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Rules for Hide and Seek in Iraq

By Ivan Oelrich

A new round of UN weapons inspections is about to begin in Iraq and no one seems to know what to expect. Some in the Administration argue that the inspections are nothing but an Iraqi smoke screen and delaying tactic while others, most often among our allies, believe the inspections have some reasonable chance of either uncovering Iraqi weapons of mass destruction programs, or even showing that Iraq is free of forbidden weapons.

Much of the discussion about inspections has focused on the difficulty of finding chemical and biological weapons, but nuclear weapons are our greatest concern. If we focus on determining whether nuclear weapons are being built in Iraq, what rules would we need for inspections, and what are the chances that inspections could be successful? To answer those questions, we need to understand how inspectors

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Simulation for Skills Training in Medicine

By Gerry Higgins

Computer-based simulation has been used extensively in the airline industry and in the military for effective training of cognitive, perceptual and motor skills.[1] Medical simulators may include both three-dimensional (3D) models of human anatomy displayed on a computer monitor coupled with a "haptics" device that conveys a sense of touch to the user. Advances in computer technology now permit realistic modeling of human anatomy and physiology (See Box on p. 5). Computer-based simulations are now regularly used for training military medics in emergency and trauma skills.[2] The American College of Surgeons and other accreditation organizations are now encouraging the use of virtual reality simulation trainers for assessment of technical proficiency in medicine.

Advantages of Medical Simulations

A human patient simulator offers medical and emergency response personnel a hands-on opportunity to learn how to use new equipment and practice intricate procedures without endangering human life. Other advantages include:

- Significant anatomical differences in animals (and ethical considerations) are not encountered
- Problems associated with the cost and limited supply of cadavers are avoided
- The ability to train anytime without waiting for a patient to become available
- The opportunity to practice the same procedure multiple times

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The FAS Public Interest Report

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About FAS

The Federation of American Scientists (FAS), founded October 31, 1945 as the Federation of Atomic Scientists by Manhattan Project scientists, works to ensure that advances in science are used to build a secure, rewarding, environmentally sustainable future for all people by conducting research and advocacy on science public policy issues. Current weapons nonproliferation issues range from nuclear disarmament to biological and chemical weapons control to monitoring conventional arms sales; related issues include drug policy and space policy. FAS also promotes learning technologies and limits on government secrecy. FAS is a tax-exempt, tax-deductible 501(c)3 organization.

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- Military medical personnel can practice battlefield trauma care skills that they would have almost no chance to do during peacetime
- The chance to experience treating unusual diseases and practice rare procedures
- Groups can train together in the same simulated virtual environment for such events as terrorism events involving weapons of mass destruction
- Feedback is allowed by the ability to replay the entire computer-based simulation at whatever level of detail and from whatever point of view desired
- Computer-based simulators provide an ongoing assessment of the performance of the trainee, including metrics such as judgment, timing, sequencing of procedural steps, spatial accuracy, errors, etc.

The usefulness of simulators extent is beyond merely training new skills. Like playing a musical instrument or flying a plane, medical procedures involve both cognitive and technical skills that demand frequent rehearsal for proper execution. Unfortunately, skills such as Cardiopulmonary Resuscitation (CPR) are easily forgotten (see Figure 1). Treating a patient in crisis with the added burden imposed by dangerous settings such as a mass casualty event may produce a stressful experience for the medic. Crisis scenarios sometimes lead to faulty decisions and medical errors, and are not the ideal time for the medic to try to recall underutilized training. Simulators can be utilized by medical and emergency personnel to refresh their skills without having to practice on real patients.

The Effectiveness of Simulation-based Training

Many studies have found simulation to be an extremely effective training instrument. These include studies in which a meta-analysis of the simulation literature has been performed to provide a more sensitive measure of the benefits of this type of training, using "field effects analysis" and other statistical methods.[3]

There are several ways in which simulation-training efficacy can be

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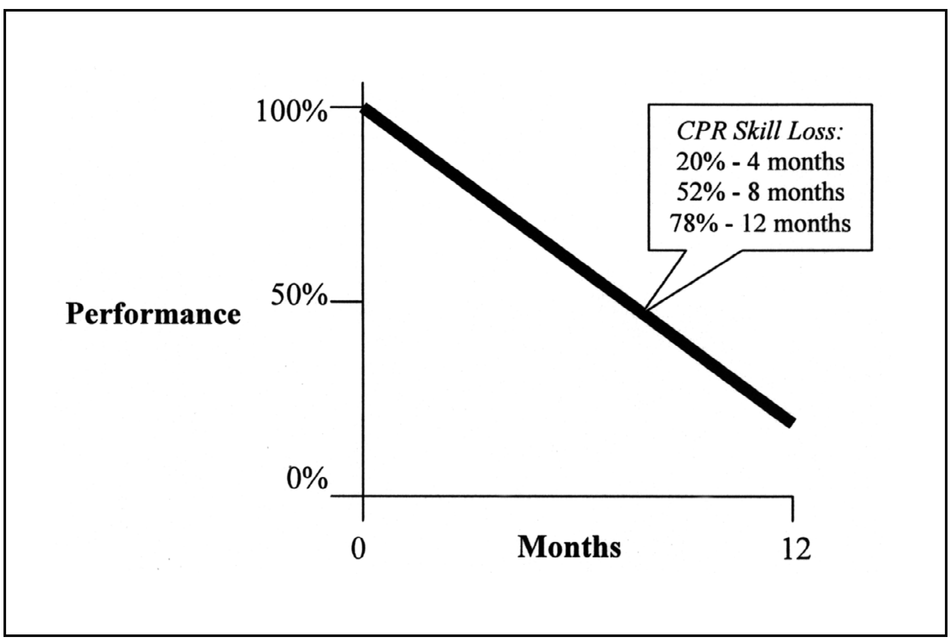

Figure 1: The 'Curve of Forgetting'. Decline in the number of soldiers able to perform CPR at an adequate level without refresher training. Adapted from Hagman and Rose (1983).

The Value of a Collaborative Learning Science and Technology Research and Development Roadmap

By Kay Howell

In order to fully realize the potential of information technology and dramatically improve how we teach and learn, we must first address many challenges. A key first step is to develop a research plan or roadmap that outlines a plan for progress – a well-articulated plan for how we get from here to there. Previous hype and over-promising has understandably resulted in much skepticism regarding the value of technology-enabled education. A detailed roadmap of the R&D needed to enable next generation learning systems can help address this by identifying key research questions and technical requirements and detailing a chronology of R&D activities over the next ten years, along with short- and long-term benchmarks with metrics for success. The process of developing the roadmap is essential. It will encourage discussion and debate throughout the community and lead to a scientifically informed map of research opportunities that can be used as a guide for agenda-setting, budget planning and project selection by government and industry.

Current research demonstrates that a fundamental transformation in education and training is now possible given recent advances in learning science and information technology. Research results and numerous research pilots have shown the potential of simulation-based microworlds, virtual laboratories, collaboratories, shared virtual realities, and intelligent tutoring environments to greatly enhance learning. These efforts provide strong evidence that the time is right for us to take action to enable affordable, routine use of these types of learning environments and to facilitate development of education and training content. To do this we need to develop of a wide range of interoperable, well-performing and extensible software tools that can decrease the cost of entry for educational materials and systems. These tools and educational systems, when evaluated and disseminated, will make possible education technology solutions that can scale in terms of users and economics.

Creating effective tools and testing new learning technologies — and the instructional management systems needed to exploit them — will be extraordinarily difficult. It will require significant and sustained R&D investment spanning decades. The scope of the effort will require a strong partnership with government, industry and private foundations. Development of a technology roadmap is essential to enable such a partnership. Current investments in learning science and technology are fragmented and often discontinuous, both within and across public and private sectors. There are many players in the learning technologies space, including for-profit companies (software, publishers, educational companies), educational institutions such as universities, colleges and schools, government agencies, and non-profit enterprises. There are no dominant companies or standards, and the application markets are extremely diverse and fragmented. The process of developing a technology roadmap will serve an important function to help focus this fragmented community. The roadmap should serve to improve communications and common purpose and provide a guide to research opportunities of value. The roadmap will provide an invaluable guide to define what progress is possible, the size and scope of investment needed to achieve the desired outcomes, the types of teams needed to undertake the R&D, the types of research programs required and metrics for evaluating progress.

The technology roadmap should attempt to answer the question "What advances in technology and learning theory are needed to ensure continuous progress towards the long term goal of increasing the effectiveness, efficiency, and accessibility of life-long education and training?" While the roadmap should be designed to achieve ambitious long-term goals, it should be also crafted to ensure that the supported research will continuously yield results that can be converted readily into viable products and services. The outcome of the research should not be a specific, marketable course or product, per se, but rather pre-competitive concepts and tools that can be adapted to multiple contexts.

Research topics to be explored should include:

- **Learning Science and Technologies** – how to make the most effective use of technology-enabled approaches to learning by combining the tools of cognitive science, pedagogy, instructional design and information technology.
- **Learning Tools** – how to build technically accurate virtual environments that permit exploration-based pedagogy; how to enable easy formation of teams and groups; how to provide responses to learners' questions; how to enable easy to assemble course building tools and support instructional designers in their selection of learning tools and pedagogical approaches.
- **Evaluation and Assessment** – how to measure the impact of the new approaches to learning services is essential for ensuring that real benefits are being achieved (and that a sound business case can be made for shifting to a new form of learning).

Inventing effective tools will require bringing an array of management tools to the innovation process in learning that, while widely used in other parts of the economy, are currently unknown in education. This includes an ability to manage a complex and systematic research enterprise capable of disassembling a large problem into components, and assigning goals to each component endeavor. The roadmapping activity should include a discussion of the management structures needed to manage the research and innovation process. ***PIR***

"Simulators" *Continued from page 2*

Simulator	TER	Student Time Savings	Acquisition Savings	Operating Savings	Life-Cycle Cost	Amortization
Flight	0.48	50%	30-65%	10%	65%	2 years
Maintenance	0.60	20-50%	20-60%	50%	40%	4 years

Table 1: Benefits Realized with Military Flight and Maintenance Simulators (Adapted from Orlansky et al, 1994)

measured. The measure most commonly used in aviation and the military for determination of simulation-based training efficacy is "transfer," that is, how much student performance can be transferred from the simulator to actual, real world procedures. The performance of a student trained only on a simulator can be compared to a control student trained with conventional methods by testing both students on the same criterion task. These data are evaluated using statistical tests designed specifically to compare simulation performance with actual performance in the real world. The results determine transference.

For all military simulators that have been examined for effectiveness and cost savings, training with simulators has been shown to be as effective as training on actual equipment. Many studies aimed at evaluating the effectiveness of simulation training have compared the amount of training time needed to perform a specific task in an airplane after training either only in an aircraft or following training in a simulator. This can be expressed as a quantitative value as the Transfer Effectiveness Ratio (TER). For example, Table 1 shows the median of 34 TERs compiled from 22 flight simulation studies is 0.48, meaning that about one half hour is saved in the air for every prior hour spent learning the same task in a simulator. Although this can be expressed as a transfer effectiveness ratio (TER), which has been reported for a number of cases in the literature,[4] more recent studies have not involved a formal determination of TER, but rather a combination of objective and subjective measures.[1,2,3,5]

Data is also emerging on the training effectiveness of medical simulators. For example, an objective evaluation of surgical residents randomly separated into two groups showed that the group that practiced weekly using a laparoscopy simulator and outperformed (statistically and clinically) the one that did not (laparoscopic surgery is a minimally invasive approach to common surgical problems in the abdomen accomplished through small keyhole incisions).[6] Also, the group that trained on the simulator showed a strong positive association between the number of their practice session and their performance.

Challenges

More progress is needed in a variety of areas before the full training benefits of medical simulations are realized. Examples include:

- Tissue models that respond in real-time to trainee inputs
- Improved haptic interfaces that provide a realistic sense of touching and manipulating in a virtual environment
- Graphics and visualizations that better replicate the real working environment of that medical and emergency personnel
- Improved metrics for assessing skill transfer
- Establishment of open source architectures that will allow researchers to read and modify the source codes of simulation software ensuring continuous improvements.

Computer-based medical simulators will not replace traditional training methods. Hands on experience with real patients with the supervision of an experienced instructor can not be replaced but advanced medical simulators can provide an ideal environment to try new techniques and procedures (and refresh one's skills) without risk to a patient.

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Digital Human

The Digital Human Project is an Open Source Software Consortium using information technology tools to represent the body's processes from DNA molecules and proteins to cells, tissues, organs, and gross anatomy.

Medical research is providing volumes of digital information about the human body. The breadth and quantity of emerging data has, however, made it difficult for researchers, students, teachers, patients, and clinicians to keep pace. The specter of an enormous library of knowledge with no card catalogue, no search engine, and no way to link new volumes of data is a very real concern. Fortunately, as our library of knowledge is filled with volumes of data about the human body, new computer tools are available to locate needed information and to grasp this information quickly by modeling how the complex systems of the body function and interact. By building a complete, functioning library of interactive views and simulations of human anatomy, physiology, pathology, histology and genomics based on the most accurate computerized imaging and simulation techniques available, we would have the complete *Digital Human*.

The medical benefits of a digital human will be significant. A *Digital Human* will provide a test platform to speed the development of new drugs and therapies. Physicians will be able to practice on simulated humans, reducing medical error and reducing the need to practice on patients. As medical knowledge expands, the model will keep pace allowing the specific pathology and disease of an individual to be displayed and customized for very individualized therapies. These may include surgery, drug interventions to modify physiological function, and tumor and cancer resections, with full knowledge of the exact spread of the problem and the margins of safe and effective therapy. Complex surgical procedures could be rehearsed in the virtual environment using the patient's anatomy prior to the actual procedure.

As they are developed, portions of the Digital Human could be adapted for use in education from high school biology to the certification of healthcare personnel and practicing clinicians. They could be used to evaluate medical devices, drugs, and therapies before they are tested on animal or human subjects. The system could also be used to improve the safety of automobiles, aircraft, and other vehicles, and for a variety of other civilian and military purposes.

For more information: http://www.fas.org/dh/index.html

"Iraq" *Continued from page 1*

would go about looking for nuclear weapons development.

The greatest challenge to making a nuclear bomb is getting the nuclear material, either plutonium or enriched uranium. The Iraqis have demonstrated clearly that they are following the uranium route and uranium enrichment will be a primary focus of UN inspections. Unlike production equipment used for chemical and biological weapons, it has no commercial equivalents, so it can provide unambiguous evidence of efforts to build a bomb.

The Iraquis have seriously pursued two enrichment technologies. They first investigated the use of large electromagnets. This approach is not very efficient, but it did provide an advantage to the Iraquis because the equipment could be produced indigenously, which is important when trade in nuclear equipment is restricted. The electromagnets used for uranium enrichment are distinctive but viewed from the outside a facility would not stand out from other industry. The process does require substantial amounts of electricity, though, so following the power distribution system could suggest possible inspection sites.

The Iraqis had problems developing the ion sources that would allow them to quickly produce enriched uranium using electromagnets, so they turned to centrifuges. Enrichment centrifuges spin at tens of thousands of revolutions per minute to separate the slightly lighter fissionable uranium from the slightly heavier, more common form of uranium. The aluminum tubes Iraq was trying to import were allegedly intended for use in these high speed centrifuges. Unfortunately, gas centrifuges are like electromagnets in only one regard: While the equipment is also distinctive, from outside the building housing a centrifuge facility would not stand out from other light industry.

Since nuclear weapons production requires distinctive equipment and processes, but most can be housed within otherwise ordinary-looking industrial buildings, the trick is in knowing what roofs to look under. Given this, what are the chances that UN inspectors will be able to find evidence of Iraq's nuclear program?

> ...the entire nuclear development program could, in theory, fit within just one of the presidential "palaces," so keeping them off limits would fatally undermine the inspections' integrity.

If we had to start cold, the chances would be poor. But we are not starting cold. Previous inspections have taught us a great deal about Iraq's old nuclear program. We know their sites, we know Iraq's preferred approaches, we know their people, and we have it all well documented. The Iraqis could have resumed activity at their old sites or started new construction, but either course risks alerting Western intelligence. It is highly unlikely that Iraq would abandon technologies that in 1998 they judged to be most promising, so inspectors know they are looking first for centrifuge work and second for electromagnetic separators.

Inspectors can interview those who were central to the weapons program. These scientists and engineers should be able to give coherent accounts of their professional activities over the last five years. Fabrication would be difficult. Orchestrating a consistent account of hundreds of lives will be nearly impossible.

Previous inspectors also collected prodigious numbers of documents — several hundred thousand pages worth — creating an audit trail that, although now years old, is vast and will suggest many likely inspection sites. Add to all this hints from Western intelligence and the odds are good that inspectors will be able to uncover some part of an Iraqi weapon's program. And finding just part is enough. The political environment has changed. Unlike the last round of UN inspections, which combined inspection with disarmament and needed, therefore, to be quite thorough, these inspections need not find all of Iraq's nuclear program, just enough to show that Iraq is still working toward a nuclear weapon.

Expecting to find something assumes, of course, that the inspectors are allowed to inspect whatever they need to. A cascade of one or two hundred centrifuges could produce enough uranium for a bomb in a year and would need only several thousand square feet of floor space. Unfortunately, this is small compared to what is available just within the presidential "palaces" that Saddam Hussein wants to keep partly off limits. Other critical components, for example, the conventional explosive "lenses" that drive nuclear explosions, can be designed, built, and tested in much smaller spaces than these sprawling restricted areas. In other words, the entire nuclear development program could, in theory, fit within just one of the presidential "palaces," so keeping them off limits

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would fatally undermine the inspections' integrity.

Most recently, discussion concerning Iraq has turned to whether surprise inspections of the palaces will be allowed; a crucial dissatisfaction is what constitutes "surprise." Chemical and biological munitions could be moved with short notice, even stored on a truck, but uranium enrichment equipment is bulky, permanently fixed, and thus much harder to move. If the Iraqis get less than a couple days of warning, inspectors should expect to find something. This knowledge should guide America and the U.N. in setting demands for the timing of inspections.

Aggressive inspections, then, operating with unfettered access, should find some evidence of a nuclear program if there is one there to find. But the question still remains: What should we do if, after thorough searches, inspectors come up with nothing? Indeed, there is a small risk that inspectors could come up empty handed even while Saddam is aggressively developing nuclear weapons, or he could be seeking black market enriched uranium, which would allow construction of a bomb with almost no chance of detection.

The real limitation of inspections, however, is not that they might fail to find an ongoing Iraqi program. It is that even perfect inspections will not reveal Saddam's long term intentions. And while Saddam Hussein's *intentions* may be the Administration's primary concern, they have tried to galvanize American support for action against Iraq by contending that Iraq not only wants nuclear weapons, but that it is actually *developing* them. Inspections will never resolve concerns about Iraq's future intent, but, conducted properly, they can go a long way toward answering questions about the state of his nuclear program right now. *PIR*

Two New Senior Reseach Associates Join the Strategic Security Program

Subrata Ghoshroy comes to FAS from the US General Accounting Office, where he served as Senior Defense Analyst and provided technical advice in the evaluation of weapons systems such as Airborne Laser, Land Warrior, Joint Tactical Radio, and most recently, in the evaluation of allegations of fraud in the National Missile Defense testing program.

Before moving to the policy world, Mr. Ghoshroy worked for 20 years as an engineer. He holds BS from Jadavpur University in Calcutta, India, and an MS degree from Northeastern University, both in electrical engineering. Mr. Ghoshroy also holds an MS in Public Policy from the University of Michigan. He began his professional career at Princeton Plasma Physics Laboratory, followed by two years at Brookhaven National Laboratory. He spent 12 years at Textron Defense Systems, where he worked as a program manager for high-energy laser programs.

In 1996, Mr. Ghoshroy was awarded a Congressional Science and Engineering Fellowship to work with the House International Relations Committee. Before moving on to the General Accounting Office, Mr. Ghoshroy spent two years as a Professional Staff Member for the House Armed Services Committee, where he was responsible for Science and Technology programs and Department of Energy nuclear weapons programs.

At FAS, Mr. Ghoshroy's work will focus on the weaponization of space and non-proliferation in South Asia. Mr. Ghoshroy is also a Senior Associate with the Science Technology and Public Policy Program at the John F. Kennedy School of Government at Harvard University.

Ivan Oelrich comes to FAS from the Institute of Defense Analyses (IDA), where he was a Research Staff Member. Dr. Oelrich received his BS from the University of Chicago and a PhD from Princeton University, both in chemistry. He continued with postdoctoral positions at Lawrence Livermore National Laboratories and in the Physics Department of the Technical University of Munich in Germany where he continued his work in nuclear physics.

Dr. Oelrich's introduction to national security began at the IDA, where he spent a total of 12 years. During his initial tenure, he evaluated new technologies for defense applications, including new sensors and advanced propulsion systems and aircraft, and supported the START and INF negotiations. When he returned to IDA 5 years later, Dr. Oelrich focused on environmental restoration of lands belonging to the Departments of Defense and Energy, new technologies for environmental testing and cleanup, and provided technical support to the land mine arms control treaty negotiating team.

Dr. Oelrich has also held a number of positions outside of IDA. He spent one year as a fellow at the Center for Science and International Affairs at Harvard University where he wrote on conventional arms control limits, followed by 4 years as a Senior Analyst at the Office of Technology Assessment studying the defense industrial base. Dr. Oelrich also spent one year at the Defense Threat Reduction Agency, where he focused on emerging nuclear threats and supported General Shalikashvili's review of the Comprehensive Test Ban Treaty.

At FAS, Dr. Oelrich will work on issues related to nuclear testing and the testing moratorium as well as sizing military forces in the post-Cold War world. *PIR*

Should We Recommend that People Stay Indoors During Smoggy Days?

By William Fisk

Public health officials and air quality management districts frequently recommend that people stay indoors during air pollution episodes. Given the risks of indoor air pollution, is this good advice?

It has been well documented that the indoor concentrations of many air pollutants are normally much higher that outdoor concentrations (e.g., Ott and Roberts 1998, Wallace 2001). These elevated indoor concentrations occur for pollutants emitted indoors, for example, from smoking, cooking, building materials, and consumer products, and for pollutants like radon that enter buildings from the surrounding soil.

People are advised to remain indoors primarily when outdoor air concentrations of ozone or particles are several-fold higher than typical concentrations outdoors. The health risks of elevated outdoor ozone and particle concentrations have been well documented, resulting in National Ambient Air Quality Standards for these pollutants. Buildings do, in fact, provide significant sheltering from ozone and particles from the outdoor air, at least when windows and doors are closed. The sheltering from ozone occurs because ozone reacts with indoor surfaces, reducing indoor concentrations below those outdoors. Ozone concentrations are almost always higher outdoors than indoors, because most buildings have no significant ozone sources. In homes, the indoor ozone concentrations are normally less than 50% of outdoor concentrations (Weschler 2000). Hence, remaining indoors will nearly always reduce our exposures to ozone.

The benefits of remaining indoors to reduce particle exposures are less clear-cut, because many buildings have significant indoor sources of particles. In residences, indoor particle concentrations are, on average, approximately equal to outdoor concentrations (e.g., Clayton et al. 1993). However, if one just considers the particles from outdoor air, the building provides sheltering because particles are removed indoors by deposition on surfaces and, in many buildings, also by particle filtration. Thus, concentrations of particles originating outdoors will be lower indoors than outdoors. The degree of sheltering varies considerably with particle size and building characteristics and can be intentionally increased, for example by using efficient filters in a sealed building. Despite the existence of indoor sources of particles, remaining indoors during episodes of high outdoor particle episodes may still reduce total particle exposures. If indoor and outdoor particle concentrations are normally comparable, during periods of highly elevated outdoor particle concentrations, total indoor particle concentrations will usually be lower than concentrations outdoors. Also, the adverse health effects of outdoor-air particles are, at present, more clearly documented than the health effects of indoor-generated particles.

So, should we recommend that people stay indoors during outdoor air pollution episodes? Staying indoors will increase our exposures to the indoor-generated pollutants, such as formaldehyde and many other volatile organic compounds, allergens from pets, and tobacco smoke. We trade off one risk for another, and these risks are not quantified with sufficient precision for a definitive answer. However, in my opinion, it is probably good advice in general to recommend that people stay indoors during episodes of unusually high outdoor air pollution, unless the building has particularly strong indoor pollutant sources such as tobacco smoking. ***PIR***

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Academy Report Addresses CTBT Issues: Where Do We Go From Here?

By Lynn R. Sykes

In July the National Academy of Sciences issued its long-awaited report "Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty." This thorough, intelligent and easy to read study addresses three main topics: the safety and reliability of US nuclear weapons under a test ban, monitoring and verification, and the potential impact of possible foreign testing on US security interests and concerns. This study, like the Academy's 2001 report on climate change, is one of its most important documents in several years; it deserves to be read and distributed widely. The report provides a strong rationale for the Senate to hold thorough hearings on the test ban treaty, which were largely lacking prior to its defeat of the CTBT in October 1999.

General John Shalikashvili (US Army, ret.), a former Chairman of the Joint Chiefs of Staff and then the Special Advisor to the President and the Secretary of State for the CTBT, requested the Academy study in April 2000. Committee members included former directors of the Los Alamos, Sandia, and Oak Ridge national laboratories; other experts on nuclear-weapon design, testing, and maintenance; a leading expert on seismic verification of nuclear explosions; and a former commander in chief of US forces in the Pacific. Harvard professor John P. Holdren, who deserves much credit for seeing the report finalized and published, chaired the committee. Studies of this type require extensive security reviews by several federal agencies before they are released.

Verifying the CTBT

The study finds that verification of the Treaty would be accomplished through a combination of the International Monitoring System (IMS) established under the treaty, openly available geophysical data collected for other purposes, and information gathered by US military and intelligence agencies. To my knowledge the report represents the first summary of global and regional capabilities for the four types of monitoring systems employed by the IMS for all environments-the atmosphere, the oceans, underground, and outer space. Monitoring capability is described in the report in two ways. First for tests conducted as in the past without evasion, the conclusion is that "nuclear explosions with a yield of 1 kiloton (kt) or more can be detected and identified with high confidence in all environments." A kiloton is equivalent to 1,000 tons of chemical high explosive. The weapons that opened the nuclear age in 1945 had yields of 13 to 25 kt; today's strategic thermonuclear weapons are typically 100 kt or more.

The report finds that verification capabilities are significantly better than has commonly been believed and extend down to a yield of 0.1 kt (100 tons) for underground explosions in hard rock if they are conducted anywhere in Asia, Europe, North Africa, and North America. Second, accepting the possibility of serious evasive efforts, the report points out the many layers of difficulty in the two evasion scenarios that need to be taken seriously, and concludes "an underground nuclear explosion cannot be confidently hidden if its yield is larger than 1 or 2 kt." Only highly experienced nuclear-weapon states such as the US, Russia, and China would be likely to succeed at concealment at smaller yields. Such constrained testing, however, would not add significantly to the nuclear capabilities those states already possess.

Maintaining Reliable Weapons in U.S. Stockpile

The report concludes that the US has the technical capabilities to maintain confidence in the safety and reliability of the weapons in its existing nuclear stockpile without periodic nuclear explosive tests, provided that adequate resources are focused on the essential ingredients of a strategy for achieving this. Those ingredients include maintaining a rigorous stockpile surveillance program, maintaining the capacity to remanufacture aging nuclear weapons to the original specifications, conducting rigorous reviews of any proposed changes to those specifications, and attracting and retaining a high-quality work force in the nuclear-weapons complex.

The report recommends periodic independent reviews of "the acceptability of age-related changes relative to original specifications and the cumulative effect of individually small modifications" in stockpiled weapons. The study concludes "Even in the absence of constraints on nuclear testing, no need was ever identified for a program that would periodically subject stockpile weapons to nuclear tests. . . nuclear testing never provided—and was never intended to provide—a statistical basis for confidence in the performance of stockpiled weapons. . . Thus, nuclear testing in itself is intrinsically ill-suited to monitor the health of the stockpile." It goes on to find "Stockpile stewardship by means other than nuclear testing, then is not a new requirement imposed by the CTBT." Finally, the committee states that the high costs of major new initiatives at the weapons labs, such as the National Ignition Facility, "should not be allowed to crowd out expenditures on the core stewardship

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functions, including the capacity for weapons remanufacture. . ."

> The report concludes that verification capabilities are significantly better than has commonly been believed...

Potential Impact of Foreign Testing with and without a CTBT

I found that the chapter on "Potential Impact of Foreign Testing: U.S. Security Interests and Concerns" to be the most informative and new part of the Report. It describes what additions to nuclear capabilities other countries could achieve through testing at yields that might escape detection, what they could accomplish if they adhered to the CTBT, and what they could do in the absence of the Treaty. My review here does not do justice to the much informative and wise conclusions of this chapter. The committee admits that the chapter gives some attention to items that are not wholly technical in nature including related military and political questions of the impact of foreign testing on the security interests and freedom of action of the United States. While not strictly in their charge, they conclude that these must be mentioned by way of context for the narrower questions they address.

Table 3-1 of the Report lists what can be accomplished by testing in six different yield regimes for countries of 1) little prior test experience and/or design sophistication and 2) those with greater experience in both areas. They summarize the possibilities for Russia and China, for India and Pakistan (states with very limited test experience), and for countries without nuclear test experience (North Korea, Iran and Iraq). What Russia and China might achieve from clandestine testing would not add significantly to the nuclear threats they already pose to the US. The Report states that considerable weapon-design experience is required to achieve low yields. Hence, other states are much less likely to succeed in concealing significant tests.

Where Does the United States Go from Here?

The Executive Summary of the Report ends with a powerful conclusion "The worst-case scenario under a no-CTBT regime poses far bigger threats to U.S. security—sophisticated nuclear weapons in the hands of many more adversaries—than the worse-case scenario of clandestine testing in a CTBT regime, within the constraints posed by the monitoring system." A potential indirect effect of a no-CTBT regime is a "breakdown of the Non-Proliferation Treaty, manifested in more widespread testing (by such countries as North Korea, Iraq, and Iran, for example), which could lead in turn to nuclear weapons acquisition by Japan, South Korea, and many others."

A report submitted by Gen. Shalikashvili to the President on January 4, 2001 in his role as special advisor for the CTBT is well worth reading along with the Academy's document. He states, "My discussions over the last ten months have only strengthened my view that the Treaty is a very important part of global non-proliferation efforts and is compatible with keeping a safe, reliable U.S. nuclear deterrent. I believe that an objective and thorough net assessment shows convincingly that U.S. interests, as well as those of friends and allies, will be served by the Treaty's entry into force." He urges that the Test Ban Treaty be re-evaluated "as part of a bipartisan effort to forge an integrated non-proliferation strategy for the new century." He recommends several measures to provide for increased verifiability and stockpile reliability. He advocates a joint ten-year Executive-Legislative review of the full range of issues bearing on the Treaty's net value for national security in response to concerns about the Treaty's indefinite duration.

Clearly, Gen. Shalikashvili's recommendations and the findings of Academy argue for thorough Senate hearings on the Treaty. President Bush has said that he does not intend to end the nuclear testing moratorium that the United States has observed since 1992, but also that he opposes the treaty and does not intend to seek its ratification. These two reports represent an opportunity to rethink that position. The Washington Post featured the Academy study in its editorial for the August 6 anniversary of the Hiroshima bombing stating, "Now the substantive arguments [against the CTBT] have been addressed by a committee of unquestioned experts and have been found meritless. This treaty, once near-dead, ought to be revived." Nevertheless, few other media covered the Academy Report. FAS and other NGOs need to take the lead in making it and Gen. Shalikashvili's report better known.

The State Department issued

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press guidance for August 6 (Hiroshima Day)—what to say in response to the question "What does the State Department think of the study released by the NAS on CTBT? Answer: The committee that drafted the study makes clear that it was not asked to make policy recommendations and did not do so. This administration reviewed issues related to nuclear testing, including those considered by the National Academy, and concluded that as a policy matter it did not consider the CTBT to be in the interest of the United States. We have no plans to ask the Senate to reconsider the Treaty." Clearly, those responsible for this statement did not read even the last sentence of the Academy's Executive Summary, which goes well beyond mere technical details.

The present U.S. moratorium, of course, could be overturned at a moment's notice. In the last 6 months some DoD officials and right-wing Congressional Republicans have pushed for a renewal of U.S. nuclear testing, stating concerns in all three areas covered by the Academy Report: decreased stockpile reliability as weapons age without testing; reputed intelligence findings that Russia and China are testing at low yields, and the need for new more useable nuclear weapons to deal with post-Cold War threats.

One oft-stated perceived need is for the development and testing of a deep-penetrating nuclear warhead to attack deep underground facilities such as bunkers. The use of such a weapon, however, would result in major radioactive leakage to the atmosphere (and hence to the surrounding territory) and to the loss of many lives if detonated in or near a populated area (see Robert W. Nelson, PIR, vol. 54, #1, 2001). While the Academy study finds that the stockpile of existing weapons can be reliably assured without testing, it notes that new advanced nuclear weapons of any country cannot be counted on to work without testing. China and countries with little or no test experience have more to gain vis-à-vis the U.S. or Russia if nuclear testing restarts. The recent reports of Russian and Chinese testing in the media are non-specific as to even approximate dates. The claims of Russian nuclear testing on two dates in September 1999, however, were challenged on the grounds that no seismic waves were detected from the Russian test site at any times on those dates. The data for more recent claims need to be examined by independent scientists who hold appropriate security clearances.

The road to U.S. ratification of the CTBT will not be an easy one since the divide among Senate Republicans over the Treaty is representative of a deep philosophical clash between internationalist and unilateralist approaches to foreign policy. The internationalists in the Party need to be assured that the Treaty and an integrated non-proliferation strategy as advocated by Gen. Shalikashvili are in the national interest.

About the author:

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Correspondence

Dirty Bombs: An Exaggerated Threat

As physicists with decades of experience in handling radioactive materials, we question several aspects of the article "Dirty Bombs: Response to a Threat," in the March/April 2002 PIR.

First, missing are the source terms — isotope quantities, pulverization, dispersal parameters — and radiation consequences. And, despite the statement that the analysis could be found on the (otherwise outstanding) FAS Web site, it was not posted. Subsequently, the PIR printed some minimal information, which actually reinforced our original concerns, confirming that the assumptions (e.g. "complete dispersal") were based on a worst-case analysis, not unlike that which skewed Cold-War arms build-ups and still continues with exaggeration of the hazards from radiation.

Second, ignored are the carefully considered findings of the Heath Physics Society and the congressionally mandated National Council on Radiation Protection and Measurements. The latter's web site (www.ncrp.com) advises that there is a "need . . . to be attentive to the psychosocial effects of terrorism involving the dispersal of radioactive material. The . . . release of a tentative 'worst case' assessment may unduly alarm the public." In other words, don't resort to hyperbole. Inducing fear in a population plays into the hands of terrorists.

Third, the article fails to assess realistically the likelihood that terrorists could disperse radioactive material with the efficiency assumed.

Fourth, the FAS missed an opportunity to spotlight a dubious

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supposition: It is misleading to unquestionably apply the "linear no-threshold" (LNT) model of radiation damage, when it is an unsubstantiated assumption that has been widely and competently challenged.

Fifth — LNT controversy aside — a more serious transgression is to unduly mislead and alarm the public by invoking a hypothetical, fraction-of-a-percent increase in cancer probability without putting it in context.

The report would have benefited from external review commensurate with its technical parameters and significance to public policy. Although we disagree with the report's analysis and "Conclusions" regarding dirty bombs, we do concur with the FAS "Recommendations" on dealing with credible radiation threats.

— A. DeVolpi and G. S. Stanford (long-time dedicated FAS members and former members of the FAS Council)

FAS responds:

Contrary to the writers' claim, our results were not "worst case"—for example, changes in deposition velocity and atmospheric stability class can increase the "contaminated areas".

We did not assess the difficulty of dispersing the materials out of concern over releasing too much information. Statements in the press that a dirty bomb can be made simply by wrapping radioactive materials with dynamite are incorrect, but neither are assumptions that it is prohibitively difficult to release the materials.

The purpose of our analysis was not to calculate fatalities, but to estimate what areas would fall within decontamination guidelines; the guidelines are based on the linear, no-threshold model of radiation damage. In addition, we did place the numbers in context—that is why our maps were labeled with percentage-cancer increases rather than simply "EPA contaminated area." We also noted that we felt the guidelines were too strict.

The writers assume incorrectly that the work did not undergo external review. In fact, our assumptions were reviewed by individuals in academia and government, including at least one FAS board member, before publication. After publication they were favorably reviewed by several other experts experienced in radiation and weapons effects.

— Michael Levi *PIR*

ATTENTION FAS MEMBERS:

In our continuing effort to provide FAS members with lively and timely articles in national security policy and other areas of science and technology policy, we are inviting members to submit proposals for articles in areas of interest to FAS members (maximum 1000 words). Selection of the articles is at the discretion of the Editor. Completed articles will be peer reviewed.

Proposals should be sent to the Editor, *PIR*, Federation of American Scientists, 1717 K St. NW, Suite 209, Washington, DC 20036, or to fas@fas.org. Please provide us with your full address including email in all correspondence.

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