea, and now Syria. At home the fear of WMD is driving our planning for Homeland Security.

Kahlil Gibran said that the fear of need is greater than the need itself. This is equally applicable to WMD: the fear that weapons of mass destruction will destroy our country is driving U.S. taxpayers to spend unheard of sums for national defense and for Homeland Security and has been used to justify continuing assaults on our civil liberties. Unfortunately, the perceived threat from WMD is distracting our citizens and overworked local officials from the <u>real</u> threats.

We have heard amazingly inconsistent messages from Washington. One day, the administration tells us that the war in Iraq will not spawn hundreds of Osama bin Ladens, as some predict; the next day Homeland Security Secretary Tom Ridge is on television telling us that because of the war there <u>**is**</u> a heightened threat from terrorism. The threat level was lowered back to yellow with the explanation that the war in Iraq was now over - as if that would matter to someone like bin Laden who is bent on hurting the United States sooner or later, no matter what.

As far as Homeland Security is concerned, I'm much more concerned about homely threats such as someone setting fire in the Washington, D.C. public transit system, the Metro. It might not kill anyone, but it would tie up the city in the same way that a farmer who drove his tractor into the reflecting pool on the Mall tied up the city for several days. As a new resident of Los Angeles, my personal sense of risk is much higher than it ever was when we lived in Washington, D.C., but not from WMD, just from traffic accidents on the freeways and surface streets of L.A.

With regard to WMD, the administration's inconsistent policies and fear-mongering rhetoric are not only driving the U.S. public crazy, they also threaten to increase the threat to the United States from the one true WMD threat that remains in today's world.

When asked why the administration's policy of invading Iraq for regime change would not be applied to North Korea, Secretary of Defense Donald Rumsfeld said that it was because North Korea already had nuclear weapons and Iraq didn't. Of course, that sent a message to other non-nuclear countries – and any subnational enemies of the United States - that that they'd better get them while they still can. This is exactly what India and Pakistan have already done.

The United States is doing it, too! According to the *Oakland Tribune*, "The Pentagon is drawing up its first formal demand for a new or modified U.S. nuclear weapon since the mid-1990s. On March 19, 2003, Assistant Defense Secretary Dale Klein confirmed that he is seeking 'sign-off' inside the Pentagon for a new, nuclear 'bunker buster' ". The *San Jose Mercury News* has reported this as well.

Think about what we are saying. If the United States of America - the most powerful country in the world, a nation with unmatched conventional weapons that we have seen work so effectively in Iraq - if <u>we</u> need nuclear weapons to counter non-nuclear threats and blow up bunkers, then why don't weaker countries have even more need for nuclear weapons, particularly countries facing far more immediate security threats?

Defining WMD: Impact on Future Developments in North Korea and Iran

Accordingly, the recent developments in North Korea and Iran should be of great concern.

In October 2002, North Korea admitted to having a program to enrich uranium for nuclear weapons. The United States saw this as a violation of the 1994 Geneva accord known as the Agreed Framework. North Korea said the 1994 accord halted only plutonium processing, not uranium.

Through a series of diplomatic missteps on both sides, the United States and North Korea have been escalating ever since. In recent months, to try to get the Bush administration to take it seriously, North Korea has taken a half dozen actions - any one of which would have been cause for great alarm were they not obscured by the situation in Iraq.

In November, the United States and its allies agreed to suspend fuel oil shipments to North Korea promised under the Agreed Framework.

In December, North Korea removed the seals and monitoring cameras from a nuclear reactor shut down under the 1994 pact, and expelled inspectors from the United Nation's International Atomic Energy Agency (IAEA). Seals were also removed from some 8,000 spent nuclear fuel rods that could be used to make weapons-grade plutonium.

In early January 203, North Korea first threatened to withdraw and then withdrew from the Nuclear Non-Proliferation Treaty, designed to prevent the spread of nuclear weapons.

In February, the IAEA declared North Korea to be in violation of non-proliferation accords and referred the crisis to the UN Security Council. Also in February, North Korea restarted its five-megawatt nuclear reactor that could produce plutonium for nuclear weapons, and began to move nuclear fuel rods that could signal the start of reprocessing that fuel into nuclear weapons.

In March, the United States and South Korea began a month-long war game described by North Korea as a prelude to invasion. You may think North Korea was being paranoid to view those war games as a prelude to attack, but war games in Kuwait preceded the attack of Iraq on March 19, 2003.

In early April, North Korea said it had begun reprocessing those 8,000 spent fuel rods into weapons-grade plutonium - but South Korea asserted the statement is ambiguous and should not be taken literally.

For its part, the United States has refused to negotiate directly with North Korea, refused to consider a non-aggression pact with North Korea, and in February put 12 B-52 and 12 B-1 bombers on alert for deployment to Guam to be closer to North Korean territory.

The situation in Iran is not without stress either. In the summer of 2002, two secret nuclear sites were revealed by an Iranian opposition group. The first is a gas centrifuge uranium enrichment plant currently under construction in Natanz. Overhead imagery suggests it could house 50,000 centrifuges (enough to produce highly enriched uranium for scores of bombs/year). After an interim period of official silence, the Iranian government has since said that this facility will be used to produce low-enriched uranium for its Bushehr reactor, and several other reactors planned for construction by 2020. Such a large facility could, however, be rapidly converted to produce highly enriched uranium for nuclear weapons. Iran continues to insist that it has only peaceful intentions for these plants. The IAEA's Mohammed Al Baradai recently commented that this was a "very sophisticated" centrifuge project, putting Iran in the company of only about 10 other countries around the world with such capabilities. While this plant may indeed be used only to process reactor fuel for peaceful civil power, there will be little, if any, safeguards in place to prevent the transfer of centrifuge technology for nuclear weapons.

The second site identified by the Iranian opposition was at Arak, and is a heavy water production plant. While heavy water may be an essential component for the reactors Iran currently has on the drawing board, its one, declared reactor in Bushehr does not require heavy water for operation. This has raised concern that a second, secret reactor may already be in operation or that Iran has other nuclear weapons purposes in mind.

In December 2002, Iran canceled a scheduled IAEA inspection visit, following the revelations concerning these two sites.

By February 2003, the Iranian government was more forthcoming. President Khatami explained that Iran was operating or building uranium mines, uranium concentration and conversion facilities, and fuel fabrication plants for civil purposes. However, Iran has refused to sign the IAEA "Model Additional Protocol" that would allow for further assurances concerning these two sites.

The point of these grim recent histories, for Iran and for North Korea, is that the United States needs sophisticated and artful diplomacy to deal with such issues - and that blunt, muscular diplomacy, coupled with U.S. pursuit of new nuclear weapons, has so far only succeeded in driving us farther away from peace.

By contrast, the high technology of U.S. conventional weapons has permitted unprecedented judgement and restraint to be exercised in the midst of battle. There has never been a war where the nation on the offensive went to such lengths to avoid civilian targets - mosques, schools and hospitals. In Iraq (and Afghanistan), the U.S. military has made extraordinary efforts to avoid both military and civilian casualties with precision satellite-guided bombs and laser-guided weapons.

No adversary will master anytime soon the combination of technologies the United States has for modern warfare as it was practiced in Iraq and Afghanistan. A number of countries could develop nuclear weapons to attack their neighbors or potentially a large U.S. city.

So, what should we be doing about this? I'll give you five first steps:

- First, the United States needs to temper its rhetoric and get down to the business of building peace. Just as it has not been productive with Iran and North Korea, threatening military action and calling for regime change will not be a productive approach.

- Second, we need to not lose sight of the dangers from nuclear weapons while we are worrying about chemical or biological weapons, or "dirty bombs." We need to sustain our focus on the real dangers from nuclear weapons. The United States does not need to go to war again because of hyped-up fear of these sorts of weapons, as we have just done in Iraq.

- Third, we need to recognize that the U.S. government needs the United Nations' support and assistance. Most immediately we need to get the UN Inspectors back into Iraq. We know inspectors can find weapons with a certainty and level of control that is impossible in war. Between 1991 and 1998, UN weapons inspectors methodically destroyed more weapons than were destroyed during the whole of the Persian Gulf War, including 40,000 chemical munitions, 690 tons of chemical warfare agents, 3,000 tons of precursor chemicals, 48 Scud missiles, a "super gun," and biological warfare-related factories and equipment. The IAEA found and dismantled a developing Iraqi nuclear weapons program. This is exactly what we want the UN and IAEA inspectors to do again now.

  By contrast, in March 1991 during Operation Desert Storm, when U.S. troops blew up a cache of chemical weapons containing sarin gas at the Khamisiyah site in Iraq, they set off a decade long inquiry into what actually happened. It took the Department of Defense five years to officially recognize that chemical weapons were present at that site and that U.S. soldiers had destroyed them. The blast also exposed large numbers of U.S. troops to chemical agents, one of the leading theories for the cause of Gulf War Syndrome - a debate that, to this day, 12 years later, is still unresolved.

  This is exactly what we don't want to happen again.

  Now that U.S. and coalition forces have cleared the way, UN inspectors can resume the work they started before the war but without interference from Saddam Hussein's guards and "minders." The United States can help to populate these teams, but shouldn't monopolize the job. UN inspectors are trained and equipped for this work, and have a proven track record of success.

- Fourth, we also need to get the UN inspectors back into Iran and North Korea.

- Fifth, we need to realize that we need the United Nations more broadly than for just its inspectors, or its highly competent food, health, education, and economic development bureaus. We need the United Nations, not to do our bidding, but to hold us accountable from an international perspective. Some people have said the United Nations has become irrelevant because it didn't call for military action against Iraq. That is nonsense. For the United States, the relevancy of the United Nations is a mirror in which we can see how we are viewed by other nations. For the United States, the United Nations is a way to "touch the wall" - to reach out and learn and respond to the views of others.

In summary, we must work hard at restoring clarity to our discussions about fighting terrorism, the weapons of terrorism, and the real weapons of mass destruction. We must carry this clarity into sustained involvement in the United Nations, especially for rebuilding Iraq and - through diplomacy - halting nuclear weapons and nuclear weapons technology in North Korea and Iran.

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Sunday, April 27, 2003

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Ballistic Missile Defense Revisited

W. K. H. Panofsky

The American Physical Society has issued a report entitled "Boost Phase Intercept Systems for National Missile Defense, Scientific and Technical Issues." This is an independent study of one of the 'layers' of ballistic missile defense now pursued by the Missile Defense Agency.

The report itself is a sobering identification of the scientific and technical factors involved in just one component of the larger problem – preventing the hostile detonation of nuclear weapons on U.S. soil. Such a catastrophe could be produced not only by short- or long-range ballistic missiles, but also by cruise missiles, aircraft of all kinds, detonation of nuclear explosives in U.S. harbors or smuggled across U.S. land boundaries. Moreover, the essential components to fashion a nuclear weapon can be introduced clandestinely and assembled in small buildings. Should terrorists acquire a nuclear weapon, delivery by ballistic missile is the least likely means by which they would introduce such an explosive into the United States.

Intercontinental Ballistic Missiles can be attacked during three phases: the 'boost phase' during powered flight as the missile ascends, 'mid-course' in the vacuum of outer space, and 'terminal defense' after re-entry of the missile into the atmosphere. The Administration projects a 'layered system' including all these phases. The largest fraction of today's approximately 10 billion dollar budget for missile defense is for mid-course intercept, but substantial increases for boost phase defense are planned. Note that thus far about 100 billion dollars has been spent on overall BMD with little to show for it.

Each of the three phases of an enemy missile's trajectory offers advantages and disadvantages to a defense. During the boost phase, the rocket plume emits very intense radiation that can only be decoyed by another rocket. In contrast, in mid-course all objects follow the same trajectory, be they heavy or light; therefore discriminating decoys from the target is a serious issue. During re-entry the atmosphere screens out light objects but a defense at that point can only protect a small area. Because of the large and distinct technical difficulties each layer imposes, the Administration has adopted what it terms a 'capabilities-based' approach, which translates to: do what you can, irrespective of a careful evaluation comparing effectiveness against projected threats in relation to costs and effort.

In the case of the boost phase intercept, the APS study provides little comfort. The burn time of the booster averages three to four minutes, severely constraining placement of potential interceptors and limiting the decision time to launch such an interceptor to a minute or less. Thus the decision has to be automated or pre-delegated to local commanders – a prescription for attacks on hostile missiles or peaceful launchers alike! Launches from certain small countries, such as North Korea, could be intercepted from land, sea or air, and even this becomes impossible if more rapid burning solid fuel boosters are employed. Launches, accidental or deliberate, from larger continental countries such as Russia, China, or Iran become inaccessible. To intercept launches from space, even one launch from a single location, would require over 1,000 satellites carrying heavy interceptors – several times the total launch capacity of the United States! Thus boost phase intercept systems add little to the already unpromising technical capability of the mid-course BMD system now under test by the Defense Department.

This test program has been much in the public spotlight. Opponents of BMD decry each test failure as evidence that "BMD does not work," while each successful test is ballyhooed by proponents as proof that BMD can offer comprehensive protection. In fact, these developmental tests have been carried out under far from realistic conditions: intercepts have occurred at speeds well below those realistically expected and the launchers knew the target trajectory in advance. Unfortunately, discussion of Ballistic Missile Defense (BMD) is now so highly politicized that basic scientific factors controlling a BMD's performance have been largely overridden by policy arguments. BMD has become a political litmus test for support of the Administration. The Defense Department has now thinned out the test program and imposed increased secrecy over test performance.

But the fundamental question remains: Is the nation taking the necessary steps to minimize the risk of a nuclear explosion on United States soil, considering *all* available means of hostile delivery? Technical and scientific realities cannot be coerced by policy. In my view the political prominence of BMD has resulted in a costly and dangerous distortion of priorities among the efforts designed to reduce the real nuclear risk to this Nation.

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Protecting Nuclear Material and Facilities: A Standards-Based Approach

Charles D. Ferguson

Without access to fissile material, radioactive sources, or nuclear facilities, terrorists cannot successfully carry out nuclear or radiological terrorism. While other prerequisites, such as highly motivated and technologically skilled terrorists, are needed before such attacks can occur, arguably the most effective way of preventing nuclear and radiological terrorism is to block access to the nuclear materials.

What is the level of physical protection of nuclear material and facilities after September 11, 2001?[i] Answering this question requires comparison to the agreed standards of physical protection. Unfortunately, no international binding standards or requirements exist for the protection of nuclear material or facilities within a state. Physical protection measures vary from state to state.

This paper offers five physical protection standards for consideration. It also discusses some impediments to achieving universal application of the standards. Before introducing the standards, the paper defines the four threats of nuclear and radiological terrorism. Throughout this paper, the word “terrorists” refers in shorthand to those terrorists who are highly motivated to unleash nuclear or radiological terrorism. A forthcoming Center for Nonproliferation Studies report will examine in depth the motivational issue as well as other issues briefly covered here.

First, terrorists might seek to acquire enough highly enriched uranium (HEU) or plutonium to build an improvised nuclear device (IND), or crude nuclear weapon. Second, terrorists might try to seize an intact nuclear weapon. Third, terrorists might launch an attack against a commercial nuclear power plant or other nuclear facility. Fourth, terrorists might construct a radiological dispersal device (RDD) – one type of which is popularly known as a “dirty bomb” – to spread radioactive material.

Physical protection standards should strive for maximizing the risk reduction of nuclear or radiological terrorism. Although these standards will not entirely eliminate the risk of nuclear and radiological terrorism, the closer they approach universal application the more the risk will be reduced.[ii] The first two standards below are not new and were articulated by the National Academy of Sciences almost ten years ago, as documented in the references, while the other three standards arise from national and international efforts to address the security of radioactive sources, nuclear power plants, and the large stockpiles of HEU.

Proposed Physical Protection Standards

Spent-Fuel Standard: Make weapons plutonium “roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel.”[iii] The highly radioactive fission products (especially the prevalent cesium-137 with a half-life of 30 years) in spent fuel provide a lethal barrier against theft.

Non-weapon-usable plutonium contains 80% or more of plutonium-238, which has the highest rate of spontaneous neutron emission as compared to other plutonium isotopes. The higher the spontaneous neutron emission rate the more probable a mixture of plutonium isotopes would result in a dud or “fizzle” nuclear bomb because of pre-initiation of the chain reaction. All other mixtures of plutonium isotopes are, in principle, weapon-usable. Weapon-grade plutonium typically has 93% or more of plutonium-239 (the most desirable plutonium isotope from a weapon design standpoint mainly because of its relatively low rate of spontaneous neutron emission) and from 3 to 7% of plutonium-240. Depending on the burn up of the nuclear fuel, reactor-grade plutonium usually has about 65% of plutonium-239 and from 18 to 30% of plutonium-240. Although there is some controversy[iv] about whether any state has actually built or tested a nuclear weapon using reactor-grade plutonium, there is no physical reason why it cannot be used in a nuclear explosion.[v]

Stored Weapons Standard: Weapon-usable nuclear materials should be guarded as securely as stored nuclear weapons.[vi] In 1997, the Department of Energy officially adopted this standard. Although all the details of the implementation of this standard in the United States are not openly published, by analyzing open source U.S. government documents, George Bunn has pieced together a definition of the stored weapons standard.[vii] First, the standard defines the "design basis threat," or DBT, which is a credible threat that authorities must design their storage sites to withstand. The DBT for stored nuclear weapons or weapon-usable material would in rough terms posit "a violent external assault by a group using weapons and vehicles, possibly with inside assistance." To try to defeat this DBT, the stored weapons standard would require, among other safeguarded details, "a strong, secure storage vault with a single entry surrounded by two layers of strong fences and an open, lighted area where no one could hide. Access to the vault should be limited to personnel with a need for access, who are cleared through full-field background investigations and accompanied by another such person (the 'two-person' rule). Such access limitations should be enforced by both armed guards and electronic monitoring devices, supported in case of need by nearby armed backup forces. All of these personnel should be trained to deal with design basis threats, and their competence checked periodically in exercises like war games."[viii] In a subsequent study, George Bunn and his colleagues at Stanford University showed in a survey that many states do not meet this standard.[ix]

High-Risk Radioactive Source Security Standard: Prioritize enhanced security efforts on those radioactive sources that have the potential to cause serious human health effects or radioactive contamination if used in an RDD.[x] In May, the U.S. Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE) published the findings of an Interagency Working Group that used a radiological basis to determine what radioisotopes and radioactive sources would pose the greatest RDD risk.[xi] The threshold radioactivity levels (curie content) that would trigger a federal response if the radioactive material were used in an RDD were not published in the NRC/DOE report. However, based on some NRC and International Atomic Energy Agency (IAEA) presentations at the International Conference on Security of Radioactive Sources in Vienna in March, these threshold levels would depend on the type of radiation emitted (whether alpha, beta, or gamma) and would not be less than about ten curies. These levels imply that only a small fraction of the millions of radioactive sources used or stored globally would pose an inherently high risk of causing significant harm if used in an RDD. Nonetheless, in absolute numbers, perhaps tens of thousands of sources would belong to the high-risk category.

Prioritizing security enhancements on this group of sources would achieve the greatest RDD risk reduction in the shortest period of time. The IAEA is working with member states to try to reach consensus on the prioritization standard. As part of this process, the IAEA is revising the Code of Conduct on the Safety and Security of Radioactive Sources and the Categorization of Radiation Sources in order to place more emphasis on enhanced security.

Hardened Nuclear Facility Standard: Ensure that all nuclear fuel bearing elements including reactor cores and spent fuel are protected inside hardened structures such as containment buildings, dry storage casks, and spent fuel pools that are fortified against attack by explosives or high kinetic energy projectiles, such as crashing airplanes. Although such hardening would not prevent terrorist attack against these facilities and would not obviate the need for a well-trained and well-armed guard force, implementing this standard would greatly diminish the likelihood of an off-site radiological release if an attack occurred.

In general, U.S. nuclear power plants (NPPs) and other U.S. nuclear facilities tend to meet this standard. For instance, all U.S. NPPs protect their reactors with containment structures. Notably, however, a recent study has pointed out that terrorist attacks on some spent fuel pools may cause release of radiological materials.[xii] Outside the U.S., some dozen Chernobyl-type, or RBMK, reactors continue to operate in Russia and Lithuania. Lacking containment structures, these reactors would not meet the hardened nuclear facility standard. The world witnessed in April 1986 the massive release of radioactivity resulting from the Chernobyl accident.

HEU Elimination Standard: Because of the relative ease by which HEU, especially weapon-grade HEU, can be used in a simple IND, there should be a global effort to eliminate HEU by phasing out civil commerce of HEU, by down blending existing stocks, and by agreeing to stop enrichment of LEU into HEU. Weapon-grade HEU typically contains 90% or more uranium-235 (the uranium isotope which is desirable for nuclear weapons).

Down blending weapon-grade HEU to the 3 to 5% LEU enrichment level for use in commercial light-water reactor fuel would certainly eliminate the possibility of that material being used to fuel a nuclear weapon. The Megatons-to-Megawatts deal between the U.S. and Russia has been applying this process to 500 tons of Russian weapon-grade HEU. However, after several years of effort, much less than half of this HEU has been down blended; the current rate is about 30 tons per year. Considering the urgency of the terrorist threat, this deal is progressing at too slow of a rate to make rapid headway. Recent proposals have sought to accelerate the blend down of Russian weapon-grade HEU by only going to the 19% enrichment level.[xiii] Although the dividing line between LEU and HEU was set at 20% enrichment in uranium-235, LEU that is enriched to 19% uranium-235 can be used in nuclear weapons. However, the bare critical mass would be greater than 800 kg, an amount unlikely to be acquired by terrorists.

Even increasing the blend down of Russian weapon-grade HEU to its maximum rate will still mean that several years will be required to complete the process. In parallel, the U.S. and Russia need to step up their efforts to ensure that all weapon-usable HEU meets the stored weapons standard.

Some Impediments to Universal Compliance of Physical Protection Standards

These or comparable standards are not universally applied. In general, a global strategic plan to prevent nuclear and radiological terrorism is needed to guide U.S. and international security work. Such a strategic plan would seek to meet the types of physical protection standards outlined above. Importantly, the plan would have to specify what steps are necessary to achieve the standards. Last year’s G8 Global Partnership meeting made some progress toward developing a plan by putting the G8 leaders on record as to the urgency of stopping nuclear terrorism.

However, only continued high level political effort will lift barriers to reaching effective standards and will lead to a workable strategic plan. Impediments to establishing such standards include the potentially high costs to implementing the standards, political resistance, culture of secrecy, varied national practices, and some commercial interests at odds with one or more of the standards. Due to space limitations, only a few impediments will be discussed below.

Many countries lack adequate regulatory systems to control radioactive sources. Near term efforts, such as the Department of Energy’s plan to secure the most highly radioactive sources in the most vulnerable locations, can make rapid progress in enhancing security. Nevertheless, a long term, sustainable plan requires addressing the systemic weaknesses in the world's regulatory controls of radioactive materials. Additional political and monetary support of the IAEA's efforts to assist states' regulatory organizations is needed.

In Russia, numerous security upgrades are still required in order to meet the stored weapons standard for tons of weapon-usable fissile material, according to a recent General Accounting Office report.[xiv] The GAO report pointed out that the major stumbling block is lack of access to several Russian facilities. U.S. policy guidance in January 2003 between DOE and DOD prohibits U.S. security assistance to operational sites because it might enhance Russia's military capabilities. However, due to the concerns about the security of many Russian tactical nuclear weapons, this policy should be revisited. In parallel, a presidential level initiative is needed to eliminate tactical nuclear weapons under a verified agreement.

In Russia, Lithuania, and the United Kingdom, many nuclear power reactors continue to operate without containment structures that would reduce the likelihood of an off-site radiological release in the event of an accident or devastating terrorist attack. Since the G7 meeting in Lisbon in 1992, the U.S. and the other G7 states have emphasized the nuclear safety hazard posed by the continued operation of many Soviet-designed nuclear power plants, especially the RBMK Chernobyl-type plant without containment structures. How willing is the U.S. to push the shut down of these plants? Cost estimates for the energy replacement are as high as several billion dollars. Do these plants pose a big enough safety and terrorist sabotage risk to justify spending money to shut down these plants? A compromise position between demanding near term shutdown of these plants and acquiescing in their indefinite operation could be for the G7 to strive for Russian commitment to phase out the operation of the RBMKs over the next decade and to promise to not build any more reactors without containment structures and other vital safety features. Reaching agreement on this position would be difficult mainly because Russia does not consider the RBMKs to be unsafe. Encouragingly, Lithuania appears likely to shut down its RBMK plant as a condition of European Union membership. The UK also is working toward closure of its NPPs that do not have containments.

Although civil commerce in HEU has substantially reduced over the past 25 years that the Reduced Enrichment for Research and Test Reactors (RERTR) program has promoted the conversion of these reactors from HEU to LEU use, some commerce in bomb-grade HEU continues. Two proposed amendments in Congress (the Burr Amendment in the House of Representatives and the Bond Amendment in the Senate) could reverse this progress toward phasing out HEU commerce by repealing the 1992 Schumer Amendment. The Schumer Amendment bars U.S. export of HEU to reactor facilities unless the owners of these facilities commit to converting from HEU to LEU use. Supporters of the Burr and Bond Amendments claim that removing the Schumer Amendment is necessary to ensure an uninterrupted supply of medical isotopes from commercial radioisotope production reactors. However, this legislation is unneeded because the Canadian company MDS Nordion, the world's largest producer of these isotopes and the largest importer of U.S. HEU, has stockpiled four years supply of HEU targets for its new production facility. Also, Nordion would not be denied HEU exports under the Schumer Amendment as long as this company makes progress toward conversion. Even if the flow of medical isotopes from Nordion were interrupted, the U.S. could make up the difference by turning toward producers in Belgium, the Netherlands, and South Africa. Furthermore, the Burr and Bond legislation is misguided because, if enacted, it would have the unintended consequence of undermining U.S. nonproliferation interests and increasing the risk that terrorists could seize HEU that is suitable for an IND.[xv]

Conclusion and Recommendations

The United States should work with other nations and the IAEA to ensure that nuclear materials and facilities meet the highest physical protection standards. Such standards support the goal of decreasing the likelihood that terrorists could gain access to nuclear and radiological materials by securing and accounting for the materials (e.g., meeting the stored weapons standard), eliminating materials (e.g., blending down HEU to LEU), converting the materials to unusable or undesirable forms (e.g., transforming weapon-grade plutonium or combining separated plutonium with highly radioactive waste to meet the spent fuel standard), stopping production of materials (e.g., stopping the separation of plutonium from spent fuel and stopping the manufacture of weapon-grade plutonium in Russian production reactors), and fortifying nuclear power plants and other nuclear facilities against attack (e.g., ensuring fuel bearing components are protected by hardened structures).

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LETTERS

Forum "Hijacked" by Moralists?

After reading the "commentaries" … by Fay Dowker and Daniel Amit in the July, 2003 newsletter, I must express my concern about the potential for our Forum to be hijacked by fringe elements more interested in polemics than physics. These writers, and others of their ilk delight in expressing their personal outrage at the "bad" properties they perceive in fundamentally good countries and organizations. Dowker's righteous indignation is provoked by unintended civilian deaths (in the range of a few thousand according to best current estimates) in the recent war in Iraq. I searched in vain for any similar outcry from her about Saddam's intentional slaughter of many times this number. Likewise for the new low he established in human conduct and child abuse in the outright purchasing Arab youths to strap bombs to their bodies to go blow themselves up together with civilians riding buses. She is hardly alone; very few of those currently venting over American behavior have spoken out about the behavior of Saddam. The same can be said for Daniel Amit -- now happily residing in the country most responsible (together with Germany) for bequeathing to the world modern fascist ideology.

I am unconcerned about whether or not these … moralists find an outlet in Physics and Society. We do, however, have a obligation to our Forum not to allow it to become an uncritical pulpit for a ,,, Dowker to attack a well-regarded physicist like Garwin; or for a … Amit to attack the foreign policy of the nation which (in our own generation) liberated with its blood the country in which he now resides.

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Threats to Scientific Collaboration Questionable?

I thank you for sharing with members of the Forum the views of two colleagues from Europe (Physics and Society, newsletter July 2003, vol32, No. 3) In the Commentary section it is expressed and I quote "Now, it seems we have the possibility of threats to scientific collaboration and trust

among scientists from presumably friendly nations".

Do I have to interpret that Fay Dowker's criticism of the Forum is a "threat to scientific collaboration"? I profoundly differ with that implication; one of the tenets of democracy, we value so much, is the right to dissent. In fact, as put by L. Krauss (APS News, June 2003, vol12, No.6, pag.4) "[we] scientists have a special ethical

responsibility at this particular time to QUESTION (my editorializing) our government's action" and so much so our own organizations.

Fay Dowker, in my view, does not "threats ... trust among scientists from presumably friendly nations"; on the contrary, she is embracing the highest values of freedom and democracy. In any case, I do not know what to do with the "presumably friendly nations" paragraph; are we "friend" only with others if they adopt a supine position and assent to our views? I do not think so!

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Foreign Opinions Not Unique

There is no reason to think that the regrettable opinions reported in the July "Commentary" from two foreign physicists are unique to, much less typical of, foreigners. I have no doubt that there are many US readers of the newsletter who tend to agree with an anti-war, anti-Bush position, albeit with (I hope!) less emotion and more substance. Still, it is a rare observer who can so easily damn (my old friend) Dick Garwin as a war-monger or worse. In spite of his long record of patriotic service to the country, many right-wing hawks have long ago consigned him to the lowest levels of anti-American behavior.

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A Reply

I reply to the Commentary by Fay Dowker, published in P&S of July 2003. She characterizes my talk at the Forum session on "Nuclear Weapons and Missile Defenses" in April 2003 as "the most shocking ... outrageous."

In general she criticizes all five talks for two shared assumptions,

1. "The U.S. government is sincere when it claims to want to safeguard the security of the U.S. population.

2. "What critical scientists can contribute is an assessment of whether or not particular technologies can achieve specific objectives demanded by government. The objectives themselves, and wider government aims served by those objectives, are not to be subject to scrutiny and criticism."

I have often written about insincerity on the part of government officials (and supporters) and continue to do so. But I do believe that most people in the government are sincere in wanting to safeguard the security of the U.S. population. Some of them believe that to do so requires limiting individual freedom, denying information, and in other ways going against the judgments expressed by the majority of the population or which would be assessed by the majority of the population. But a scientist, as scientist, gets nowhere by a blanket accusation of insincerity. Anyone can read my papers at www.fas.org/rlg, where I often criticize individuals and programs.

As for (2), I quite agree with that assumption. I think that this is the proper goal for a scientist, as scientist. Physicists are entitled and encouraged, as citizens, to differ with specific objectives and wider government aims. But I do not believe that is a matter for the American Physical Society or American Physical Society meetings.

I did not say that I had "worked enthusiastically on many types of nuclear weapons." I worked willingly, but I doubt that I used "enthusiastic." I still work on nuclear weapons.

But what I can add to the public debate is my considered judgment (backed up by unclassified analysis, and by experiences which I cannot fully disclose) summarized (for the United States) as "Who Needs Nukes?" I also went on to say that we still need nuclear weapons for strategic deterrence, but that an immediate decrease to 1000 total nuclear warheads (including weapon usable material) would more than satisfy U.S. strategic needs.

On the nuclear weapons front, my continuing assessment of the U.S. nuclear weapons Stockpile Stewardship Program persuades me that we do not need nuclear explosion testing to maintain a stockpile of safe and reliable nuclear weapons, and that there is little to be gained by nuclear weapons of new design which would require nuclear explosion testing. For some other people, there are benefits to resuming testing-- the general freeing of the United States from external constraints; the training of new weapons designers; the exercising of manufacturing capability. To me, as a physicist and a worker in international affairs, the peril this poses to the Non-Proliferation Treaty far exceeds in damage to the United States the modest benefits that would be achieved.

I don't celebrate the destructive capability of weaponry. I have had a lot to do with bringing conventional weapons and systems for using them to the level at which only one percent as many bombs are required to achieve a given objective, and that even concrete-filled bombs, guided to their target by laser or GPS, will demolish a building without much damage to its neighbors.

War is physically destructive and kills people. I don't join in "radical opposition" but I am opposed to programs and actions which are not justifiable for the net good which they accomplish. There are "good"s in addition to the national security of the United States.

We should have intervened in Cambodia to stop the killing. Also in Rwanda.

My opposition to the war in Iraq at the time arose from clearly inadequate planning for the aftermath of the war and security in Iraq (which was evident last Fall), and also that Iraq posed no threat to the United States with its WMD (nuclear programs and biological weapons).

To a large extent, this was because even if Iraq possessed some capability in BW, it was deterrable. As stated by CIA, Saddam Hussein would be likely to use WMD if his regime and his life were in danger, but not until that point.

So my own feeling was that the United States should work more effectively with the United Nations in order to pursue U.N. inspections programs, with the commitment to mount military operations in the Fall of 2003 if the inspections and other activities did not provide assurance that there were no significant WMD or programs to produce them.

I did not credit the claim that Iraq was a threat in potential sharing of its BW with terrorists. Unfortunately, as proved by the anthrax letters in the United States, a little bit of BW is well within the capability of terrorists groups, or of individuals involved with pathogenic organisms in non-terrorist states.

I encourage Dr. Dowker to pursue her political goals, but unless they involve her special knowledge as a physicist, to leave the physics profession out of it.

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How much Should be Covered Inquiry-based Physics Teaching?

Two cheers for Daphne Burleson's article in support of inquiry-based teaching of physics. I've been involved with this kind of teaching for quite a few years now, mostly in college courses for non-scientists, and I agree that it's the right thing to do. Alfred North Whitehead coined the term "inert knowledge" for what you get when you're not active in learning something.

But how much can you cover? Advocates of inquiry-based teaching, including those who prepared national standards for secondary schools, recognize that it takes more time to treat a given subject in an inquiry-based manner, and so some coverage of material has to be sacrificed. But how much? Physicists often say, following Kelvin, "If you don't understand something quantitatively, you don't understand it at all." Why abandon this principle when it comes to education? We also know that order-of-magnitude estimates are better than no estimates at all.

Let R be the ratio of the amount of subject matter students can learn in an inquiry-based program (per unit time) to the amount of subject matter present in a typical course (per unit time). What is R, and how does it vary with the level and grade of the course? In my experience in courses for the non-scientist major, I estimate $R = 0.2$. How much coverage are we prepared to give up? At meetings, when the question of "coverage" is raised, I have heard the response, "Less is more!" As if argument by slogan is appropriate for a scientist.

It's not that I oppose inquiry-based teaching. In fact I support it vigorously, and practice it (sometimes). But it demands that we face up to the question, What do we really need to cover in, say, a calculus-based introductory course, a middle school physical science course, a college course for the non-scientist.

One more point: Inquiry-based teaching doesn't only mean labs. Complex mathematical analysis, of the kind that's traditional in good introductory college courses for science majors, is inquiry, in that students are asked to solve problems that are not rehashes of the problems in the textbook. It's something that has been part of physics, and typically not part of teaching in other sciences. It's the reason physics is seen as "hard". But we've given it up in physics at lower levels, and we might want to find appropriate ways to put it back.

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NEWS

Congress Shows Interest in Nuclear Power and Personnel Required to Make it Go

One of the provisions of the Senate energy legislation currently being considered would provide federally-backed loan guarantees for up to half the construction costs of six or seven nuclear power plants. The nuclear plant loan guarantee provision was very controversial, and survived an attempt to remove it from the energy bill on a close vote of 48 to 50. "No matter how narrow and how hard-fought, it is a victory, and it won't get undone," said Senator Pete Domenici (R-NM), who has worked diligently to promote greater use of nuclear energy. No nuclear plant has been ordered since the Three Mile Island accident in the late 1970s, and the Senate vote was seen as a major victory for nuclear energy proponents. Besides the loan guarantees, S. 14 has other incentives to promote nuclear energy.

There was far less controversy at a House Science Committee hearing on university nuclear research programs. Energy Subcommittee Chair Judy Biggert (R-IL) opened this hearing by declaring, " . . . even as there is renewed interest in nuclear energy as one of the solutions to the nation's energy problems, there has been a growing concern that fewer Americans are entering the nuclear science and engineering field, and even fewer institutions are left with the capacity to train them." The number of four-year trained nuclear engineers is at a 35-year low, she said. Up to 30% of the current nuclear engineering work force could retire in the next five years. Biggert successfully incorporated a number of provisions in the House energy bill, H.R. 6, to strengthen university-based nuclear engineering programs.

There was general agreement that university programs are important and should be strengthened, primarily through the support of DOE. A witness commented that electrical generation from nuclear power could grow from its current national share of 20% to as much as 60%, and said that the role of university training is "critical." An industry spokesperson explained that there had been a 50% reduction in four-year programs since 1970, with more than a 50% decline in operating university research and training reactors since 1980.

Rep. Vern Ehlers (R-MI), a Fellow of this Forum, spoke of how he has fought to maintain funding for the nuclear reactor at the University of Michigan, "without a great deal of success, frankly. There is just not a lot of public support." Market concerns are also a formidable obstacle. Ehlers asked the witnesses if any corporation was likely to invest $2 billion or more in a new nuclear plant. While interest was expressed in the Domenici provisions in S. 14, the witnesses were divided over how likely it would be for private industry to move forward.

Excerpted by AMS from the American Institute of Physics Bulletin of Science Policy News, Number 97: July 23, 2003, by Richard M. Jones, AIP Media and Government Relations Division

House Challenges DoD on Need to Speed Up Capabilities for Nuclear Weapons Testing

The House Appropriators Committee denied the Administration's request for funding to reduce the current 24-36 month test readiness posture at the Nevada test site to the proposed 18 months. Their report, 108-212, excerpted below, provides important insights about the Defense Department.

"… The Committee is concerned with the open-ended commitment to increase significantly

funding for the purpose of Enhanced Test Readiness without any budget analysis or program plan to evaluate the efficiency or effectiveness of this funding increase. Recent reports done by the DOE Inspector General and two NNSA management studies done at the Committee's request all identified significant problems with the current test readiness program, but the Department's proposal does not address the fundamental difficulties in maintaining test readiness during a testing moratorium.

"The September 2002 Office of Inspector General audit (DOE/IG-0566) identified several problem areas impacting the ability to resume testing within the existing 24 to 36 month requirement: decline in the number of employees with testing experience; the deterioration of necessary systems and equipment; the inability to keep pace with new technology; and a delay in conducting required safety studies. …Neither past performance nor any program or planning documentation provided to the Committee supports the Department's contention that an additional $100 million over three years and a$45 million increment every year thereafter is likely to result in a consistent 6 to 12 month improvement in test readiness posture when the current requirement has not been successfully maintained.

"The Department's rationale for the change to an 18-month posturewas included in the April 2003 Report to Congress on Nuclear Test Readiness, 'An 18 month posture is appropriate because this is the minimum time we would expect it would take, once a problem was identified, to assess the problem, develop and implement a solution, and plan and execute a test that would provide the information needed to certify the fix.' The NNSA's July 2002 Enhanced Test Readiness Cost Study stated that even during the Cold War era of routine testing, the national labs required 18-24 months to design and field a nuclear test with full diagnostics. The Committee questions a proposal to move to and attempt to indefinitely maintain a test readiness state that is the absolute minimum amount of time necessary to conduct a test designed to produce meaningful diagnostic results. The proposal reflects a disturbing 'cost is no object' perspective in the Department's decision making process.

" The Committee supports the continued maintenance of the Nevada Test Site as a valuable resource for the NNSA nuclear weapons complex. Indeed, the Committee provides significant resources every year to fund a wide variety of activities at NTS that support the overall Stockpile Stewardship program. However, the Committee will not spend money on a perceived problem when the Department has not provided a rationale or a plan that addresses the underlying problems inherent in maintaining a testing capability during a testing moratorium. The Department's report states, 'The NNSA has made a deliberate decision, in consultation with DOD and other agencies with the Administration, to move to an 18-month nuclear test readiness posture by the end of fiscal year 2005.' The Committee does not recognize the NNSA declaring a revised test readiness posture as a new requirement nor is it convinced that the decision can be successfully implemented based on the planning information provided to date. The Committee challenges the NNSA to work within the significant funding provided each year for its site readiness activities to demonstrate the ability to meet its current requirements before additional funds are added to meet a more problematic goal."

Excerpted by AMS from the American Institute of Physics Bulletin of Science Policy News, Number 100: July 28, 2003, by Richard M. Jones, AIP Media and Government Relations Division

House Complains About DoD Process for Determining Need for Nuclear Weapons

Relevant selections, critical of the relationship between the Defense Department and Energy Department, from House Report 108-212 follow.

"Nuclear weapons budget requirements- This Committee continues to believe that our nation's nuclear arsenal provides a vital deterrent to potential aggressors. In order to maintain a modern nuclear stockpile, the Nation needs to have a modern, efficient, and flexible nuclear weapons complex with the necessary design, production, testing, refurbishment, and dismantlement capabilities.

Unfortunately, the country possesses neither a modern stockpile nor a modern nuclear weapons complex. Instead, both are largely carryovers from the Cold War era. After careful consideration, the Committee has concluded that much of the current situation results from a flawed budget process. Under the current process, the Department of Defense (DoD) establishes the military requirements for Nation's nuclear weapons stockpile (i.e., numbers and types of warheads), which in turn dictates the requirements that DOE must meet to ensure the safety, security, and reliability of those weapons. The size, capability and cost of DOE's weapons complex is a direct result of the specific requirements established by DoD for warhead refurbishments, design modifications, testing, and dismantlement. However, when DoD develops their requirements their decision process is not constrained by the normal types of budget trade-offs that an agency confronts in the process of formulating a budget request. In effect, DoD sets the requirements and leaves it up to DOE to come up with the budget to support the nuclear weapons complex each year. If these costs were funded directly by DoD, the nuclear weapons activities would be considered against other national defense priorities, such as developing improved conventional weapons, procuring more of existing weapon systems, paying ever-increasing operational and training costs, and providing a better quality of life for our soldiers, sailors, and airmen. Similarly, if the costs of the nuclear weapons complex were solely determined by the DOE, they would be balanced against other DOE priorities, such as nonproliferation, science research, improving the Nation's energy supply, or accelerating the cleanup of contaminated sites. Instead, the weapons activities portion of the NNSA budget is effectively insulated from any such tradeoffs - DoD sets requirements that another agency has to fund, and DOE treats the weapons activities budget as untouchable because DoD set the requirements.

"There needs to be a serious debate about whether the approximately$6 billion spent annually on DOE's nuclear weapons complex is a sound national security investment. Until that debate occurs and the DOE weapons budget request is subject to meaningful budget trade-offs, this Committee will not assume that all of the proposed nuclear weapons requests are legitimate requirements."

Excerpted by AMS from the American Institute of Physics Bulletin of Science Policy News, Number 99: July 28, 2003, by Richard M. Jones, AIP Media and Government Relations Division

Graduate Research Student Rejected on Non-Academic Grounds

From the British newspaper THE TELEGRAPH: Outrage as Oxford bans student for being Israeli By Julie Henry, Education Correspondent (Filed: 29/06/2003). Excerpted by AMS

Andrew Wilkie, the Nuffield professor of pathology [at Oxford] and a fellow of Pembroke College, is under investigation after telling Amit Duvshani, a student at Tel Aviv university, that he and many other British academics were not prepared to take on Israelis because of the "gross human rights abuses" he claims that they inflict on Palestinians.

A series of attempts have been made to isolate Israeli scholars in protest at their country's operations in the West Bank and Gaza Strip. In Britain, calls for an academic boycott have been led by Steven Rose, an Open University professor.

Last year the University of Manchester Institute of Science and Technology was forced to hold an inquiry after The Sunday Telegraph revealed that Mona Baker, a professor, had sacked two Israeli academics from the editorial boards of two journals because of their nationality. A Umist inquiry found that Prof Baker had not acted improperly under its rules because the journals she owns were not connected to the university.

Giles Henderson, the master of Pembroke College, said of Prof Wilkie's case: "The college will await the outcome of the university's investigation."

REVIEWS

A Serious But Not Ponderous Book About Nuclear Energy

By Walter Scheider, Cavendish Press, Ann Arbor, MI, 2001, 275 pages, $22.95 hard back, $14.95 paperback. Order from www.cavendishscience.org

Walter Scheider has a PhD in biophysics from Harvard, was a research scientist in biophysics at the University of Michigan for 17 years and a physics and math teacher in the Ann Arbor public schools for 20 years. He has won several awards for teaching and published educational material, including a previous book "A Serious But Not Ponderous Book About Relativity."

Scheider writes well and is clear in explaining the basic concepts of fission, reactors, and radioactivity. His approach to nuclear forces is to use analogies to chemical bonds. Avoiding quantum mechanics, he does get across the basic concept of energy release in fission and fusion. It is difficult to conclude whether he is for or against nuclear power, a characteristic valuable in dealing with students. However, I suspect he leans against, since 54 pages are from descriptions of the Three Mile Island accident events as recorded in the 1979 Kemeny Commission's Report on the Accident at Three Mile Island. He writes that this description was read aloud in a high school class for eighteen years to open a discussion on whether it could happen again. Nevertheless, there are few, if any, books that introduce pre-college students to nuclear energy. Given his many years of teaching high school students, Dr. Scheider knows how to present material to get across basic understanding. As debates on global warming have rekindled interest in and discussion of nuclear power, this is a useful text for high school science teachers to use to educate today's students.

Explaining these topics to pre-college students can be difficult. When used by someone who understands the concepts, this could be a useful text. There are several points that would need qualification: plutonium is consumed in a normal reactor since U238 does capture some neutrons; it no longer is "quite normal for a reactor to experience several SCRAMs each year"; France has not sold breeder reactors to other countries, but has sold pressurized water reactors (PWRs); the Department of Energy would be delighted if the cleanup of nuclear waste "will cost billions and take upwards of 20 years to clean up" since current estimates are for more than one hundred billion dollars and up to 70 years; and his concept that photons have mass needs explaining (he uses the mass equivalence of the photon's energy).

In response to my inquiry, Dr. Scheider said he was interested in getting his students to understand "that there is much more to being intelligent about policy than to make a decision to be for or against the whole thing." His students were fortunate. This is useful book for introduction to nuclear energy at the pre-college level and I enjoyed reading it.

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Risk and Reason: Safety law and the Environment.

By Cass R. Sunstein, Cambridge University Press. 2002. 346pp. ISBN 0 521 79199 5 (hard-cover $24.00 at www.bn.com)

This book is not what I expected. The "other" book I have on my shelves on the subject has 9 chapters on basic models, risk statistics, and specific quantitative analyses applied to a variety of problems, and one final chapter on the translation of analysis to decision making. Sunstein's book has no mathematical analyses, and is devoted largely to the material in the final chapter of my other book. Those with a mathematical mind may find this disappointing, and laborious to read. On the other hand it is an education to become aware of the complications involved in applying the technical analysis to the decision making process, to the political process and to the formulation of laws. These are the aspects with which this book is mainly concerned.

In Britain in 2000 a train crashed at Hatfield, injuring dozens of passengers and killing several of them. After the crash, railway travel suddenly became "unsafe" to many people and one third of the rail travelers started using the highway instead, despite the fact that Britain's roads are ten times more dangerous than its railways. This illustrates many of the problems studied in this book, including the public over-reaction to dramatic events, the over-reaction to small risks, and the failure of public intuitions as a basis for action. It also illustrates the need for understanding and dealing with the psychology of the public mind which is an essential part of this book. The author considers cost/benefit analysis as the better but imperfect basis for policy decisions. But the analysis must be complete, taking into account the myriad of consequences of a given line of action. For example, the effort to regulate a risk should not produce other more serious risks. Such an analysis involves very difficult decisions on how the various costs and benefits can be quantified--for example, how do you put a value on human life?

The first six chapters explore the history of the treatment of risks since the inception of modern-day environmentalism in the 1970s, and the general understanding of the background problems, particularly those involving the public misconceptions of risks. The author believes that if cost/benefit balancing is done well, regulation is likely to be more sensible than it is now, but he also admits and carefully explores its limitations.

With this background, the author examines in some detail the controversial suspension by the Bush Administration of the Clinton Administration's Arsenic in Drinking Water regulation. In this case, an analysis taking into account the uncertainties accompanying the quantification of basic costs and benefits produce such a wide uncertainty in the final result, that there is no precise answer to what the optimum allowable value of the arsenic concentration should be--only a broad range of possibilities. One of the important perennial uncertainties which physicists will recognize is the presence or absence of a threshold in the concentration of arsenic versus poisonous affect (dose-response) curve. In contrast, it seems that benefits clearly surpass the costs of the Clean Air Act. Decisive or not, the cost benefit analysis is valuable in clearly "putting on the screen" all the consequences of a line of action.

The resulting complexity can be mind boggling. Indeed, at weak moments I even develop some sympathy with the EPA (Environmental Protection Agency) and its administrator over the problem they face in deciding appropriate allowable levels of contamination. And that is not all. The EPA, the NHTSA (National Highway Safety Administration), OSHA (Occupational Safety and Health Administration) etc. have their mandates from Congress. The interpretation of these mandates can result in numerous court actions. A full chapter is devoted to the legal problems and what might be expected from reviewing courts.

This leads in the final chapter to the author urging a large scale shift in the law of risk reduction away from rigid government command and control regulations towards alternative strategies which allow for some flexibility on the part of the companies involved. In part, the rationale for using these strategies is that the same risk reduction can frequently be achieved at a much lower cost, potentially saving billions of dollars. These strategies include more effective communication to the public of risk information; economic incentives like emissions trading in the area of global warming; risk reduction contracts, and free market environmentalism.

The book is heavily documented throughout with footnotes. A series of four appendices give some useful and illustrative statistics and an interesting collection of dose response curves for a variety of systems.

In conclusion this book is basically concerned with the appropriate evolution of policy with respect to risk management. The technicalities dealing with the mathematics and statistics of risk are implied but not studied as such. The book is very highly detailed making it very significant reading for those interested in policy matters. The " technician" who does not normally work in these fields may feel that the book delivers more detail than he/she wants to know, but the book will be an eye-opener to those who persevere in their reading.

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[i] This paper stems from trying to answer that question for a presentation given at the panel discussion "Physical Protection of Nuclear Material and Facilities Post 9/11" at the American Nuclear Society's Annual Meeting on June 3, 2003.

[ii] Matthew Bunn, Anthony Wier, John P. Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*, Harvard University and the Nuclear Threat Initiative, March 2003, examine in detail the issues of standards and performance metrics as these pertain to the security of fissile material.

[iii] National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*, National Academy Press, Washington, DC, 1994, p. 34.

[iv] Bruno Pellaud, "Proliferation Aspects of Plutonium Recycling," *Journal of Nuclear Materials Management*, Fall 2002, pp. 30-38.

[v] J. Carson Mark, "Explosive Properties of Reactor-Grade Plutonium," *Science and Global Security*, Volume 4, 1993, pp. 111-128.

[vi] National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*, National Academy Press, Washington, DC, 1994, p. 31.

[vii] George Bunn, "U.S. Standards for Protecting Weapons-Usable Fissile Material Compared to International Standards," *The Nonproliferation Review*, Fall 1998, pp. 137-143.

[viii] Ibid, p. 138.

[ix] George Bunn, "Raising International Standards for Protecting Nuclear Materials from Theft and Sabotage," *The Nonproliferation Review*, Summer 2000, pp. 146-156.

[x] Charles D. Ferguson, Tahseen Kazi, and Judith Perera, *Commercial Radioactive Sources: Surveying the Security Risks*, Occasional Paper No. 11, Center for Nonproliferation Studies, January 2003.

[xi] DOE/NRC Interagency Working Group on Radiological Dispersal Devices, "Radiological Dispersal Devices: An Initial Study to Identify Radioactive Materials of Greatest Concern and Approaches to Their Tracking, Tagging, and Disposition," Report to the Nuclear Regulatory Commission and the Secretary of Energy, May 2003.

[xii] Robert Alvarez et al., "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States," *Science and Global Security*, Vol. 11, 2003, pp. 1-51.

[xiii] See for example, Matthew Bunn, John P. Holdren, and Anthony Wier, Securing Nuclear Weapons and Materials: Seven Steps for Immediate Action, Managing the Atom Project, Harvard University, May 2002, pp. 65-72; and Robert Civiak, *Reducing Stockpiles of Weapons-Usable Highly Enriched Uranium in Russia and Other Nations*, Federation of American Scientists, May 2002. Both reports discuss in detail how to structure a rapid down blending deal.

[xiv] U.S. General Accounting Office, "Weapons of Mass Destruction: Additional Russian Cooperation Needed to Facilitate U.S. Efforts to Improve Security at Russian Sites," GAO-03-482, March 2003.

[xv] Alan J. Kuperman, "Loose Nukes of the West," *The Washington Post*, May 7, 2003, p. A31; and Kuperman et al. letter to Senator Pete Domenici, Chairman, Committee on Energy and Natural Resources, May 28, 2003.