Testimony to the
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Hearing on
REDUCING THE COST OF THE U.S. NUCLEAR WEAPONS COMPLEX
Room 2362B Rayburn

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www.fas.org/RLG/
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Thank you for the opportunity to present my views on the relationship of nuclear weapon stockpile levels to the nature and cost of the infrastructure.

BACKGROUND

I am Richard L. Garwin. Since 1950 I have worked with the U.S. government on nuclear weapon technology. I have been involved also with radar and defenses against aircraft and missiles, and also with conventional forces, navigation, and arms control and nonproliferation. I chaired the State Department's Arms Control and Nonproliferation Advisory Board from 1993 to 2001, and I continue to work with the JASON group on its studies for NNSA. Most recently I was a member of The National Academies' Committee on nuclear weapons QMU (Quantification of Margins and Uncertainties); our report was published November 11, 2008[1]. My biography is appended to this testimony.

NUCLEAR WEAPONS ARE THE PURPOSE OF THE COMPLEX

The nuclear weapons complex (NWC) exists to support U.S. nuclear weapons. So long as nuclear weapons exist, the U.S. will (and should) have them, and must ensure that they are safe, secure, and reliable. The NWC must store and transport warheads that are no longer needed, dismantle them safely and in an environmentally acceptable fashion, and store valuable and hazardous materials until they are transferred to non-weapon use as we further reduce the number of our nuclear weapons.

The metal “pit” of each nuclear weapon primary contains kilograms of plutonium (Pu), and the secondary in general contains uranium enriched to varying degrees—some of it highly enriched uranium--HEU. Excess enriched uranium has intrinsic value for use in nuclear power plants, and both U.S. and Russian weapon uranium is used currently to fuel half of the nuclear power in the United States. Excess U.S. weapon Pu is stored initially in the form of pits at the PANTEX plant in Amarillo, TX, and will ultimately be disposed of either in the form of mixed-oxide fuel (MOX) for common power reactors, or will be immobilized by mixing with highly radioactive material and disposed of in a mined geologic repository, perhaps to be mined later for use in breeder reactors.

[1] http://books.nap.edu/catalog.php?record_id=12531

An essential requirement for Pu or HEU is secure storage—that it should be extremely well protected against theft by stealth or by force, theft that could make it available for use in improvised nuclear explosives that could well have yields like the bombs that destroyed Hiroshima and Nagasaki in 1945 and that could kill hundreds of thousands of people if detonated in a U.S. city. A comprehensive discussion of needs and means is to be found in the annual report, "Securing the Bomb 2008."[2] The nuclear weapons themselves must be protected to the utmost, and the experience of 2007 in which we lost track of 6 nuclear-armed advanced cruise missiles for 36 hours shows how necessary are the reforms ordered by Secretary Robert Gates. We need to ensure that U.S. nuclear weapons are not used against us.

THE FUTURE OF US NUCLEAR WEAPONS

The number of nuclear weapons in the stockpile strongly influences the required infrastructure, as does their nature. For instance in the single year 1959, 5646 nuclear bombs or missile warheads were added to the US stockpile[3]. Plutonium or highly enriched uranium (HEU), or both, need to be formed into metal of precise shape. Many intricate components are required to make a military nuclear bomb or warhead. Secure transport vehicles are needed to move the warheads; and guns, gates, and guards as well as the best available technologies to keep them secure. It is urgent to set the levels of nuclear weapons in the future in order to define the size and structure of the nuclear-weapon complex. Clearly it is not a function of NNSA or DOE to set the numbers of weapons, nor of the Defense Department. This needs to be done at the level of the National Security Council, which I hope will take into account the Nuclear Posture Review to be done by DOD and also the report of the Commission on Strategic Posture.

The heart of the Complex is not so much the land and the buildings, but the functions it carries out and the people necessary for those tasks.

THE SCIENCE-BASED STOCKPILE STEWARDSHIP PROGRAM

The Science-Based Stockpile Stewardship Program (SSP) was initiated about 1992 as the moratorium on nuclear testing began. SSP has been a tremendous success. New experimental capabilities, both bench scale and large facilities such as DARHT (the Dual-Axis Radiographic HydroTest facility at LANL) have combined with the million-fold increase in computer speed and advanced analytical and mathematical tools to enable far more sophisticated 3-D simulation of nuclear explosive phenomena. DARHT is not yet fully operational and the National Ignition Facility—NIF—has begun its campaign to reach ignition of tiny amounts of thermonuclear fuel. We are close to routine "button-to-boom" simulations, which, of course, to make any sense must be validated against experiment. The experimental base includes the more than 1000 underground nuclear explosions of the past, plus ongoing activities that include surrogate materials and so-

[2] www.nti.org/securingthebomb
[3] http://www.nrdc.org/nuclear/nudb/datab9.asp

called "sub-critical" experiments that may use segments of actual nuclear weapon primaries, for instance. Much work has gone into preserving and making available to the weapons experts at Los Alamos and Livermore the database of nuclear explosion testing and to archive the knowledge and wisdom of weapons experts.

More than buildings, more than facilities, it is the expert personnel who must be preserved and replaced in order to provide the judgment essential to maintaining a force of nuclear weapons that is safe, secure, and effective. This question is treated very well in a contribution by Marvin L. Adams and Sidney D. Drell, prepared for a joint study last year.[4] Such scientists and engineers, primarily at LANL and LLNL are essential to the informed judgment as to the legitimacy of small material substitutions, the adequacy of numerical simulation and the correlation with experiment, and the annual assessment that nuclear weapons are safe and reliable. These are the people who must play an increasing role in the determination of solutions to problems analyzed in the SFI (Significant Finding Investigations) and who must help to enforce "change control" over individuals and organizations who quite naturally want to ensure that the most modern technology is incorporated in these important nuclear weapon systems. In the past it has often been weapon designers who have played very important roles in dealing with the production facilities and in helping to solve problems that arise there. This has permitted modernization of the nuclear weapons stockpile, especially as regards elements outside the "nuclear package," and their involvement is essential for modifications or proposed repairs inside.

The experts have done much good and even inspired work, but they must be asked now to build an edifice of nuclear-weapon physics and understanding by more rigorous publications, sometimes in forms that respect the secrecy required in portions of a weapons program. The discipline of publication and the accessibility of published material to new members of this important cadre of nuclear weapons scientists and engineers are important to ensure that modifications and modernization contribute safety, surety, and reliability of our nuclear weapons.

One of the fruits of the SSP program is the announcement in late 2006[5] by NNSA that the weapon laboratories have established that the plutonium pit at the core of each of the U.S. nuclear weapons will survive more than 85 years. An ongoing result is the ability of the Directors of the weapon laboratories to assess each year that the weapons under the SSP remain safe and reliable. And we now have at LANL the proven capability to manufacture certifiable W88 replacement pits. The striking agreement of boost-cavity shape predicted by the simulation with that observed in radiography now and in PINEX tests before 1992 exemplifies the increase in understanding that makes it possible for some to imagine putting a new-design weapon into the stockpile without verification by nuclear explosion testing, provided that it is sufficiently "close" to designs that have had nuclear-explosion tests. Key to the ability to perform the annual assessment of stockpile

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[4] "Technical Issues in Keeping the Nuclear Stockpile Safe, Secure, and Reliable," by M.L. Adams and S.D. Drell. (http://cstsp.aaas.org/files/DrellAdamsBrief.pdf). The full report, "Nuclear Weapons in 21st Century U.S. National Security" is to be found at http://cstsp.aaas.org/content.html?contentid=1792.

[5] As submitted, this was erroneously stated as 2007.

weapons and to determine the performance of warheads yet to be built is the process of “peer review” between the two U.S. nuclear-weapon-design labs—Los Alamos and Livermore. The peer-review team in one lab is tasked with analyzing the performance of a specific design or modification proposed by the other lab. Despite its essential role, peer review has not been formally funded, as it should be. When the peer review team is not actually engaged in the process, it should be building its skills and tools and might be used to evaluate some of the work of its own laboratory.

Of course problems are discovered in the SSP, and the so-called significant findings ("SF") are promptly investigated and resolved. Almost all of the significant findings have to do with elements outside the nuclear package, and these can be re-engineered, tested without nuclear yield as they always have been, and modified, with great care that they do not impact the performance of the nuclear package itself.

REPLACEMENT WARHEADS

With the knowledge gained from the SSP, NNSA undertook the design of the Reliable Replacement Warhead-- RRW-- with the constraint that it not require a nuclear explosion test. As I indicated in my December 2008 Arms Control Today article[6], I think the RRW design effort has energized the nuclear laboratories and is something that should be encouraged and repeated every five years or so. That does not mean that I believe that a replacement weapon could now be certified without a nuclear test, a question that depends on the detailed design and probably on the acquisition of more expertise under the SSP. Quite independent of the feasibility of introducing a new nuclear warhead without nuclear explosion testing, though, is the determination of benefits and costs of doing so. An improvement in an individual nuclear weapon does not automatically extend to the entire fleet of nuclear weapons, and this is particularly true of surety improvements against nuclear theft and misuse. We will discuss this later.

Replacement warheads are likely to be motivated by and to include capabilities such as those in a January 2008 description by Bruce T. Goodwin at LLNL:

> *“The goal of the RRW approach is to replace aging warheads with ones manufactured from materials that are more readily available and more environmentally benign than those used in current designs. RRWs can include advanced safety and security technologies, and they are designed to provide large performance margins for all key potential failure modes. Large margins enhance weapons reliability and help to ensure that underground nuclear testing will not be required for design certification.”*

REPLACEMENT WEAPONS AS AN OPTION, NOT A NECESSITY

I see replacement weapons as an option and not a necessity. The apparent disagreement with a statement by Defense Secretary Robert Gates,

[6] http://www.armscontrol.org/act/2008_12/Garwin

> “*there is absolutely no way we can maintain a credible deterrent and reduce the number of weapons in our stockpile without either resorting to testing our stockpile or pursuing a modernization program*.”

may be due to the interpretation of “modernization.” We have, of course, long been modernizing our weapons, but every “improvement” or fix to a nuclear weapon must be thoroughly reviewed. It is costly and potentially hazardous to open a nuclear weapon and then to reseal it, so that modifications that will extend the life of the weapon or improve the performance, even though they deal with elements outside the nuclear package but within the outer skin of the warhead or the bomb, must be evaluated and often are done in batch mode, rather than individual modifications.

Assuming the U.S. continues to have nuclear weapons, it is unrealistic to expect that every plastic part, insulated wire, or lubricated mechanism will work perfectly 20 or more years from now. Indeed, there has been from the earliest days an ongoing stockpile surveillance program that guided modifications of weapons or motivated replacement by a new weapon development if it was not worthwhile to remanufacture or replace parts; in the days of nuclear explosion testing, the replacement warhead was tested in development and eventually after manufacture, a production verification test would be conducted on a weapon headed for the stockpile.

Without nuclear testing, replacement parts outside the “nuclear package” that contains the weapon primary and secondary can be replaced by identical, qualified parts; or a major non-nuclear system or subsystem might be replaced by a new-development system that could be thoroughly tested without a nuclear explosion, as was always the case. The choice between replacement and substitution should be based on cost of new development and of fabrication, and the forecast benefits of longer life and reduced surveillance costs, all the while ensuring that current standards of safety, security and effectiveness are maintained – and, if possible, improved. These overall benefits are clearly less with a smaller stockpile, which makes it more difficult to amortize the up-front development and first-item manufacturing costs across a smaller stockpile, in comparison with a strategy of replacement with identical components. Such modifications are usually packaged in a Life Extension Program—LEP—for a particular weapon type. Modern simulation using the NNSA massive computing capability should then be done to determine the behavior (nuclear yield) of the warheads as built—including any accumulated changes to the warhead.

Thus modernization of the many parts of the warhead outside the nuclear package is neither inhibited by the absence of nuclear tests, nor would it be helped by nuclear testing. Batteries, fuzing systems, radars, can all be modernized, and because the replacements are usually smaller and lighter, they may be accompanied by dead weight to maintain warhead weight and balance. Within the nuclear package I have long favored replication—remanufacture to original specifications and dimensions, with a strong discipline of “change control.” With declining stockpiles there is the possibility of reuse of parts that would otherwise need to be remanufactured.

In short, I believe that the existing weapons can remain closer to their test pedigree than a replacement weapon will be to any specific nuclear test, and that responsible choice of modifications to the existing weapons would result in *increased* confidence in their performance with time, rather than the *erosion* of confidence. It has long been advocated to increase the margins against failure for the existing weapons, primarily by a substitution of a different type of reservoir for the deuterium-tritium "boost gas," and this is now happening. Although the *margins* for a replacement warhead can be larger than in some existing weapons, the *uncertainties* are also larger because the exact configuration has not had a nuclear test.

It will always be to someone's bureaucratic interest to claim that a new device or system is better and more reliable than the existing system, and that the existing system cannot be responsibly maintained. This was the case in the 1960s when I chaired the Military Aircraft Panel of the President's Science Advisory Committee under Presidents Kennedy and Johnson, when the Air Force argued that the B-52 could not be flown beyond about 1970 because of metal fatigue. B-52s are still a mainstay of the U.S. bomber force. It was the case with the MX missile, which have now come and gone and the Minuteman is still our sole ICBM.

BENEFITS AND COSTS OF REPLACEMENT WEAPONS NEED TO BE ASSESSED

Some believe enhanced surety against theft and misuse dominates all other considerations and that the replacement weapons are absolutely necessary because a new development permits improved surety that cannot be achieved in most of the existing weapons. Even if this priority were to be accepted, what counts in this regard is the overall vulnerability of the United States to nuclear attack from our own weapons, and that depends not on the characteristics of the individual weapons but on the characteristics of the entire force. Thus, if we were to maintain a 5000-weapon force, and if replacement weapons were built at the rate of 50 per year, it would take 50 years for them to replace half of the existing force. And it is likely that this would not improve the surety of the force one bit, since miscreants could concentrate on the older portion of the force.

Of course, if the United States were maintaining a force totaling 500 weapons, a 50/yr production rate for replacement weapons could replace the entire force in ten years.

Evidently, if replacement designs are deemed essential, an ongoing stream of newly built warheads would be required. First, to satisfy those who believe that the introduction of weapons of new design (even if they don't provide new military capability) is the only way to maintain the expertise of the laboratories; and, second, to avoid dependence of the future stockpile on cloning a single design. In any case, NNSA specifically proposed at least two types of RRW.

WILL WE LONG RELY ON AN "UNTESTED" REPLACEMENT WARHEAD?

I am concerned, though, that if a replacement warhead were to be certified without a nuclear-explosion test, it would not be long before from some influential quarter would come the complaint that the United States security was based on untested nuclear weapons. I think it likely that this would lead to a test and therefore to the destruction of the CTBT regime and of the Nonproliferation Treaty (NPT) with it. In particular, both China and Russia appear quite ready for nuclear explosion testing if the CTBT moratorium should end, and China could add significant military capability from a few tests beyond its current base of 40. This would be an unfortunate outcome of the program which motivates many supporters with the proposition that a replacement warhead is the best way for the United States to join a global ban on nuclear explosion testing –the comprehensive test ban treaty, CTBT.

OVERCOMING PROBLEMS WITH EXISTING WEAPONS

If there are specific limitations imposed on a particular existing weapon, one cannot automatically say that a replacement program will immediately fix it. The replacement warhead would need to be a substitute for that bomb or warhead, for instance-- and it would not be available until after a substantial time for development and manufacturing. If the need for such a capability were urgent, there would be no alternative to modifying (repairing) the nuclear explosive package of the existing weapon. This would need to be done with common sense and judgment and responsibility, and verified by the full simulation of the performance of the bomb, as modified.

WOULD ONGOING STOCKPILE CONFIDENCE TESTS BE NECESSARY FOR THE EXISTING NUCLEAR WEAPONS?

Even if laboratory management in the future would find it easier, as the SSP expertise and tools advance, to do the annual assessment of existing weapons and to find them safe, reliable, and secure, might not some influential critic in the future -- even a STRATCOM commander -- simply state that he or she could not be responsible for a fleet of weapons that had not been tested for 30 years, for example?

But what would be the function of a nuclear test?

In an underground nuclear-explosion test, one typically removes much of the flight hardware, or disables it. That is, one cannot mimic underground the specified stockpile-to-target sequence that is required for arming the warhead. If part of the operation depends on the vacuum of space that needs to be simulated. One often uses a different initiator (pulsed neutron source), and, of course, the fuzing system is entirely different. Furthermore, the environment underground is significantly altered from that for an explosion in air. There is no strong deceleration as is the case for the airburst of a bomb or warhead in the atmosphere, and no spin of the warhead in test.

What would be tested? A nominal weapon under nominal conditions? Or a weapon near the end of boost-gas life, under the most stressing temperature conditions, and under the greatest conditions of combat stress? Of course there would be very many experimental data obtained because the opportunity to test instrumentation and to diagnose every aspect of the weapon performance would not be missed, but the benefit to a skeptic who urged the test would largely be the yield-- whether the weapon "worked" or not.

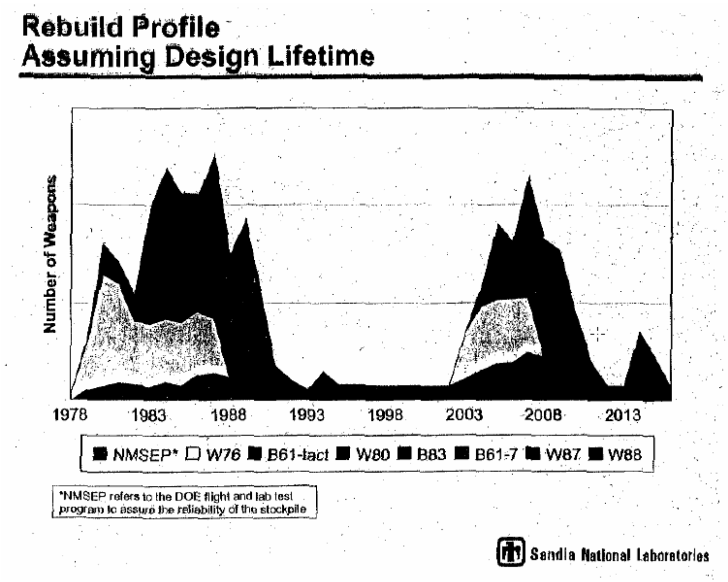
HISTORIC LACK OF INTEREST IN STOCKPILE CONFIDENCE TESTS

In the era of US underground nuclear tests, concern was sometimes expressed that much of the fleet had not undergone a test of weapons that had been in the stockpile for years or decades. In fact, routine production verification tests were sometimes delayed for years. After congressional and JCS insistence on stockpile confidence tests (SCTs), I believe that only two were conducted. On the other hand, high-fidelity flight tests (without nuclear yield) provide essential information about the performance of our weapons in their normal environment; they must continue.

HOW CAN COSTS BE REDUCED AS WARHEAD NUMBERS FALL?

The goal of cost reduction is not universally shared. The taxpayers' interest in spending the least amount to achieve a given capability conflicts with the interest of industry and local government and their representatives to have more spending and employment in a given region or activity. There can be honest disagreement about the optimum approach. For instance, when I served on a panel of the DOE Energy Research Advisory Board to review proposals for new U.S. uranium enrichment facilities, the cost of future enrichment by gas centrifuge seemed unrealistically low. It turned out the proposal involved putting the support facility for the first 6 centrifuge buildings in the first tranche of construction, so that the cost of later expansion was indeed very low; the flip side, of course, was that the cost of the first unit was extremely high, and that was not mentioned or perhaps even known by most of the proponents.

For the present task of maintaining and modifying the nuclear weapons complex (NWC), the lesson is that the system should be designed for the foreseeable task, with "load leveling" as appropriate. For example, in 1996, this subcommittee considered the chart provided by Sandia National Laboratories, "Rebuild Profile, Assuming Design Lifetime"



Although in the black and white reproduction it is impossible to distinguish the different warhead types, what is clear is that this chart assumes that the original build rate must be echoed approximately 25.0 years later by rebuild of the warheads. Assuming that some warheads are more in need of rebuilding than others, a less expensive proposition would be to rebuild over a period of ten years—say from 20 to 30 years after initial build, thus reducing the capital cost of the rebuild establishment by about a factor two. If for some reason this were not acceptable, then rebuilding some warheads five years before their assumed end of life would also reduce the capital cost, even though some funds would be spent before absolutely necessary. This is just an example of the benefits from a NWC that could be considerably smaller than one that blindly echoed the needs or programs of the past. Although the details of the options are not available, the plan to build the Chemistry and Metallurgy Research Building (CMRR) at Los Alamos to include not only the CMRR Radiological Laboratory, Utility, and Office Building (CMRR-RLUOB) as well as a CMRR Nuclear Facility for handling bulk plutonium does not seem to reflect clearly defined missions. Again, it would be best to wait for an understanding from the National Security Council on the future nuclear warhead needs, and to see whether these can be met by the plutonium facility at TA-55 at LANL.

It was apparently assumed by many that we needed to have a nuclear weapons complex that could mirror the historical build rate, lagged by 30 years, on the assumption that the nuclear weapons had a planned life of 30.00 years. Rather than providing the capacity to build 5646 weapons in a single year, it was clear, however, that the conditions could be met at lower cost by advancing the replacement of warheads during peak years by a few years, so that some warheads would be replaced at 27, 28 or 29 years of age, with a NWC that was considerably smaller than one that blindly echoed the needs or programs of the past. Paradoxically, it is cheaper to replace weapons “before their time” (even assuming that there is a fixed lifetime for weapons) because the reduced capital investment to support the lower peak build rate more than outweighs spending money sooner than would otherwise be required. It is as if you brought your car in for service a bit early because there was a substantial special that would save you money even though you are spending it earlier than necessary.

Despite the reluctance of LANL to be involved in "production" of plutonium pits, I think this is exemplary of what needs to be done in the rest of the complex, bringing manufacture closer to the design and evaluation expertise. Make no mistake, though, the Pantex plant at Amarillo, TX, will be busy dismantling nuclear explosives, and the work to demilitarize and eventually dispose of the plutonium from pits has scarcely begun.

SUMMARY

1. There is a national need for the National Security Council to specify numbers of nuclear weapons vs. time, taking into account the forthcoming reports of the Congressional Commission on U.S. Strategic Posture and guiding the Nuclear Posture Review centered in the Department of Defense.
2. Within the nuclear weapons complex, the greatest resource is quality, knowledgeable people—scientists and engineers, who form the basis for judging and maintaining the safety, security, and reliability of these enormously dangerous weapons. The cadre of expertise and their working tools need to be maintained and refreshed so long as the nation maintains a nuclear weapon capability. The peer review process between Los Alamos and Livermore should be recognized and supported as an essential ingredient in our nuclear capability.
3. It should be recognized that confidence in the reliability of existing weapons under a responsible stockpile stewardship program is likely to *increase* with time – because of increased understanding and technical tools – rather then diminish. This is a desirable goal. Let's make it happen.
4. Replacement-warhead programs lack quantitative assessments of benefit, risk and cost streams as new warheads are assumed to enter the force—overall improvements in surety, reliability, and safety need to be evaluated within the force numbers to be prescribed by the National Security Council. The replacement-warhead benefits over time must be compared with benefits in safety, security and reliability that might be obtained through alternative expenditures, such as improved transport containers and security measures that are tailored to the evolving threat.
5. Smaller weapon stockpiles will reduce the cost of the nuclear weapon complex only if that is a major goal of NNSA and the Congress. Cost reductions can be achieved by increased co-location of production and design activities and by modular approaches to the tasks, so that capabilities could be expanded by replication of bays, tools and staff rather than by over-sized new facilities for large-scale operations.

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