FAS
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FAS Celebrates 60 Years

The Federation of American Scientists will mark its 60th Anniversary with a day-long symposium at the National Press Club in Washington, DC, on Wednesday, November 30, 2005.

The event will include two panel discussions, each followed by questions from the audience. The panels will focus on the two major issues of importance to the founders of FAS.

The morning panel will feature the international control of nuclear materials, an idea recently revived by the Secretary General of the International Atomic Energy Agency and Nobel Laureate Mohammed ElBaradei. The afternoon panel will discuss whether development of nuclear weapons should remain under the civilian control of the Department of Energy or be moved to the Department of Defense.

To RSVP for this event, please email events@fas.org or call 202-546-3300. ■

Thinking About The Reliable Replacement Warhead

By Ivan Oelrich, Vice President of Strategic Security for FAS

The United States maintains an arsenal of thousands of nuclear weapons with yields of hundreds of kilotons. All of these weapons are left over from the Cold War and sometimes called "legacy weapons". Although modifications to existing weapons, such as enhancements to allow greater shock-wave coupling to the earth, are possible and sometimes explored, the Administration is not developing wholly new types of nuclear weapons. Nor does the United States currently build replacement weapons; it maintains existing weapons. When any sophisticated piece of machinery ages, confidence in its performance will wane unless some measures are taken to assure its reliability. This is true of nuclear weapons and the United States has developed elaborate procedures for monitoring changes in its nuclear weapons while predicting and mitigating the effects of any discovered changes. The overall program of inspection, monitoring, and maintenance is called the Science-Based Stockpile Stewardship Program (SBSSP).

While almost all nuclear experts agree that the SBSSP is now adequate to assure extremely high confidence in the current stockpile, many have concerns about the long-term ability to maintain the stockpile for an indefinite future.[1] Even those who believe that long-term maintenance is possible believe the cost of the program will continually increase.[2] In addition, there is a growing realization that the types of nuclear weapons the country has left over from the Cold War are not appropriate for current or future nuclear missions (although there is no agreement about what the future missions and arsenal should be). A Reliable Replacement Warhead (RRW) has been proposed as

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Journal of the Federation of American Scientists

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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 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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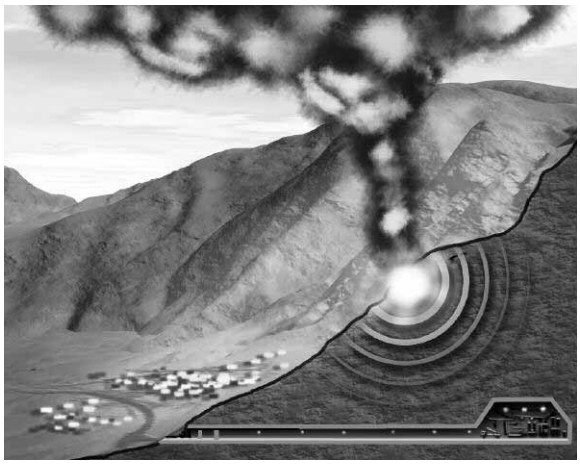
The Nuclear Bunker Buster Is Dangerous, Ineffective, and Unneeded

By Ivan Oelrich, Vice President of Strategic Security for FAS



On October 26, Pete Domenici, Republican Senator from New Mexico and Chairman of the Senate Committee on Energy and Natural Resources, announced that Congress halted funding on the Robust Nuclear Earth Penetrator (RNEP), or "nuclear bunker buster," at the request of the administration. The effort will be transferred from the Department of Energy's nuclear weapons lab to the Department of Defense, which will seek conventional, non-nuclear solutions for this military mission.

This is a major victory for a saner nuclear policy. There was widespread confusion in the public and press about nuclear bunker busters — confusion that the administration did little to correct.

A number of reports conflated nuclear bunker busters with so-called "mini-nukes." Putting aside for the moment that a "mini" nuclear weapon is defined as one with an explosive yield of five thousand tons of TNT, or one third the size of the bomb that destroyed Hiroshima, the bunker busters were genuinely gigantic bombs. The largest being considered had a yield of 1.2 million tons of TNT.

The other misconception was that the bombs would burrow deep inside the Earth before detonating, substantially reducing effects on the surface. In fact, the bombs would penetrate at most only a few meters into rock, causing no reduction in blast, fire, or fallout damage on the surface. The largest RNEP would have blown out a crater almost a thousand feet across and thrown a cloud of radioactive fallout tens of thousands of feet into the air where it would then be blown hundreds of miles downwind.

Even with this enormous power, nuclear weapons are not particularly effective at destroying deep underground tunnels. The National Academy of Sciences reported that even megaton bombs could not reliably destroy tunnels more than 300 meters deep.

Nations around the world started putting critical facilities underground in response to precision-guided weapons that made virtually all fixed surface targets vulnerable. The response to a nuclear bunker buster is obvious: just dig deeper. Any nation that can dig under a hundred meters of hard rock can dig under a kilometer of hard rock.

U.S. nuclear weapons simply have no remaining role on the battlefield of the future. Abandoning the RNEP is a big step toward a more rational, safer, nuclear policy. ■

Attention FAS Members

In our continuing effort to provide the FAS community with timely articles about national security policy, learning technologies and other areas of science and technology policy, we are inviting members to submit proposals for articles (maximum of 1,000 words). Selection of articles is at the discretion of the Editor and completed articles will be peer-reviewed.

Please provide us with your full mailing address, including email in all correspondence.

Proposals should be sent to: Editor, *PIR,* Federation of American Scientists, 1717 K Street, NW, Suite 209, Washington, DC 20036, or to press@fas.org.

one solution to both the problem of maintenance and appropriateness.

Intelligent debate about the RRW is difficult or impossible at this point because of two important deficiencies: (1) it is not clear what the RRW is[3] and (2) there is no consensus about what the RRW is for. The second shortcoming is the more crippling to discussion and must be addressed first. Indeed, deciding what the RRW is for will define what it ought to be.

Nuclear Missions and Doctrine

Almost two decades after the end of the Cold War, the United States does not have a coherent strategy and doctrine for the deployment and use of nuclear weapons. The United States does have a written nuclear doctrine.[4] Like any such high-level statement, U.S. nuclear doctrine is short on specifics; in the case of nuclear doctrine this lack of specificity is intentional as well as inevitable. Even with the doctrine being quite general, the gap between doctrine and the actual U.S. posture is huge, to the point that they seem unconnected.

U.S. doctrine recognizes that the world is much changed since the Cold War. The doctrine emphasizes threats from smaller regional nuclear powers, terrorists, and "rogue" states and is sometimes quite aggressive in discussion of nuclear attack against these threats.[5] Yet the nuclear forces the United States has today are not at all suited to these missions. In fact, the weapons best suited — small tactical nuclear weapons including nuclear artillery, intermediate range nuclear-armed missiles, ground-launched cruise missiles, and gravity bombs delivered by tactical aircraft — are precisely the weapons the United States has retired and dismantled since the last years of the Cold War. If the United States had kept all the nuclear weapons it got rid of over the last quarter century and got rid of all the nuclear weapons it kept, it would today have a nuclear arsenal more appropriate to its *stated* nuclear doctrine.

The most glaring disconnect between rhetoric and reality involves Russia. Officially, the United States does not consider Russia an enemy and does not target nuclear weapons against Russia. The U.S. nuclear arsenal is justified as a response to nuclear and other threats from China, Iran, North Korea, Syria, and, until recently, Iraq and Libya, plus potential unspecified threats that might arise in the future. Yet the sum of all these real and potential threats does not come anywhere close to justifying the thousands of nuclear bombs currently sitting atop highly accurate, fast-flying missiles ready to launch at a moment's notice. In particular, the listed threats do not require constant forward deployment of thousands of accurate, powerful warheads aboard missile-carrying nuclear submarines. The U.S. arsenal was designed for, and still deployed for, a disarming surprise first strike against Russian central strategic nuclear forces. This mission is easily the most stressing one faced by U.S. nuclear forces and it determines U.S. nuclear force structure and deployment and it is the one targeting mission that U.S. doctrine explicitly excludes.

The principal ostensible justification for nuclear weapons is deterrence, yet most current discussions of deterrence offer little guidance for evaluating the RRW. Most agree that deterring a war is better than fighting a war. Even the most ardent advocates of nuclear weapons get queasy about suggesting their actual use, but advocating nuclear weapons as a deterrent is widely acceptable. When proposing new nuclear weapons or capability, such as the Robust Nuclear Earth Penetrator (RNEP), the Administration is careful to emphasize that the threshold for nuclear use is and will remain high and the primary purpose of any nuclear weapon is to deter. Yet what is being deterred is rarely spelled out with any clarity.

What is the RRW?

Given that U.S. nuclear doctrine is both vague and unhinged from reality, how are we to evaluate the RRW? How can we judge whether it meets its goals and missions if we cannot publicly admit what those are? Should the RRW be a weapon of last resort, able to retaliate for nuclear attack on the United States, and thereby deter such attack? Is it a battlefield weapon? Capable of a disarming first strike against Russia? Must it be always ready for instant use or could it be stored disassembled? Without answers to these questions we do not know what yield it should have or whether it is to be a missile warhead or an aircraft-delivered gravity bomb or fit on a cruise missile. Some language in the House defense appropriations bill list goals for the RRW but does not specify the RRW's physical parameters.[6]

The minimalist approach to an RRW would be modification of existing warheads. This might be as simple as selecting parts that currently need frequent evaluation or replacement and carefully redesigning them for longer life or easier manufacture. Modifications might include some fundamental changes, such as widening the radiation channels between the primary and secondary, that clearly make the warhead performance less sensitive to small deviations from design specifications.

The RRW could be a warhead not now in the inventory: either a genuinely new warhead or resuscitation of one based on some existing, well-tested design that is not now deployed. Some nuclear experts seem certain that the United States could have complete confidence in a new design without testing, provided the warhead was designed for simplicity and reliability and not for maximum yield and minimum weight. (Regardless of the actual engineering need for testing, some argue that a new warhead would inevitably require testing just to give U.S. and foreign leaders confidence in its reliability.) There are many designs available that are well tested and could form the basis for a new, reliable warhead.

Importantly, "the" RRW might be more than one warhead. Some have suggested developing a few simple primary and secondary designs that could be com-

bined in various ways to cover a wide range of performance.[7]

Evaluating the RRW by Arms Control and Arms Reduction Goals

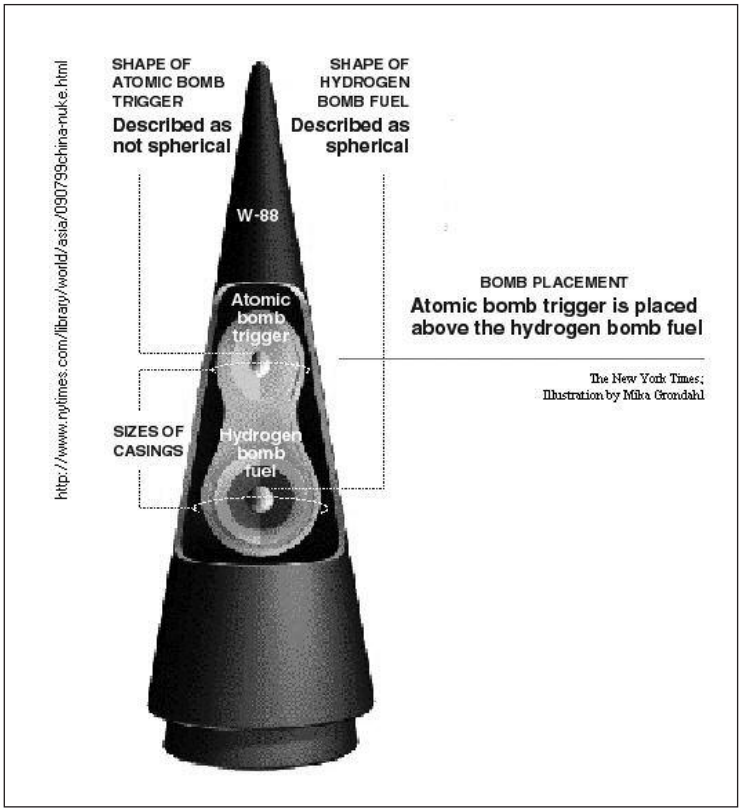
Congressman Hobson and others have called for a long overdue top-to-bottom reevaluation of the post-Cold War roles[8] and missions of nuclear weapons and the RRW could be the ideal vehicle for that debate. Indeed, that debate should shape and define the RRW as it evolves.

The following discussion is from the perspective of one who wants to substantially reduce the political and military salience of nuclear weapons, both for the United States and the rest of the world. In that case, what should RRW be? Is there any potential RRW that moves us in the right direction? It seems inevitable that some proposal for some sort of RRW will come forward, forcing discussion on several issues that are now quiet. Moreover, nuclear advocates have shown signs of trying to craft supposed tradeoffs to confound opposition to the RRW. For example, if the United States could conduct just a few nuclear tests, then the resulting increase in confidence would allow, so it is argued, major future reductions in numbers of nuclear weapons. If this were a genuine tradeoff — which it is not — then it would present a genuine conundrum for those who both oppose testing and want to further reduce nuclear arsenals. The RRW could present several such conundrums. Some of the possible RRWs will be clearly beneficial or at worst harmless; other possibilities will clearly be undesirable. For most cases, however, whatever the question about the RRW, the answer will be the same: "it depends." Often, what it will depend on is whether Administration promises of a deal can be trusted. An RRW might be sold as a way to reduce weapon numbers. But once it is developed and deployed, will a future Administration actually keep its promise and destroy existing warheads? What may seem clearly to be a good deal in theory may be viewed suspiciously in the real world.

One reason the United States keeps its large inventory of nuclear weapons is as a hedge against system-wide failure in any particular type of weapons. For example, while the W-88 is the newest deployed warhead on U.S. submarine-based missiles, W-76s are kept active in case the W-88 is discovered to be unreliable. In general, following this approach, for every deployed warhead, at least two, of different types, must be active and maintained.

The RRW might be able to address this problem of redundancy. If the United States had total confidence in an RRW, there would be no need for backup warheads. It could replace both the W-86 and the W-76 (recognizing that the RRW might be a modification of one of these two warheads). Thus, an RRW might foster reductions in numbers. Not necessarily, however. Perhaps the Pentagon would just use the RRW to replace the warhead with the lower perceived reliability. Then we have different warheads, but the same number. If two types are good, then three might be judged to be better and the RRW does not replace, but augments, existing warhead types. Numbers could then go up. The only advantage of that outcome is that pressure to test might go down.

If the current Administration proposes an RRW to allow reduction in warhead redundancy, it will almost certainly propose designing, developing, and then producing the new warhead to "see how it goes," before destroying existing warheads. Prudence cannot justify this approach. If the proposed RRW is by design very simple to manufacture, very simple in operation and therefore reliable and, moreover, designed to be reliable without testing and is, in fact, never tested, then we will know everything we can ever know about the weapon's performance when it is still a drawing. Being designed for simple manufacture, we will know everything there is to know about its production after the first unit is assembled. If this is the form the RRW takes, Congress may wish to stipulate that, for every unit produced, one or more existing weapons must be dismantled.



Arms control advocates are divided between those with the long term goal of nuclear abolition and those who want to reduce nuclear weapons to a small, but finite, number, perhaps hundreds or even dozens held by the established nuclear powers. If the goal is abolition, then one could imagine getting there through an ongoing, long-term dismantling of existing warheads until none are left. Building an RRW would introduce an additional, and unneeded, step on that long path. Thus,

abolitionists might oppose the RRW. But abolitionists do not foresee achieving their goal soon. Most abolitionists probably believe that, short of zero, smaller numbers are better than bigger numbers. Thus, it might be a fair trade to develop an RRW that allowed steep reductions sooner even if eventual abolition is put off for another generation. In this case, even abolitionists might support some form of RRW.

Even some anti-nuclear voices argue that abolition is impossible because knowledge of nuclear weapons cannot be erased. Moreover, abolition may actually increase worries about nuclear weapons and be inherently unstable. If a potential enemy has one nuclear weapon — instead of zero — that is a great concern, while the difference between one hundred and a hundred and one is of little concern. Thus, the most stable arrangement, some argue, is for the established nuclear powers to have a very small number —probably in the double digits — of invulnerable secure warheads. It is almost dogmatic among most nuclear opponents that neither the United States nor any other nation should assign new missions to nuclear weapons. Some argue that this implies that there should be no new types of nuclear weapons. But if the goal is some very small and indefinitely stable nuclear arsenal, then current nuclear weapons are almost certainly not appropriate and some types of RRW might help us move toward this desired end state.

If an RRW is going to be part of a long-term, much reduced arsenal, what should the RRW be? The minimalist RRW, simply making small changes in existing warheads, maintains the status quo. This is an acceptable, indeed the least risk, option for those who put the highest premium on not creating new missions. Some possible RRWs could be radically different weapons, however. For example, some have suggested that the RRW might use uranium rather than plutonium to fuel its primary.[9]

Indeed, the RRW could go back to the simplest possible nuclear device, a gun-assembled uranium bomb designed to be extremely reliable without testing and could be easily stored disassembled for safety. This RRW would have a yield substantially less than today's thermonuclear weapons. A significantly lower yield suggests significantly different missions.

Arguments about yield are complex. When debating building the thermonuclear bomb in the 1950s, some denounced the weapon as being genocidal, and too large for any conceivable military target (this was before the development of strongly hardened missile silos that might require an enormously powerful bomb for their destruction). Once built, however, such blatantly excessive weapons developed a certain appeal to those who wanted to reduce the likelihood of nuclear use because these huge weapons seemed completely unusable in any rational way.

Opponents of nuclear weapons are particularly wary of efforts to produce very low-yield weapons that appear more "usable" or that blur the line between nuclear and conventional explosives. But this is a different debate and a different distinction than the one between several-kiloton and near-megaton weapons. Weapons of Hiroshima-like yield should not blur the conventional/nuclear divide. If one believes that megaton weapons have no chance of being used and several kiloton weapons have some small chance of being used, then megaton weapons might be preferred. If, however, the likelihood of using megaton weapons is not zero but merely very small then, to calculate a net risk, the likelihood of using each must be weighed against the consequences of using each. No one has any experience on which to base such judgments so this is a difficult and always clouded decision.

In fact, a weapon limited to several kilotons is less of a new capability than it might appear. Many thermonuclear bombs have selectable yields. Most modern weapons have a boosted fission primary and a fusion/fission secondary. The simplest yield selection is to make some provision for not igniting the secondary, limiting the yield to that of the primary. The primary can then be either boosted or not. Thus, three yields: low kilotons, tens of kilotons, and hundreds of kilotons, is easily achievable in one weapon. A gun assembled uranium bomb would have a yield of tens of kilotons and would appear very different from a bomb with close to a megaton of yield. Another way to look at it, however, would be to consider the new weapon limited just to the middle range of yields already available, thus, reducing the number of available yields (and presumably missions) rather than shifting to new yields and new missions.

RRW and the Long-Term Future

While this essay has tried to offer a logical decision tree for assessing the RRW, the reader probably suspects the author has an opinion. I do. As stated above, I want to reduce the salience of nuclear weapons in the world. As long as the world contains independent nation-states, nuclear abolition is, in my opinion, neither feasible nor desirable. The ideal long-term stable state is that the P-5 each be allowed a few dozen nuclear weapons in not-readily-accessible, monitored, invulnerable storage. Weapons would be stored separately from their delivery vehicles, which would be slow flyers. Nuclear weapons would have one function, to deter nuclear use by any power by threatening retaliation against economic and military targets. Eventually, the weapons could come under some form of international monitoring and even control.

The only threat faced by the United States that could end it as a society is Russia's nuclear force and that is made more dangerous by being kept on alert as a counter to threatening U.S. nuclear forces. If the United States gave up on its current primary (and unspoken) nuclear mission, that is, a disarming surprise first strike against Russia, then the nuclear threat to America could be substantially reduced. This would allow both nations to move toward secure arsenals perhaps one or two percent as large as they are today. This

would also substantially reduce the risk of having a Russian nuclear weapon fall into the hands of terrorists. Such a re-alignment would require cooperative, coordinated moves by Russia and the United States, and eventually the other nuclear powers. Yet, arms control is in such total disrepute today that virtually no one is seriously discussing any follow-on to the virtually meaningless SORT, or Moscow Treaty. Indeed, most nuclear security analysts within the Administration do not think there is a follow-on to SORT, which they see as the end state or at least all that is needed as far into the future as the eye can see. Serious debate about the RRW could head in unpredictable directions and thus raises some risks. But the status quo shows no signs of cracking and it *maintains* grave risks. If an RRW debate can break us away from our current trajectory determined by momentum left from the Cold War, it should be welcomed.

The minimal RRW, that is, minor modifications or parts replacements in current weapons that reduce the maintenance burden, will be difficult to distinguish from the current SBSSP. The RRW program would be, in this case, mainly a shift in emphasis and engineering philosophy. The SBSSP seeks to preserve as long as possible the current arsenal while an RRW program might give extra stress to efforts to maintain weapons indefinitely with high reliability without nuclear testing.

The testing moratorium (and eventually the CTBT) is probably the single most important mechanism for limiting development of new nuclear weapons around the world. Originally, one of the proclaimed virtues of a test ban was that it would, in fact, reduce confidence in nuclear weapons. Reduced confidence would increase strategic stability because a putative aggressor would not have the confidence needed to initiate a complex disarming first strike but the victim, having nothing to lose, would not need any high confidence to retaliate. In the extreme, nuclear weapons would, through aging, become so potentially unreliable that they would not be part of any rational offensive military plan.

There now seems to be near universal acceptance that the U.S. must maintain extremely high confidence in the reliability of its arsenal. Indeed, one of the strongest counterarguments made to opponents of the CTBT is that the Treaty will have no discernable effect on reliability. In fact, any reduction in the perception of confidence will increase calls for renewed testing, which would be a major setback for global nuclear arms control. So an RRW that helped insure reliability would protect the test ban and be a net plus. The minimal RRW could also reduce long-term costs and that is always a benefit even if the dollar amounts are small compared to the overall military budget.

Discussions of testing requirements are, in general, easy to misconstrue. There could be some real, physical, engineering reasons to test a modification in a nuclear weapon. The overwhelming majority of nuclear experts foresee no such need now but say it is possible. There could, in addition, be a *perception* of a need to test. Since the decision to test will ultimately be made by political leaders, not nuclear weapons technical experts, a perceived need to test creates a real need to test. Discussions of these very real political perceptions need to be addressed directly but carefully so as not to have discussion of how to address the perception lend credence to the perception and somehow end up endorsing that there is an engineering need.

The more interesting case to consider is a new, or at least not currently-deployed, weapon. This RWW might be new in the sense that nothing exactly like is has ever been deployed even though it is based on well understood and well tested older designs such as the gun device. It would require no exotic parts or materials, except already accumulated highly enriched uranium. It could permanently silence questions about whether testing is needed.

Whatever position one takes on any of the points above, proposals for an RRW should be welcomed if they stimulate new debate on nuclear weapons. Current U.S. nuclear positions are based on inertia, not logic, and vigorous debate can lead us toward more rational — and substantially smaller and safer — nuclear arsenals.

References

1. The conclusion of the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile, also commonly referred to as the "Foster Panel," is that the stockpile is reliable but significant efforts must be made to insure that it will stay reliable. See *FY 2003 Report to Congress of the Panel to Assess the Reliability, Safety, and Security of the United States Nuclear Stockpile,* Harold Agnew, et al., 11 April 2003, available at http://www.fas.org/nuke/control/ctbt/text/foster03.pdf.

2. See Secretary of Energy Advisory Board, *Recommendation for the Nuclear Weapons Complex of the Future,* 13 July 2005 (Draft Final Report). It argues that the current approach will result in "…a legacy that will require an extensive and ever-more-costly maintenance program." [p. 1] This report focuses on the reorganization of the National Laboratories but makes an ancillary recommendation to develop an RRW. Available here: http://www.globalsecurity.org/wmd/library/report/2005/nwcitf-rept_13jul2005.pdf

3. Congressional language is very clear that the RRW is not to be a new warhead. That has not stopped others from appropriating the name for something entirely different so discussion of RRW can quickly become muddled by lax definition. The Congressional Research Service provides an excellent review of the RRW, *Nuclear Weapons: The Reliable Replacement Warhead Program,* Jonathan Medalia, 20 July 2005. (The report is updated occasionally.) CRS reports are not routinely made available to the public but this one is here: http://www.fas.org/sgp/crs/nuke/RL32929.pdf.

4. Astonishingly, much of the foundation of the nuclear strategy of the United States is secret. While strategy in Iraq can be discussed in a public forum, this is not true of the use of nuclear weapons. Parts of the latest Nuclear Posture Review have been leaked and are available here: http://www.globalsecurity.org/wmd/library/policy/dod/npr.htm.

5. A draft of the most recent edition of Joint Publication 3-12, Doctrine for Joint Nuclear Operations, 15 March 2005 is available here: http://www.nukestrat.com/us/jcs/JCS_JP3-12_05draft.pdf.

6. See HR 1815, section 4214. paragraph (b).

7. See Recommendations in fn 2 above, p. 4.

8. David Hobson, "U.S. Nuclear Security in the 21st Century," available here: http://www.armscontrol.org/events/20050203_hobson_text.asp.

9. John Fleck, "Scientist Raises Idea of Replacing Plutonium with Less Dangerous Uranium," *Albuquerque Journal,* 15 August 2005, available at http://www.abqjournal.com/news/state/380995nm08-15-05.htm. ■

Guilt-Free Games

By Kay Howell, Vice President of Information Technologies at FAS

These holidays I'm in the same boat as many of my fellow parents. Our kids are pestering us to buy the latest alien-war-car-crash video games. We shudder with guilt — knowing we'll cave in and buy them anyway.

I hear a lot about this from my friends. They know I am part of a movement that could get them out of their guilt for supporting a $7 billion a year industry that doesn't seem one of the nobler results of the digital age. I am working with dozens of experts to develop prototype learning games that can make learning as engrossing and challenging as today's popular video games.

Why am I optimistic? I spent twenty years in computing in the Dept. of Defense. The military pioneered use simulation for training, including pilots, sonar operators, to war planning. Only the military has the courage to call multi-million dollar training exercises "games." The U.S. Army hired top guns in the gaming field to develop America's Army. Developed as a recruiting game tool — wit over 4 million registered players — it is now also used for training.

From DOD I went to a White House job coordinating computer and networking research. I had the good fortune of working with many of the Nation's top IT researchers and technology company leaders. Thanks to their contributions to IT over the past two decades virtually every sector of the U.S. economy has transformed itself through smart use of IT to better understand their customers, personalize their products, and improve productivity — except education.

Now I direct the Learning Federation at the Federation of American Scientists. We were tasked by Congress to lay out a plan to marshal the best talent in universities, corporations and government, to build the research knowledge and IT tools that can dramatically improve how Americans teach and learn. Over two years, with over 70 experts, we devised a national "road map" to achieve this goal within a decade. The project is part of FAS' mission to assure that Americans benefit from our world-leading science and technology in socially responsible ways.

I'm optimistic that key features of games can be used to help kids and adults learn real skills. Research shows that students learn better when they are challenged. Students' learning improves when they get immediate feedback on how they are doing. Research also shows that time-on-task leads to better performance. Today's sophisticated video games are both challenging and notoriously addictive. Games draw players in by making them master progressively harder challenges within one game, and from one game to the next. Games provide immediate feedback, as well as ways to figure what you did wrong and the chance to recover and try again.

It's heartening that so many skilled commercial game builders are turning their skills to educational games. At our recent Games for Health conference we saw examples of how the health field is beginning to adopt games to educate people, help people adopt healthier life styles, and even train surgeons. A "Serious Games Summit" last fall drew about 500; presenters covered games for political action, environmental awareness, health, military, and other applications.

Finally, I am optimistic because some in Washington understand that in order to meet our Nation's critical need for better student achievement and a highly skilled workforce we must find ways to making learning more accessible and more effective. The only affordable way to do this is to take advantage of advances in IT to re-think how we teach and learn. Legislation now in the House and Senate would launch the Digital Opportunity Investment Trust. The legislation would create a trust, funded by public revenue from spectrum auctions and fees, to extend the IT revolution throughout the US education and training enterprise. Major corporations, foundations and other institutions must also step up the needed investment, too.

Many of the same technologies used by U.S. businesses industries to re-design and re-define themselves should become routine within education and training. Doing so will require work — to build the needed R&D capacity and adapt IT tools to meet the needs of teachers and students. But the rewards will be (in the words of my daughter) "totally awesome".

So I tell my fellow parents: Watch the shelves. In just a few years, you may find some good games that kids want — and haul them to the checkout counter guilt-free. ■

"Lord of War"

By Matthew Schroeder, Manager of the Arms Sales Monitoring Project at FAS

In "Lord of War," Director Andrew Niccol *(Gattaca, Truman Show, S1m0ne)* shines his cinematic spotlight on the shadowy world of illicit arms trafficking — a global scourge that has claimed millions of lives since the end of the Cold War. It is a slick, stylish film about a slick, stylish crime. Yet despite its Hollywood feel, "Lord of War" is an excellent introduction to the opaque and oft-ignored activities of the merchants of death, or lords of war.

The movie follows arms trafficker Yuri Orlov's meteoric rise to the top of his profession. Yuri, played perfectly by Nicholas Cage, is the ambitious son of Ukranian immigrants whose desire to escape the banality of New York's Little Odessa leads him to the hyper-violent war zones of post-Cold War West Africa — "the edge of Hell," quips Yuri. There, he dodges bullets and Interpol agents while delivering planeloads of weapons to a sociopathic dictator. After each sale, Yuri returns to his multimillion dollar Manhattan condo, his fashion model wife, and their young son. Yuri's transition between the two worlds is seamless, as is the ethical compartmentalization that allows him to exist in both: "Cars and cigarettes kill more people than guns," "I simply give people the means to defend themselves," etc. Slowly the corrosive depravity of Yuri's vocation eats away at this bifurcated morality and he succumbs to the vices that his weapon sales indirectly cultivate — prostitution, drug addiction, and murder.

Niccol's portrayal of international arms trafficking is inspired. At one level, gun running is an activity that lends itself perfectly to the big screen — big guns, lots of money, exotic places, shady characters. But that's only half the story. Less sexy but more important is the dizzyingly complex administrative and bureaucratic arrangements made by traffickers to hide their activities and throw law enforcement officials off the scent. Fraudulent end-user certificates, front companies, false bills of lading — all essential elements of the illicit arms trade but hardly the stuff of an enjoyable Friday night at the movies. Niccol manages to communicate these details while keeping his audience on the edge of their seats with the guns, money and shady characters.

Yuri Orlov (Nicolas Cage) in *Lord of War*. Photo credit: Garth Stead

In one particularly riveting (and educational) scene, Yuri and his brother Vitaly (Jerad Leto) are approaching the Colombian coastal city of Cartagena with a boatload of AK-47 assault rifles. Yuri is conversing with his nacro-trafficker client about the "Angel Kings" he is going to deliver. Moments later, he receives a phone call from one of his plants in a Colombian intelligence agency who informs him that Interpol is hot on his trail. Yuri goes to work. He sends one of his crew members over the side of the ship with a can of paint and hasty orders to paint over the large, white "Kristol" (the name of the ship). He then calls another paid spy who gives him the name of a clean Dutch ship, the "Kono," which he barks at the crew member on the hanging scaffold. Vitaly frantically searches their extensive collection of national flags for a Dutch flag, which has gone missing. The camera pans to a rapidly approaching Interpol patrol boat. In the nick of time, Vitaly finds a French flag which, turned on its side, looks like the Dutch flag, and the anonymous crew member finishes repainting the side of the ship.

The Interpol patrol boat pulls up along side the "Kono." Even though the name doesn't match the ship they are looking for, agent Jack Valentine (Ethan Hawke) decides to board the ship anyway. He is greeted by Yuri, who shows him to the cargo hold while a voice-over by Cage explains how he conceals his merchandise: in boxes labeled "farm equipment," in canisters marked "radio active waste," and, his personal favorite, "the combination of week-old potatoes and tropical heat," which is what Valentine finds in the cargo hold.

Real world examples can be found for nearly every reference in the scene. Using code words for weapons (i.e. "Angel Kings" for AK-47s) is a common practice amongst arms traffickers and their clients. In 2000, the Colombian military intercepted a conversation between guerrillas during which they discuss the cost of "pineapples" in terms of "lettuce leaves." The "pineapples" were hand grenades and the "lettuce leaves" were U.S. dollars.[1] Similarly, there are several documented cases of arms traffickers mislabeling weapons shipments as farm machinery. In one particularly notable case, a ship carrying an estimated $100 million in Russian and Czech weaponry, including 30 tanks

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[1] "TV broadcasts intercepted rebel conversation," BBC Summary of World Broadcasts, 28 August 2000.

Who Is Regulating Virus Research? A New Controversy For An Old Flu

By Michael Stebbins, PhD, Director of Biology Policy at FAS

Scientists have reconstructed the 1918 flu that was responsible for somewhere between 20 and 50 million deaths worldwide. This has raised more than a few eyebrows among those who fear that publication of the virus's genetic code is akin to providing potential bioterrorists with a recipe for mass death. The potential threat is not quite so grave though. Variants of 1918 flu still circulate among us, likely giving us quite a bit of immunity. And modern health conditions, medications, and vaccines are very likely to prevent a replay of the events of the turn of the last century. But this research does highlight a serious problem: There are no regulations or laws that effectively control the way research on potentially dangerous viruses is done or publicized.

The team involved with the reconstruction of the 1918 influenza virus most certainly did it correctly. They informed the Department of Health and Human Services of what they were doing, performed the work under the appropriate biosafety conditions and informed the fledgling National Science Advisory Board for Biosecurity (NSABB) about their work before publishing (Though the Board has no authority to stop publication). The key, however, is that they didn't have to. In fact, they could have legally worked on this flu under any safety conditions they chose and not informed the government at all, a sobering truth when, as a nation, we have become increasingly aware of new threats.

Since the 2001 anthrax letters, the US has dramatically increased the amount of research on nasty bugs that pose significant safety and security concerns. But the expansion did not come with mandatory national safety rules. Instead, legislation like the Patriot Act have clamped down on the free flow of foreign scientific expertise into the U.S. and put in place ineffective regulations on who can do such research, but are collectively nothing more than window dressing instead of national security. In addition, there are thousands of researchers in the U.S. who work on basic biological research subjects that could pose threats to public health and security if misused.

The academic scientific community and the government must sit down and hammer out mandatory safety conditions for work on infectious agents, mandatory rules for storage of infectious agents, and a protocol for approval and dissemination of research that affects national security. The National Science Advisory Board for Biosecurity (NSABB) was established for precisely this purpose, but it has publicly met only once and has not accomplished anything of substance since former Secretary of Health and Human Services Tommy Thompson signed its charter in March of 2004. This has nothing to do with the board members themselves. Unlike many of the President's advisory boards, the NSABB is a well-qualified group of professionals who are fully capable of effectively confronting biosecurity issues. It comes because the administration was slow in finding appropriate members and has not given them well-defined objectives and deadlines to meet.

By working collaboratively with scientists, government has an opportunity to marry national security with the academic freedom that has allowed fruitful advances. The good will and responsible conduct of scientists cannot be underestimated, but neither can the risk of leaving formidable threats unchecked because of inaction. The NSABB was established to address an important area of national security and the administration would be wise to put politics aside and take biosecurity more seriously by providing them with the clearest of objectives and then taking their advice. ■

Lord of War *(continued from pg. 5)*

and 4 million rounds of ammunition, was impounded by British officials because of paperwork problems. The captain told the Brits that he was transporting "agricultural equipment" and, upon providing the proper paperwork, was permitted to continue his journey to Angola, where he delivered his deadly cargo in violation of a United Nations embargo.[2]

Through numerous scenes like the boarding of the Kristol, Niccol constructs a surprisingly nuanced and accurate portrayal of the illicit arms trade. As an arms trade analyst, I have no criticisms, only a point of clarification concerning Niccol's use of arms trade statistics in the closing credits. While private arms dealers continue to thrive, reads his parting shot, the largest arms exporters are the five permanent members of the U.N. Security Council. Technically, Niccol is correct; the five permanent members of the Security Council are often the top five global arms exporters in dollar value terms. But the wording of this comment conflates illicit arms trafficking by private brokers with legal, government-to-government sales – two entirely different animals. For example, most of the $18.5 billion in defense articles sold last year by the world's largest arms exporter, the United States, are the so-called "big weapons" — airplanes, tanks, ships and the sophisticated munitions, surveillance and communications equipment that they use — not the assault rifles, machine guns and missile launchers peddled by Yuri. The U.S. does sell military style small arms as well, but most end up in arsenals of responsible governments. That's not to say that all legal sales are harmless. There are plenty of examples of legal, government-to-government arms transfers that have fueled arms races, perpetuated regional wars, and supported repressive regimes. But the two types of arms sales are categorically different, and should be treated that way.

That said, "Lord of War" is an edgy, innovative and darkly humorous film that appeals to lay audiences and policy analysts alike. ■

[2] Human Rights Watch Arms Project, Angola: Arms Trade and Violations of the Laws of War Since the 1992 Elections, 8 November 1994, http://www.hrw.org/reports/archives/africa/ANGOLA94N.htm.

Staff Update

Jeff M. Aron
Senior Director for Corporate, Foundation and Public Outreach

Jeff Aron replaces Henry Smith as the director of development initiatives at FAS. Prior to joining the association, Aron managed a regional development program that trained nearly 4,000 teachers in the use of integrating technology into the classroom. As a consultant, Aron also engaged in fundraising for the University of Haifa, Israel, and on behalf of the Metropolitan Washington Council of Government in support of its education programs.

For seven years, Aron served as an appointee of the Clinton administration at the U.S. Department of Housing & Urban Development (HUD). In addition to serving on the staff of the Secretary of HUD, he developed public and private partnerships supporting national distance learning initiatives that engaged low-income and minority youth at more than 1,000 community technology centers. Early in his career, Aron worked as a counselor for individuals with mental and physical disabilities. Aron received his B.A. in Social Systems, Social Movements & Law from the University of Massachusetts at Amherst.

Eitan Glinert
Learning Technologies Research Assistant

Eitan Glinert manages the development of Immune Attack – an educational video game that teaches immunology principles. Prior to joining FAS, Glinert worked as a research assistant for Prof. Peter So at the Massachusetts Institute of Technology (MIT) Bioinstrumentation Engineering Analysis and Microscopy laboratory. He also worked as a software programmer for Modul-Bio, a biotechnology start-up in France. He started his career as a simulation programmer at the MIT Artificial Intelligence laboratory. Glinert is a graduate of MIT with a degree in computer science and electrical engineering, as well as a minor in biology.

Hans M. Kristensen
Project Director of the Nuclear Information Project

Hans M. Kristensen directs the Nuclear Information project where he will provide analysis and background information on the status of nuclear forces and the role of nuclear weapons. Kristensen specializes in the use of the Freedom of Information Act (FOIA) to research and report on nuclear weapons.

He is the co-author of the NRDC Nuclear Notebook column in the Bulletin of the Atomic Scientists and the World Nuclear Forces overview in the SIPRI Yearbook (Sweden). Kristensen's other publications are available at http://www.nukestrat.com/pubs.htm.

Between 2002 and 2005, Kristensen was a consultant to the nuclear program at the Natural Resources Defense Council in Washington, D.C, where he researched nuclear weapons issues and wrote the report "U.S. Nuclear Weapons In Europe" (February 2005), and co-authored numerous articles including "What's Behind Bush's Nuclear Cuts" (Arms Control Today, October 2004) and "The Protection Paradox" (Bulletin of the Atomic Scientists, March/April 2004).

Mileva Radonjic, Ph.D.
Project Manager for the Housing Technology project

Mileva Radonjic is the Project Manager for the Housing Technology project. She works primarily with materials used in the construction industry and focuses on the durability of those materials under various environmental conditions. A geologist by training, she adopted an interdisciplinary approach in her doctoral and post-doctoral research, identifying and solving problems in the deterioration of materials. She has studied the stability of oil well cement under CO2 sequestration conditions in Texas, to the effects of acid rain on Portland stone in the city of Bath, UK, and to the alkali-carbonate reaction in concrete known as the dedolomitisation issue.

Prior to joining the FAS, Radonjic worked as a research scientist at Princeton University. In addition to collaborating with national and international teams from industries, governmental agencies and NGOs, she has networked extensively with groups like the Cement Microscopy Association, the Materials Research Society, and the Institute of Materials in the UK. She was born in Serbia and received her Ph.D. from Bristol University in the UK.

Michael Stebbins, Ph.D.
Director of Biology Policy

Michael Stebbins joins FAS as the Director of the Biosecurity Project. His work focuses on biological weapons control, training and preparedness for WMD attacks, and the responsible use of science and technology.

Through the National Human Genome Research Institute and the American Society for Human Genetics, Stebbins worked as a congressional fellow in the office of U.S. Senator Harry Reid. Before moving to DC, Stebbins was a senior editor at Nature Genetics where he coordinated the peer-review of research papers and wrote content for the magazine. He has worked as a journalist for Reuters and as a science advisor to ScienCentral — a television production company that produces stories for the ABC and NBC affiliates.

Stebbins has a B.S. in Biology from the State University of NewYork at Stony Brook and received his Ph.D. in genetics while working at Cold Spring Harbor Laboratory where he built systems to artificially control the expression of genes in the brain.

Eva Maria Vecchi
Learning Technologies Intern

Eva Vecchi is an intern in the learning technologies project. She assists with the development of the question-answer tool for the Learning Federation's Immune Attack video game. In addition to her responsibilities at FAS, Vecchi is working towards a Maste

rs of Science degree in computational linguistics at Georgetown University. For two semesters she studied linguistics at the Università di Firenze in Florence, Italy. In 2005, Vecchi graduated from the University of Colorado at Boulder with a B.A. in linguistics and with minors in mathematics and Italian. ■

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