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Abstract

This paper reviews some of the issues about verifying the dismantlement of nuclear warheads and controlling nuclear materials in the context of arms control objectives. It is asserted that information about the stockpiles of nuclear warheads and materials is necessary to analyze the impacts and verification requirements of arms control measures including warhead dismantlement and fissile material controls. It is proposed that the U.S. and the Soviets engage in a series of declarations about their stockpiles of nuclear weapons and materials. It is also asserted that currently it is more important to verify that warheads are retired to safe, secure facilities than to verify their dismantlement. It is proposed that production of new or rebuilt warheads be limited to less than the number retired each year. Verifying the number of new and rebuilt warheads deployed and the number retired avoids many of the difficulties in verifying dismantlement and material controls.

INTRODUCTION

Questions about the disposition of warheads and nuclear materials have been publicly discussed since the Intermediate Nuclear-Force (INF) ratification hearings. Now, with the signing of the Strategic Arms Reductions Treaty (START), and the President's September 27th initiative announcing additional retirements, disposition issues will undoubtedly be raised again as part of the national arms control agenda. Some will object that START like INF does not mandate the destruction of any warheads; and there is no verification planned for warhead dismantlement as a result of the President's initiative or the Soviet response.

We will discuss some of the issues raised by verifying the dismantlement of nuclear warheads and controlling the use and production of fissile materials (plutonium and highly enriched uranium). However, before focusing on the "how" of verification or even the "what" of implementation, it is useful to discuss the "why" of dismantlement and material controls in terms of arms control objectives and the need for information about the stockpiles of nuclear warheads and fissile materials.

Bottom Lines

In view of the lack of official information about the stockpiles of nuclear weapons and materials, and the need to analyze the impacts and verification requirements of arms control measures, it is proposed that *the U.S. and the Soviets engage in a series of declarations about their stockpiles of nuclear weapons and materials.*

It is generally assumed that verified dismantlement of nuclear warheads and controls on the reuse and production of fissile materials are desirable because they ensure permanence to the reductions of nuclear weapons. However, such verification may not be warranted because of the uncertainty in the size of the initial stockpiles of warheads and materials, and the need to control production of new and rebuilt warheads. This paper contends that *the most pressing arms control objectives can be achieved by limiting the number of new (or rebuilt) warheads to less than the number retired each year.* Counting the number of new and rebuilt warheads deployed and verifying the number retired avoids many of the difficulties in verifying dismantlement and material controls.

Background

In response to arms control agreements and unilateral actions driven by budgetary and other concerns. The U.S and the Soviets will retire a large number of the nuclear warheads now deployed. Important questions are being raised as to what will happen to these warheads and the fissile materials they contain. Various proposals have been made to dismantle these warheads as a part of treaty limits on delivery systems [1–3]. Other works have addressed the question of what to do with the fissile materials [4–6]. Also, the U.S. Congress [7] mandated the creation of a Presidential advisory committee to study and report on the verifiability of warhead dismantlement, fissile material production control, and end-use or ultimate disposal of fissile materials. Previous work on these issues has generally focused on the details of dismantling nuclear warheads and of controlling the production and reuse of fissile material rather than on addressing the objectives of dismantlement and material controls or on the broader goals of arms control.

Arms Control Objectives

A primary goal of arms control is to reduce the *risk* of nuclear war. For this goal, it is by far more important to reduce the number of launch vehicles (missiles and bombs) as well as silos, submarines and bombers than to dismantle warheads or control fissile materials.

Presumably, the objectives for warhead dismantlement and fissile material controls include:

1. Reducing the risk of a resumption of the arms race (breakout).
2. Reducing the risk of unauthorized use or threat of use of nuclear weapons.
3. Reducing the risk of theft of nuclear weapons (leading to nuclear terrorism).
4. Reducing the risk to people and the environment from accidental detonation or dispersal of fissile material.
5. Complying with the Nonproliferation Treaty (NPT, Article VI) obligation to work toward nuclear disarmament.

The Initialization Problem

One of the major considerations in assessing the impacts and verification requirements of potential arms reduction agreements is estimating the number of weapons and the amounts of fissile materials in the current or initial stockpiles. This can be referred to as *the initialization problem.* The efforts (costs and risks) to verify the dismantlement of warheads or to control the fissile materials should be moderated by the extent of the uncertainties in the initial stockpiles. For example, it would not be wise to expend resources or suffer the intrusiveness of verification to verify the dismantlement of a thousand warheads if the uncertainty in the initial stockpile was more than a thousand warheads.

The problem of determining current stockpiles could become critically important if, as predicted, later agreements stipulate much smaller stockpiles.

DECLARATIONS

The problem of determining initial stockpiles of warheads and fissile materials pervades the issues warhead dismantlement and the control of fissile materials, as well as other arms control issues. A first step toward solving this problem could be made by the U.S. and the Soviets initiating a series of step-by-step declarations about their stockpiles of nuclear warheads and fissile materials. This could be accomplished by a bilateral agreement, or by the U.S. and the Soviet Union making mutual unilateral declarations. Because of the abundance of information about American nuclear programs and facilities and the lack of corresponding Soviet information, it would be reasonable for the Soviets to make the first declarations. In any case, the American and Soviet declarations should alternate and become increasingly more detailed as confidence and verification measures are developed. In fact, verification measures could be proposed as a condition for continued disclosures. Warhead and fissile material declarations could be the basis for evaluating the risks mentioned above in connection with arms control objectives, as well as possible dismantlement and materials control measures and verification requirements.

Warheads

If the United States wanted to take the initiative and start the process, we could start by announcing the total number of nuclear warheads in our stockpile as of a given date, and challenge the Soviet Union to make a similar declaration, and to declare some additional information such as the number of tactical nuclear warheads in their stockpile. Following a credible Soviet response, we would announce the number of our tactical warheads and some additional information such as the number of warheads we have for land-based ICBMs. The sequence of more detailed declarations would continue until the number of warheads for each specific type of delivery system had been specified.

The details and definitions in the declaration process would have to be specified and at least implicitly agreed to. For example, a warhead could be defined in terms of a minimum amount of fissile material associated with a high explosive and a firing mechanism in the custody of the military. Later, the number of warheads and warhead parts being constructed, dismantled, or in transit could be defined and declared. Declared information would have to be updated periodically. Perhaps the best way would be to update all previous declarations whenever a new, more detailed one was made and to at least update the numbers annually. Although not trivial, these difficulties should not be insurmountable.

Fissile Materials

In order to assess possible proliferation and environmental problems in the Soviet Union, it would be useful to have some information about their stockpiles of plutonium and highly enriched uranium. Declarations about these materials could be carried on in parallel with the declarations about nuclear warheads. Again, if we wanted to start the process we could declare our total inventories of plutonium and highly enriched uranium (and total cumulative production amounts), and then challenge the Soviets to respond and declare some additional information, e.g. what portion of their materials are in nuclear warheads. As with warhead declarations, the fissile material declarations would become more detailed and intrusive as trust and verification measures were developed.

Concerns

Because of closed nature of their society, it would be much easier for the Soviets to provide false or inaccurate numbers. However, because increasingly more detailed declarations are to follow, and other, to be defined, verification measures are to be instituted, deception would become increasingly more difficult and would likely have to be planned in advance. For the declarations to be credible, they would have to be consistent, not only with later more detailed declarations, but with other verification measures such as counts of missiles, bombers, and submarines. In fact, verification measures could be proposed as a condition for further disclosures. In addition, the warhead declarations would

have to be consistent with declarations about fissile materials. Each nation's own records of weapons and materials production facilities could be disclosed and used to estimate its stockpiles of warheads and materials. These records could be checked for consistency with additional "public" records or indicators such as employment numbers, electricity used, etc.

Ultimately there would be concern about the declarations if the number of warheads in the U.S. and Soviet stockpiles became comparable to those of other nuclear powers. At this point, the other powers could be invited to join the declaration and verification process, or the declarations could be stopped or could become confidential between the U.S. and the Soviet Union.

Declarations could be useful as confidence-building measures with or without concomitant arms control agreements. In any case, we should at least challenge the Soviets to release the same kind of information about their weapons, materials, and facilities that is unclassified and has been released by the United States. A list of such information has already been unofficially given to the Soviets [3].

Because of the step-by-step nature, we risk very little by engaging in, or even initiating a series of declarations. If the Soviets do not respond with credible numbers, nothing more need be lost. Any slight advantage an adversary might gain by knowing our total number of warheads at a given time is soon eroded if no further declarations are made. What we gain, if the Soviets do respond in a credible way, is information necessary for planning how to spend up to a half a billion dollars, as well as a basis for assessing continuing arms reductions and verification measures that could lead to stockpile reductions to a few thousand warheads each. In addition a Soviet response would indicate a relaxing of the secrecy surrounding their nuclear weapons establishment which could possibly lead to cooperation in other areas such as environmental restoration and conversion, to peaceful uses, of some of their nuclear weapons facilities.

NUCLEAR WARHEAD DISMANTLEMENT

Our decisions with respect to verifying the dismantlement of nuclear warheads should reflect the fact that an arms race no longer appears to be the principal threat from the Soviet Union. After discussing the definition(s) of dismantlement and the usual notions of verification, we will look at some options and alternatives.

Dismantlement by itself only means that some number of warheads would not be available for a given period of time depending on the definition of dismantlement (degree or extent of disassembly) [8]. Thus, without any concomitant controls on production of new or rebuilt warheads, its value would be primarily symbolic.

In the case of the missiles retired under the INF treaty, the warheads were removed from the missile aeroshells but were not required to be dismantled any further. The value of the INF treaty was the elimination of the delivery vehicles (missiles). Verifying dismantlement of some warheads, such as those retired under START, while ignoring the rest of the stockpile, would have symbolic value but would not go very far toward achieving the objectives mentioned above because the number of warheads in the stockpile is not necessarily reduced.

Defining Dismantlement

There are many possible definitions of dismantlement. It could mean removal of the warhead from the reentry vehicle or bomb and separation of the nuclear explosive (physics) package from the rest of the warhead. In this case, reuse would require refitting the support equipment (including the arming, firing, and fuzing mechanisms) as well as mating the nuclear explosive package to a suitable delivery vehicle. A more complete dismantlement might mean disassembly of the physics package into the primary and secondary components. Dismantlement could also be defined as complete disassembly (i.e., separation of all the individually manufactured parts). Following disassembly, a dismantlement regime might even require the destruction of the parts containing fissile material by dissolving or melting. The dismantlement sequence and stages of disassembly are shown in Fig. 1. For U.S. weapons, the sequence on the left side can be accomplished in U.S. Department of Defense facilities, whereas the sequence on the right requires special U.S. Department of Energy facilities.

Dismantlement Facilities

In the U.S. both assembly and disassembly are accomplished at the Pantex Plant in Texas. However, in order to reduce the parts to ingots or other forms, additional facilities such as those at the Rocky Flats Plant in Colorado and the Y-12 Plant in Tennessee are required. Figure 2 shows the flow of materials and parts for assembly and disassembly in the U.S. There is much less public information about corresponding facilities in the Soviet Union [9–10].

To minimize the risk of releasing classified information and to avoid impacts such as limiting the flexibility of the U.S. weapons complex, construction of a special center for verified dismantlement has been suggested. However, constructing such a facility would probably take years and be very expensive.

Depending on the available facilities, the degree of readiness of a nation, and the definition of dismantlement, the time that it would take to redeploy dismantled warheads could be weeks, months, or years.

Limiting New Warhead Production

Most discussions of dismantlement and material controls assume, at least implicitly, that the production of new weapons will be regulated by controls on fissile materials. Prohibiting production of new fissile material and reuse of fissile material from retired warheads could limit but would not necessarily prevent the production of new warheads. The number of new warheads that could be produced would depend

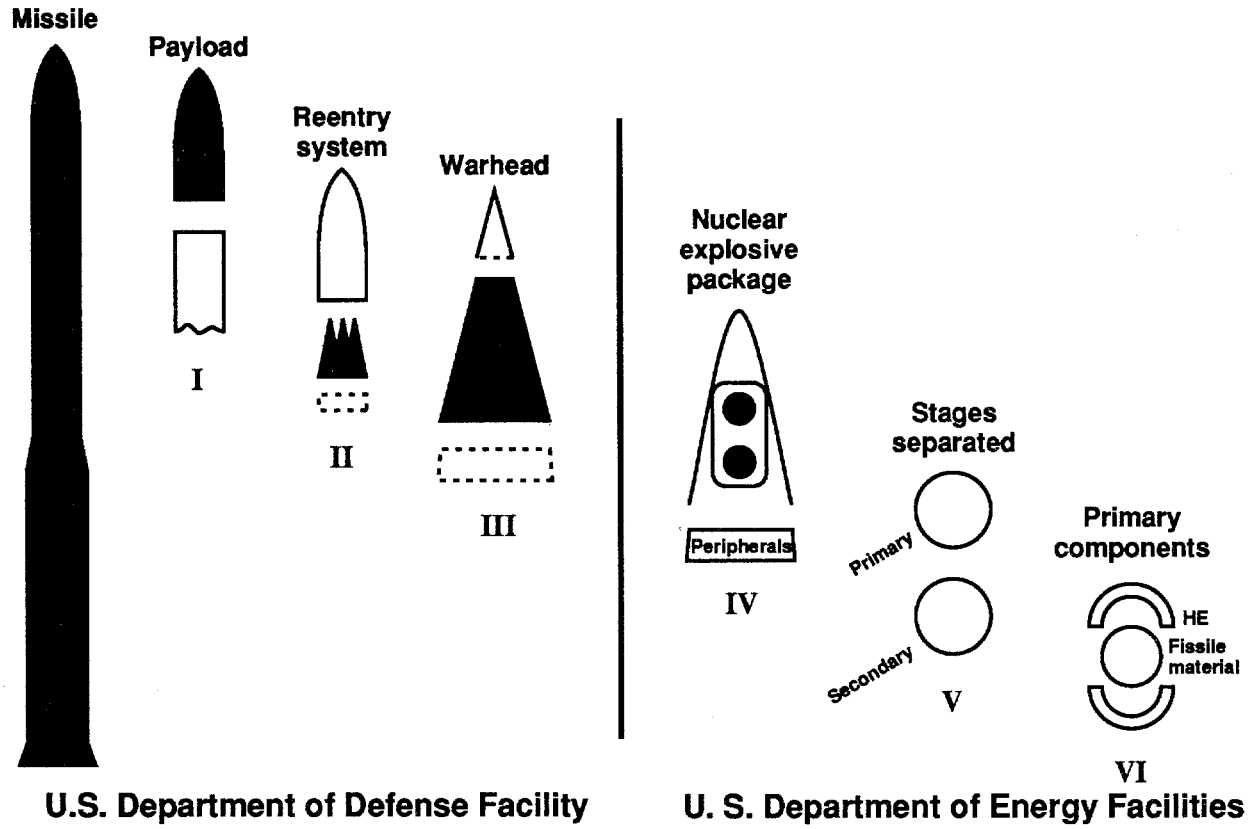

Fig. 1. Dismantlement sequence showing the stages of disassembly for a nuclear weapon system.

on the initial stockpiles of fissile materials, as well as on the possibility that a larger number of new warheads could be manufactured from existing warheads. Direct limits on the number of new and rebuilt warheads deployed is the only effective way to ensure that the stockpile will not grow.

Allowing a limited number of new warheads would provide for the production of safer, more secure warheads and new weapon systems that would be more survivable. That is, trading old warheads for new ones could contribute to achieving some arms control objectives.

Alternatives to Verified Dismantlement

Today, in the Soviet Union, the threat of an attack or even a resumption of the arms race is rapidly diminishing. This makes verified dismantlement relatively less important. Because of this and the verification costs and other impacts, alternatives to verified dismantlement should be considered. Several options exist for the disposition of nuclear warheads and materials as shown in Figure 3.

In order to reduce the risks of unauthorized use, theft, and accidents, it is more important to isolate or sequester warheads away from delivery systems to be retired (and to reduce the number of delivery systems allowed), than to require verified dismantlement. In either case, chain-of-custody monitoring, possibly involving tags and seals, would be required to ensure that warheads were transported from their delivery systems or staging areas to the appropriate facility. For warheads not directly removed from deployed systems, there is also the problem of identifying or certifying objects as real warheads. It has been suggested that radiation detectors can be used to confirm the existence of fissile material without disclosing classified design information [11]. Rather than the intrusive verification of disassembly, sequestering would only require portal and perimeter monitoring (PPM) to verify that no warheads would leave the isolation facility. PPM methods have been developed to support verification of the INF Treaty.

Because the Rocky Flats Plant is not currently fabricating fissile material into new warhead components, sequestering warheads without allowing for the reuse of componants could have the deleterious effect of impeding or not allowing for modernization of the U.S. stockpile. An agreement with the Soviets to halt production of new warheads and close their production facilities would make the situation more equitable, but the relative impacts on the U.S. and the Soviet Union would depend on the number of warheads and components or parts available, which is another manifestation of the initialization problem.

Another alternative is that the dismantlement of warheads would not be monitored, but the flow of fissile material

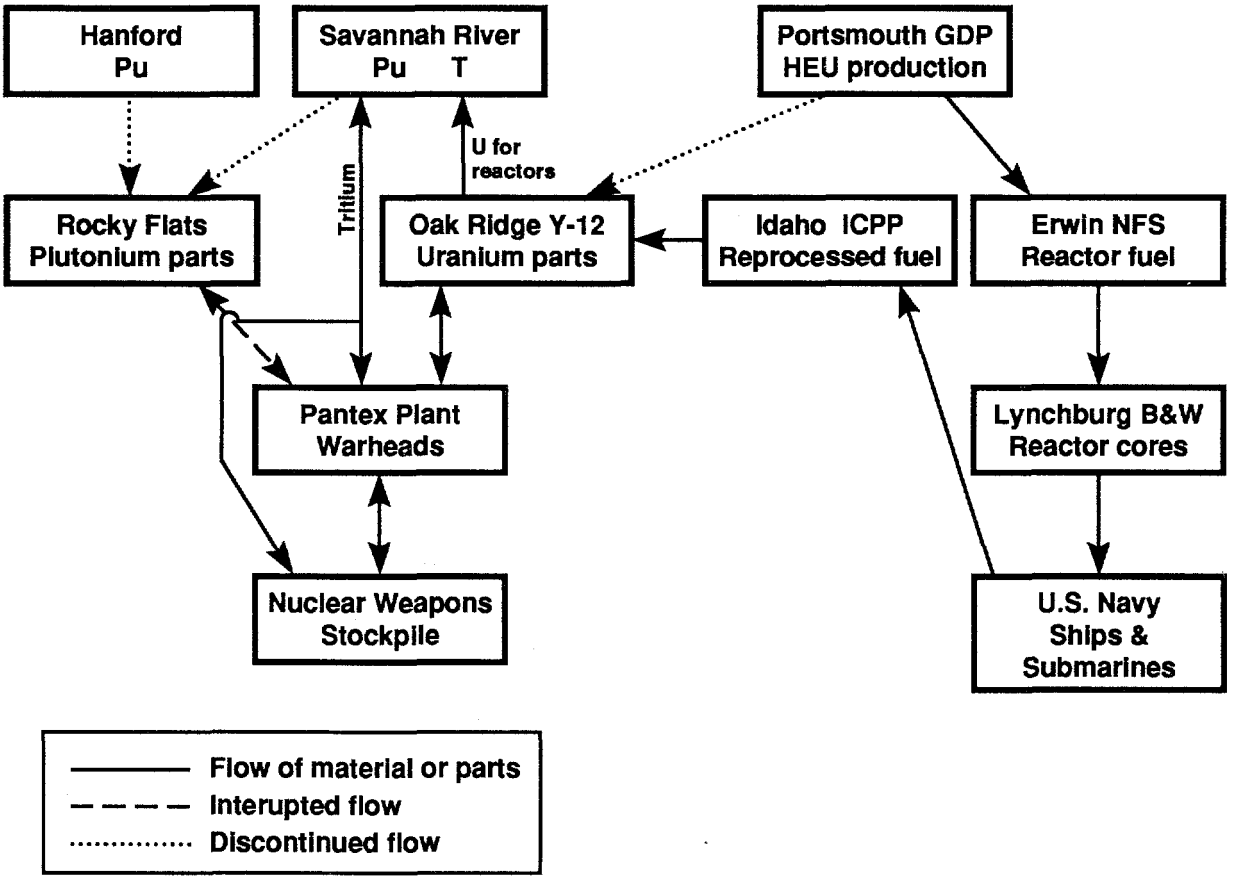

Fig. 2. Flow of warhead materials and parts in the United States.

associated with the warheads would be monitored. That is, the warheads could be dismantled without direct verification in a facility with PPM, and the fissile material would be monitored as it is transported to the outside. This facility would have to contain the necessary equipment to reshape or melt the fissile material components so that the fissile material containers could be inspected in order to measure the amount of fissile material recovered and not reveal any classified information. In the U.S., this would require the use of multiple facilities or a new dedicated facility. Whether or not the fissile material could be reused is a separate question.

Counting Production and Retirements

Dismantlement and materials controls are generally proposed as a way to "permanently" reduce the number of deployed nuclear warheads. However, currently permanency is not as important as retiring weapons in the first place, and the verification resources would better be spent on controlling production and retirements than on dismantlement. A simple, effective way to build down the stockpile of nuclear warheads is to limit the number of new (or rebuilt) warheads produced to less than an agreed upon number of warheads to be retired each year. This system supports the more important objectives of arms reduction and is less expensive, and less intrusive than verified dismantlement and fissile material controls. Another advantage is that modernization would be possible. Older and less safe, secure, and survivable warheads would likely be retired first because each side would choose its own retirements.

Figure 2 shows that counting retirements would require identification of warheads and/or chain of custody to the retirement (dismantlement) facility. Counting the new warheads produced could be accomplished with PPM at the production facility. Agreement on weight and size limits for containers holding new warheads could help prevent multiple warheads exiting as a single warhead. In any case, visually counting new warheads could also be accomplished with shrouds, which have been proposed and demonstrated [12] for counting multiple warheads on intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) for START.

By focusing on the verification or counting the deployments of new warheads and the retirements of old warheads, the U.S. and the Soviet Union can avoid the verification of disassembly, including the possible verification

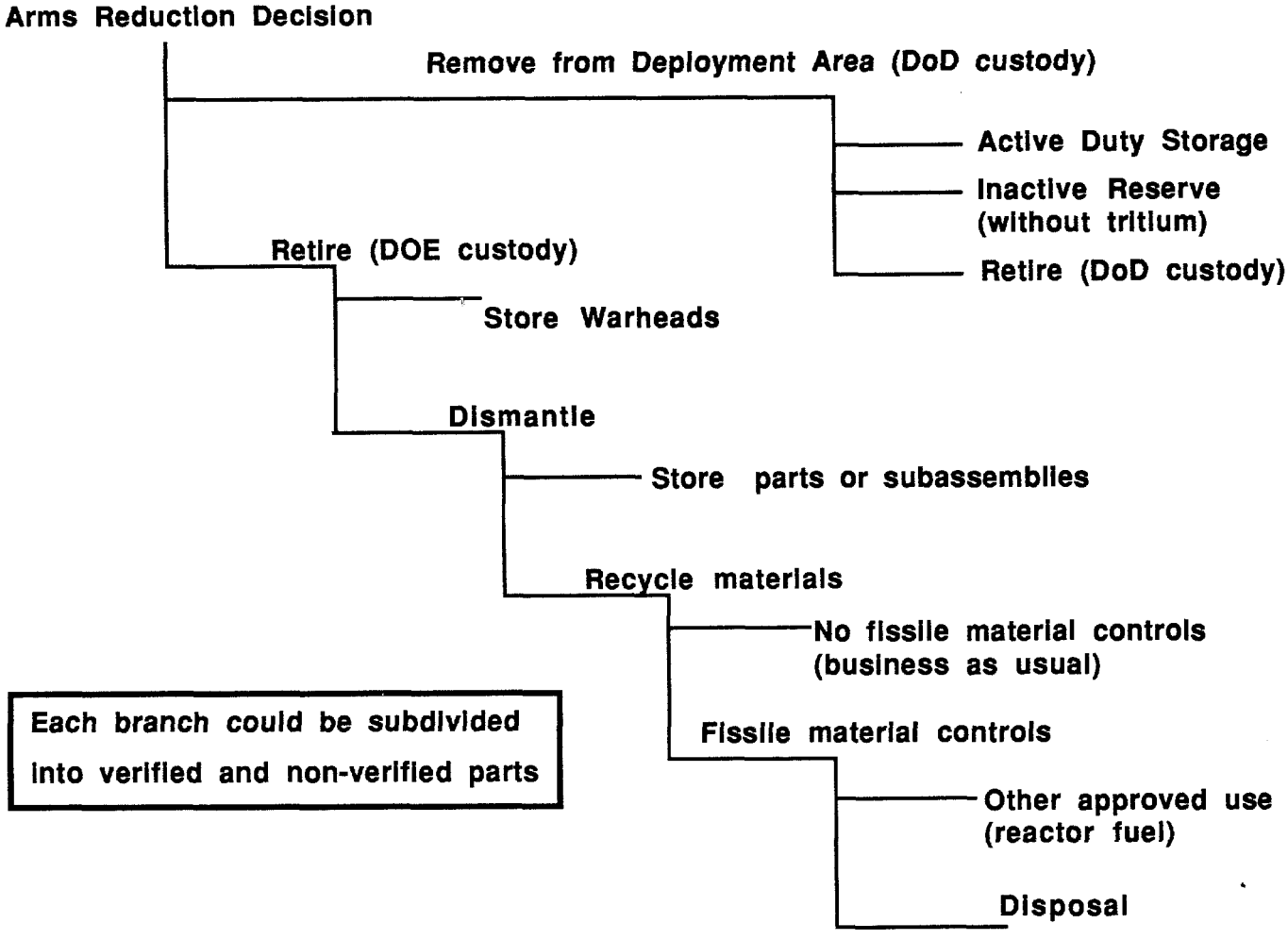

Fig. 3. Possibilities for the Disposition of Nuclear Warheads and Materials.

of amount, and assays of weapon grade fissile materials. Hence, the intrusiveness of and the qualifications for inspectors would be less demanding, and the costs of inspections would be reduced.

CONTROL AND DISPOSITION OF FISSILE MATERIAL

Control of Fissile Material

Most proposals focus on controlling fissile material in an attempt to ensure that the warheads are permanently retired, to reduce the risk of resumption of the arms race. Because warheads can be made with various amounts of fissile materials, what this really accomplishes is to increase the cost and the time required to reestablish the stockpile.

One suggestion is that fissile material from warheads retired under an arms reduction agreement be sequestered with suitable verification. This would mean that appropriate safe and secure isolation facilities would have to be provided. Both bilateral and international [International Atomic Energy Agency (IAEA)] verification have been suggested.

Aside from the verification problems, there is the problem that such a procedure might not be effective and equitable. The fairness and effectiveness of controlling or prohibiting reuse of fissile materials from dismantled warheads depends critically on the initial stockpiles of weapon grade fissile materials and the facilities to produce such materials. Banning the production or use (in weapons) of virgin materials would also be necessary for an effective regime. The questions of equity and effectiveness cannot be fully answered until more information about the Soviet facilities is available.

As an alternative to sequestering the fissile materials from weapons retired in accordance with an arms reduction treaty, the U.S. and the Soviet Union could agree to sequester arbitrary amounts of plutonium and/or highly enriched uranium (HEU), with or without the concomitant dismantlement of warheads. This would allow some flexibility for modernization of the stockpiles, but would probably require facilities to process the materials. Again, the

impact depends on the initial stockpiles and the new materials production capabilities.

Fissile Material Production

If control of fissile materials is to be used to limit the stockpile of nuclear weapons, then the use or production of virgin materials for nuclear warheads must be prohibited. A ban on the production of fissile material would mean shutting down plutonium production reactors and processing facilities and shutting down high enrichment facilities for uranium. Although there are environmental and economic pressures for such closures, such a ban might not be without problems.

Because tritium is needed for the viability of the nuclear weapon stockpiles, tritium production reactors will likely be necessary. These as well as other reactors (research and propulsion reactors) can produce plutonium. Thus, the fuel and targets and the facilities that process the exposed fuel and targets would have to be inspected to verify a ban on the production of plutonium. In addition, naval and tritium production reactors use enriched uranium as reactor fuel; therefore, a total ban on enrichment might not be feasible unless sufficient and suitable reactor fuel can be fabricated from existing weapon grade materials. The HEU from retired weapons might be adequate for all of these purposes for some period of time. However, this question is complicated by the uncertainty in nuclear weapons design and stockpile requirements of the future.

While it is relatively easy to verify that a facility is shut down, verifying that fissile material from a reactor or enrichment facility is not weapon grade or is not used for weapons requires extensive chain-of-custody monitoring and trained inspectors and intrusive measurements. "Cooperative" IAEA type inspections would probably not be sufficient. Also, separation of civilian use of fissile materials, including possible recycling and waste disposal, are not difficult in the U.S., but could be problematic in the Soviet Union.

The United States has stopped and does not intend to restart the production of fissile material for nuclear weapons [13]. The Soviet Union has said that it will cease production of plutonium by the year 2000. Thus, an agreement to ban the production of fissile material for weapons seems appropriate. However, such a ban by itself would not guarantee that the stockpiles of nuclear weapons would not grow. The effect of a materials production ban for weapons depends on whether the material from retired warheads is allowed to be recycled and on the amount initially available. This brings us back to the initialization problem, which is not just a problem of the amount but also of the type of material and enrichment.

Disposition of Fissile Material

Although the question of what to do with sequestered or excess fissile materials must be analyzed and appropriate disposition decisions must be made, it is clear that such material should be protected and safeguarded as a valuable, although possibly dangerous, resource. One way to start would be for the U.S. and the Soviet Union to declare the amounts and forms of materials retired from the stockpiles that will not be reused for military purposes. This would be a confidence-building measure and would aid in the analyses and planning for ultimate disposition.

Each nation could initially store and protect its materials in various forms, e.g., warheads, subassemblies, components, and bulk materials. After a allowing time for planning and analysis, the materials could be transferred to facilities where, while still under national control, they would be subject to bilateral or international safeguard procedures. As more confidence and verification procedures are developed, more of the materials could be converted to suitable peaceful uses (e.g., reactor fuel) or storage forms (e.g., ingots).

The question of ultimate disposition was recently addressed at the 1991 American Association for the Advancement of Science Annual Meeting [5]. Most common ideas on disposition include converting fissile material from retired warheads to reactor fuel, or disposing of it as a form of nuclear waste. The latter sometimes included a provision to dilute or denature the materials to make their use in a weapon impossible or at least as difficult as obtaining virgin material.

Disposal as waste would appear to be unacceptable. Not only has a strategy for the disposal of nuclear waste not been implemented, but in the future, some innovative uses for plutonium and highly enriched uranium, including, but not limited to, advanced (safer, smaller) reactors might emerge.

CONCLUSIONS

In the past, proposals for the control of fissile materials have been put forth as surrogates for direct arms control [14]. However, recently most proposals for verified warhead dismantlement and fissile material controls have been in the context of arms reduction treaties. This is entirely proper because the weapons, such as the missiles pointed at each other, are the primary threat. Furthermore, because it would be unrealistic to expect a high degree of confidence in verifying the initial stockpiles of warheads and materials, the primary focus of arms control measures should be on launch vehicles where the initialization problem is not as formidable. In fact, *warhead dismantlement and fissile material control measures should be viewed primarily as confidence-building measures.*

Stockpile Declarations

Estimates of the initial stockpiles of nuclear warheads and fissile materials are crucial to assessing the value of arms control agreements in general and warhead dismantlement and fissile material control proposals in particular. *U.S. and Soviet declarations about stockpiles of nuclear weapons could the basis to evaluate future arms control agreements and verification measures.* Declarations could be initiated with little risk because our national security would not be

threatened by announcing the total number of warheads and the amount of fissile materials in our stockpiles. As well as helping to solve the initialization problem, the openness demonstrated by declarations could possibly lead to cooperation in environmental restoration and in the conversion of some of the nuclear weapons facilities.

Dismantlement vs *Counting*

For dismantlement to be more than principally symbolic, it must also be coupled with warhead production and fissile material controls. In light of the objectives, it is more important to spend resources on retiring (and safeguarding) warheads than on verifying dismantlement. *Building down of the stockpiles by limiting production to some fraction of the retirement rate required by arms reduction treaties is the simplest, most direct and effective alternative to verified dismantlement.* Counting newly produced and retired warheads alleviates many verification tasks that would require new or modified facilities, trained inspectors, and a large degree of intrusiveness. It also allows the new, safer, more secure, more survivable warheads to replace older ones.

Disposition of Excess Fissile Material

Until there is a plan for the disposition of excess fissile material from retired warheads, it makes sense to protect such material as a valuable resource. The U.S. and the Soviet Union could declare the amount and forms of their excess fissile materials and store them in national facilities while, over a period of years, bilateral or international verification procedures are instituted for the safeguarding and peaceful use of these materials.

Production Ban

A ban on the production and use of new fissile material for weapons would be appropriate because the U.S. is not producing and does not intend to produce such material, and the Soviet Union plans to end its production. Verification that facilities are shut down is relatively simple.

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