Transparency and Verification Options:

An Initial Analysis of Approaches for Monitoring Warhead Dismantlement

Prepared by:

The Department of Energy
Office of Arms Control and Nonproliferation

May 19, 1997

Supported by the Dismantlement Study Group

Contributors:

Office of Defense Programs
Office of Security Affairs
Pantex
Oak Ridge Y-12
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Pacific Northwest National Laboratory
Sandia National Laboratories
DynMeridian

TABLE OF CONTENTS

EXECUTIVE SUMMARY

At the March 21, 1997, Helsinki Summit, Presidents Clinton and Yeltsin underscored their interest in further nuclear warhead reductions beyond START I and START II, as well as the need to monitor nuclear warhead inventories, nuclear warhead dismantlement, and fissile materials resulting from warhead reductions. Progress in these areas would further U.S. efforts to reduce the nuclear danger and strengthen strategic stability and nuclear security. In anticipation of an agreement requiring further warhead reductions and the monitoring of warhead dismantlement, the Department of Energy (DOE) Office of Arms Control and Nonproliferation commissioned a technical study in the Fall of 1996 to identify ***transparency*** and ***verification*** options that could be implemented at DOE facilities to monitor warhead dismantlement. For the purposes of this study, **transparency** refers to measures that provide ***confidence*** that a declared activity is taking place, and **verification** refers to measures that ***confirm*** that a declared activity is ***actually*** taking place.

A nuclear warhead generally consists of an assembly containing a "pit", a Canned SubAssembly (CSA), high explosive (HE), and other non-nuclear components. As defined by DOE, the warhead dismantlement process, which includes activities that occur at the Pantex and Y-12 facilities, involves the storage of nuclear warheads, onsite transportation, warhead disassembly, plutonium (Pu) and highly enriched uranium (HEU) component storage, and non-nuclear component disposition. A warhead is considered to be fully dismantled when the HE is removed from the "pit." After dismantlement takes place, the "pits" are stored at Pantex in Zone 4 and the CSAs are shipped to the Oak Ridge Y-12 Plant for disassembly and storage. The "pits" stored at Pantex await future disposition, which is beyond the scope of this study.

Options for Monitoring Warhead Dismantlement

The DOE study group identified ten (10) key activities that could be used as part of a warhead dismantlement monitoring regime:

- *Declarations of dismantlement schedules, warheads, and components resulting from the dismantlement process;*
- *Spot checks of the weapons receipt and storage areas and component storage areas to confirm the declarations, including the use of radiation signatures of the weapons and components;*
- *Remote monitoring of the weapons receipt and storage areas and component storage areas;*
- *Chain-of-custody of warheads and components from the storage areas to the dismantlement areas;*
- *Portal Perimeter Continuous Monitoring (PPCM) to inspect every item that passes into and out of a segregated portion of the dismantlement area;*
- *Chain of custody of warheads and components within the dismantlement area;*
- *Sweeping or sanitizing the disassembly bay or dismantlement cell before and after dismantlement;*
- *Remote monitoring or direct observation of the dismantlement process;*
- *Chain-of-custody of nuclear components from the dismantlement areas to the component storage areas after dismantlement has occurred;*
- *Monitoring of the non-nuclear components of the warhead, such as the high explosive and warhead electronics, after dismantlement has occurred.*

EXECUTIVE SUMMARY

At the March 21, 1997, Helsinki Summit, Presidents Clinton and Yeltsin underscored their interest in further nuclear warhead reductions beyond START I and START II, as well as the need to monitor nuclear warhead inventories, nuclear warhead dismantlement, and fissile materials resulting from warhead reductions. Progress in these areas would further U.S. efforts to reduce the nuclear danger and strengthen strategic stability and nuclear security. In anticipation of an agreement requiring further warhead reductions and the monitoring of warhead dismantlement, the Department of Energy (DOE) Office of Arms Control and Nonproliferation commissioned a technical study in the Fall of 1996 to identify ***transparency*** and ***verification*** options that could be implemented at DOE facilities to monitor warhead dismantlement. For the purposes of this study, **transparency** refers to measures that provide ***confidence*** that a declared activity is taking place, and **verification** refers to measures that ***confirm*** that a declared activity is ***actually*** taking place.

A nuclear warhead generally consists of an assembly containing a "pit", a Canned SubAssembly (CSA), high explosive (HE), and other non-nuclear components. As defined by DOE, the warhead dismantlement process, which includes activities that occur at the Pantex and Y-12 facilities, involves the storage of nuclear warheads, onsite transportation, warhead disassembly, plutonium (Pu) and highly enriched uranium (HEU) component storage, and non-nuclear component disposition. A warhead is considered to be fully dismantled when the HE is removed from the "pit." After dismantlement takes place, the "pits" are stored at Pantex in Zone 4 and the CSAs are shipped to the Oak Ridge Y-12 Plant for disassembly and storage. The "pits" stored at Pantex await future disposition, which is beyond the scope of this study.

Options for Monitoring Warhead Dismantlement

The DOE study group identified ten (10) key activities that could be used as part of a warhead dismantlement monitoring regime:

- *Declarations of dismantlement schedules, warheads, and components resulting from the dismantlement process;*
- *Spot checks of the weapons receipt and storage areas and component storage areas to confirm the declarations, including the use of radiation signatures of the weapons and components;*
- *Remote monitoring of the weapons receipt and storage areas and component storage areas;*
- *Chain-of-custody of warheads and components from the storage areas to the dismantlement areas;*
- *Portal Perimeter Continuous Monitoring (PPCM) to inspect every item that passes into and out of a segregated portion of the dismantlement area;*
- *Chain of custody of warheads and components within the dismantlement area;*
- *Sweeping or sanitizing the disassembly bay or dismantlement cell before and after dismantlement;*
- *Remote monitoring or direct observation of the dismantlement process;*
- *Chain-of-custody of nuclear components from the dismantlement areas to the component storage areas after dismantlement has occurred;*
- *Monitoring of the non-nuclear components of the warhead, such as the high explosive and warhead electronics, after dismantlement has occurred.*

The range of options available for monitoring warhead dismantlement is considerable. Based on the ten monitoring activities listed above, four options were considered in this report with varying levels of confidence in dismantlement and intrusiveness:

Option 1: Monitoring of warheads and components in the storage area and chain of custody monitoring to and from the gate to the dismantlement area.

Option 2: Option 1 ***plus*** portal perimeter continuous monitoring (PPCM) of a segregated portion of the dismantlement area dedicated to monitored dismantlement.

Option 3: Option 1 ***plus*** further chain of custody procedures to monitor warheads and components within the dismantlement area and to and from the disassembly bays and dismantlement cells (without PPCM).

Option 4: Option 1 ***plus*** direct observation or remote monitoring of the dismantlement process inside the disassembly bays and dismantlement cells.

As a result of the significant cultural changes regarding openness at DOE and its nuclear weapons complex over the past four years, all of the dismantlement monitoring options listed above could be applied at either the ***Confidential/National Security Information (C/NSI)*** level or at the ***Restricted Data/Formerly Restricted Data (RD/FRD)*** level, with differing levels of confidence that dismantlement is occurring.

Each of the four options was evaluated against the following seven evaluation criteria:

- ***Level of confidence*** *- the level of confidence that dismantlement has taken place produced by each option.*
- ***Negotiability*** *- a judgment of the relative ease with which the monitoring option may be accepted by the Russian Federation.*
- ***Inadvertent loss of classified information*** *- the possibility that a Russian inspector, by being present at a dismantlement facility, could either accidentally or intentionally gain access to classified information not intended to be shared with the inspectors.*
- ***Impact on operations*** *- the disruption to on-going operations at the DOE nuclear weapons complex not related to the dismantlement of excess nuclear weapons, such as stockpile surveillance and maintenance activities.*
- ***Operational readiness*** *- the time needed for a DOE dismantlement facility to be ready to host inspections, including the time required for construction and physical modifications, if needed.*
- ***Cost to prepare for and host the first inspection*** *- including any physical or procedural modifications that would need to be made to prepare for and host the first inspection.*
- ***Routine cost of hosting each inspection*** *- the recurring cost of each routine inspection after the initial inspection has taken place.*

OFFICIAL USE ONLY

The results of the analysis of the four dismantlement monitoring options are summarized below.

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness [1]	Cost of First Inspection [2]	Routine Inspection Cost [2,3]
Option 1	C/NSI	Low	High	Low	Low	1 year	$2.5 M	$0.12 M
	RD/FRD	Moderate	Low–Mod.	Low–Mod.	Low	1 year	$2.5 M	$0.12 M
Option 2	C/NSI	Moderate	Low	Low–Mod.	Moderate	2 years	$12.0 M	N/A[4]
	RD/FRD	High	Low	Moderate	Moderate	2 years	$12.0 M	N/A[4]
Option 3	C/NSI	Moderate	Moderate	Moderate	Moderate	1.5 years	$6.5 M	$0.2 M
	RD/FRD	Mod.–High	Low–Mod.	Mod.–High	Moderate	1.5 years	$6.5 M	$0.2 M
Option 4	C/NSI	Moderate	Low	High	High	2 years	$6.5 M	$0.2 M
	RD/FRD	High	Low	High	High	2 years	$6.5 M	$0.2 M

[1] Operational readiness refers , for example, to the time required for construction and physical modifications.
[2] Cost estimates are planning estimates only for Pantex and do not represent official estimates for budget purposes.
[3] Routine inspection costs are shown for one inspection, and several such inspections would likely be performed each year.
[4] Option 2 assumes permanent presence of inspectors at a cost of $5.5 million per year.

General Conclusions

Any treaty involving the monitoring of nuclear warheads, nuclear warhead dismantlement, and stockpiles of fissile materials will have a significant impact on DOE. By Presidential order, DOE has the nation's responsibility to maintain a safe, secure, and reliable nuclear warhead stockpile and to ensure that excess nuclear warheads are dismantled safely in accordance with arms control requirements. In order to minimize both the disclosure of sensitive information and the impact on stockpile surveillance and maintenance activities at Pantex, there may be some significant advantages in using a dedicated dismantlement facility such as the Device Assembly Facility (DAF) at the Nevada Test Site.

Assuming that the item which arrives at the dismantlement facility is a nuclear warhead, either warhead dismantlement ***transparency or verification can be achieved*** by implementing the monitoring activities identified in this report. Transparency in the warhead dismantlement process can be achieved by a combination of monitoring activities with up to a moderate level of confidence that dismantlement has taken place ***without requiring an Agreement for Cooperation*** to exchange classified information. Verification of warhead dismantlement will require the exchange of Restricted Data or Formerly Restricted Data (RD/FRD) under an Agreement for Cooperation.

Determining that an item to be dismantled is actually a nuclear warhead is much more difficult, and may require the use of both chain-of-custody procedures from Department of Defense (DoD) facilities (e.g., from a delivery vehicle, deployment site, or weapons storage depot) to the dismantlement facility and the use of warhead radiation signatures to correlate the signature of a given warhead with those of its components following dismantlement.

A distinction between strategic versus tactical nuclear warheads, or between warheads of different types, can only be made before the warhead arrives at the DOE dismantlement facility. Thus, if START III requires that such a distinction be made, a chain-of-custody regime may be needed beginning with the removal of the warhead from a delivery vehicle, deployment site, or from a DoD weapons storage depot.

Next Steps

Since a determination of specific warhead type, or of strategic versus tactical warhead, can only be made in conjunction with collateral information obtained outside of the DOE dismantlement facility, an analysis of potential warhead dismantlement monitoring procedures at DoD facilities should be conducted. Such a study should identify potential monitoring procedures that could be implemented at various stages of DoD custody of the warhead, including:

- *When the warhead is on the delivery vehicle and during the time of removal from the delivery platform;*
- *The appropriate starting point for chain-of-custody procedures for gravity bombs and cruise missiles, which are typically stored or staged in a location separate from the delivery system;*
- *When the warhead is at a weapon storage depot or other storage location where retired weapons are stored prior to being picked up by Safe, Secure Trailers (SSTs) for transportation to the DOE dismantlement facility.*

The U.S. should also undertake a study to identify and evaluate options for warhead dismantlement monitoring that could be implemented in the Russian nuclear weapons complex. Such a study should address issues associated with the significant asymmetries between the U.S. and Russian nuclear weapons programs, particularly the fact that whereas the DOE Pantex Plant is the only active U.S. dismantlement facility, Russia has four dismantlement facilities.

A more in-depth ***quantitative*** analysis is needed for all the options. This analysis should quantitatively evaluate the inadvertent loss of classified information, impact on operations, cost, and confidence level associated with each option.

In-depth analysis should also be conducted in the following areas:

- *Advantages and disadvantages of warhead radiation signature measurement methods;*
- *Security and vulnerability issues associated with radiation measurements on nuclear warheads and components;*
- *Cost, schedule, and impact issues associated with the use of a dedicated dismantlement facility such as the Device Assembly Facility (DAF) at the Nevada Test Site or a new, dedicated dismantlement facility incorporating monitoring measures;*
- *Options that can be implemented at DOE facilities to promote "...the **irreversibility** of deep reductions including the prevention of a rapid increase in the number of warheads," as required by the Helsinki Summit statement.*

I. OVERVIEW

There is increasing interest in both the United States and the Russian Federation in further nuclear warhead reductions beyond START I and START II as well as in the need to monitor nuclear warhead inventories, nuclear warhead dismantlement, and fissile materials resulting from warhead reductions. This interest was evidenced by the Joint Statement issued by Presidents Clinton and Yeltsin at their March 21, 1997, Helsinki Summit, as follows:

> "Once START II enters into force, the U.S. and Russia will immediately commence negotiations on a START III agreement, which will include *inter alia:*
>
> - *Establishment, by December 31, 2007, of lower aggregate levels of 2,000–2,500 strategic nuclear warheads for each of the Parties; and,*
>
> - *Measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads and any other jointly agreed technical and organizational measures, to promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads."*

Any treaty involving the monitoring of nuclear warheads, nuclear warhead dismantlement, and stockpiles of fissile materials will have a significant impact on DOE. By Presidential order, DOE has the nation's responsibility to maintain a safe, secure, and reliable nuclear warhead stockpile and to ensure that excess nuclear warheads are dismantled safely in accordance with arms control requirements.

In anticipation of such an agreement requiring further warhead reductions and the monitoring of warhead dismantlement, the DOE Office of Arms Control and Nonproliferation commissioned a technical study in the Fall of 1996 to determine what transparency and verification options could be implemented at DOE facilities to monitor warhead dismantlement. This report provides the results of that study. This study was not intended to answer all of the possible questions associated with a START III monitoring regime but rather to initially focus on the following key questions related to warhead dismantlement monitoring options at DOE facilities:

- *How can the rate of dismantlement be monitored in the event that a START III treaty requires that a specific quantity of warheads be dismantled in a specific period of time?*

- *Does a warhead dismantlement monitoring regime require an Agreement for Cooperation to exchange Restricted Data (RD) and Formerly Restricted Data (FRD)?*

- *Can the dismantlement of a specific type of warhead be confirmed and can the dismantlement of a strategic versus tactical warhead be confirmed by implementing monitoring measures only at DOE facilities, or must Department of Defense (DoD) facilities be involved as well?*

To assist in this study, DOE established a Dismantlement Study Group that included technical experts from the Office of Arms Control and Nonproliferation, the Office of Defense Programs, the Office of Security Affairs, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, the Pantex Plant, and the Oak Ridge Y-12 Plant. The list of participants in the Dismantlement Study Group is provided in Appendix A.

A nuclear warhead generally consists of an assembly containing a "pit," a Canned SubAssembly (CSA), high explosive (HE), and other non-nuclear components. As defined by DOE, the warhead dismantlement process, which includes activities that occur at the Pantex and Y-12 facilities, involves the storage of nuclear warheads, onsite transportation, warhead disassembly, plutonium (Pu) and highly enriched uranium

(HEU) component storage, and non-nuclear component disposition. A warhead is considered to be fully dismantled when the HE is removed from the "pit." After dismantlement takes place, the "pits" are stored at Pantex in Zone 4 and the CSAs are shipped to the Oak Ridge Y-12 Plant for disassembly and storage. The "pits" stored at Pantex await future disposition, which is beyond the scope of this study.

This study focused on potential warhead dismantlement monitoring procedures that could be implemented in the DOE nuclear weapons complex, particularly at the Pantex Plant and the Oak Ridge Y-12 Plant. The study group concluded that there may be some significant advantages in using a dedicated dismantlement facility such as the Device Assembly Facility (DAF) at the Nevada Test Site as a means of minimizing both the disclosure of sensitive information and the impact on stockpile surveillance and maintenance activities at Pantex. Therefore, the study group concluded that a separate, in-depth analysis should be performed to fully evaluate the cost, schedule, and impact issues associated with the use of a dedicated dismantlement facility.[1]

The study addressed both ***transparency*** and ***verification*** options that could be implemented in the DOE nuclear weapons complex. For the purposes of this study, transparency and verification are distinguished as follows:

- **Transparency:** measures that provide *confidence* a declared activity is taking place.
- **Verification:** measures that *confirm* a declared activity is *actually* taking place.

The study did not focus on potential monitoring procedures that could be implemented at Department of Defense (DoD) facilities, where nuclear warheads declared to be excess and awaiting dismantlement are stored prior to being transported to Pantex. However, the study group concluded that an analysis of potential monitoring procedures at DoD facilities should be undertaken as part of any follow-on work.

This study also did not address in detail potential monitoring procedures that could be implemented at Russian facilities. The study group concluded that it was prudent to first determine the options for warhead dismantlement monitoring in the U.S. before analyzing potential warhead dismantlement monitoring options that could be implemented in the Russian nuclear weapons complex. Having completed an evaluation of options for warhead dismantlement monitoring in the U.S. nuclear weapons complex, the study group concluded that a follow-on study should be undertaken to address the issues associated with implementing a warhead dismantlement monitoring regime in Russia. Such a follow-on study should particularly address the significant asymmetries that exist between the U.S. and Russian nuclear weapons programs.

In considering the possible monitoring options or scenarios, many of the monitoring *activities* are largely facility-independent—that is, the options might employ, for example, monitoring of weapons receipt and storage areas, or weapons disassembly areas, which in general terms would be common to either a U.S. or Russian dismantlement facility. It is the *implementation* of the warhead dismantlement monitoring options that would be facility-specific.

The study group identified ten (10) key activities listed below that could be used as part of a warhead dismantlement monitoring regime. They are general in nature and may be applied to the monitoring of warhead dismantlement at a U.S. dismantlement facility, to the disassembly of CSAs at the Oak Ridge Y-12 Plant, or to the monitoring of warhead dismantlement at a Russian dismantlement facility. For illustration, these ten activities are referenced to the applicable Pantex Plant zones in parentheses.

[1] The December 1993 Wilson Report (see Appendix C) concluded that the use of a dedicated dismantlement facility such as the DAF could reduce the risk of disclosing sensitive information and the impact on non-dismantlement operations. Since 1993, DOE has accomplished a significant amount of work in completing the DAF construction and the DAF is scheduled to have its Operational Readiness Review in the Summer of 1997. Given these changing circumstances, an updated report on the use of DAF in a START III transparency regime should be undertaken.

The ten monitoring activities are:

- Declarations of dismantlement schedules, warheads, and components resulting from the dismantlement process;
- Spot checks of the weapons receipt and storage areas and component storage areas to confirm the declarations, including the use of radiation signatures of the weapons and components (*Zone 4 at Pantex*);
- Remote monitoring of the weapons receipt and storage areas and component storage areas (*Zone 4 at Pantex*);
- Chain-of-custody of warheads and components from the storage areas to the dismantlement areas (*from Zone 4 to the gate of Zone 12 at Pantex*);
- Portal Perimeter Continuous Monitoring (PPCM) to inspect every item that passes in and out of a segregated portion of the dismantlement area (*inside Zone 12 at Pantex*);
- Chain-of-custody of warheads and components within the dismantlement area (*inside Zone 12 at Pantex*);
- Sweeping or sanitizing a disassembly bay or dismantlement cell periodically before and after dismantlement (*inside Zone 12 at Pantex*);
- Remote monitoring or direct observation of the dismantlement process (e.g., during the disassembly of the physics package and during the removal of the high explosive from the pit) (*inside Zone 12 at Pantex*);
- Chain-of-custody of nuclear components from the dismantlement areas to the component storage areas after dismantlement (*from the gate of Zone 12 back to Zone 4 at Pantex*); and
- Monitoring of the disposition of the nonnuclear components of the warhead, such as the high explosive and warhead electronics, after dismantlement.

After careful consideration of the details of current Pantex and Y-12 operations, and as a result of the significant cultural changes regarding openness at the DOE and at the Pantex and Y-12 Plants during the past four years, the study group concluded that all of the ten monitoring activities listed above could be applied at either the **Unclassified to Confidential National Security Information (U to C/NSI)** level or at the **Restricted Data (RD)/Formerly Restricted Data (FRD)** level. The monitoring activities cannot be completely implemented on the unclassified level because some of the activities include monitoring the movement of weapons and components. Under current classification guidelines, dates and times of movements of weapons and components outside a protected area are classified as C/NSI. The study group also concluded that the confidence in each monitoring activity would depend critically on which classification level was chosen, with higher classification levels generally yielding higher confidence in warhead dismantlement.

In addition, the study group concluded that, ***assuming the item arriving at the dismantlement facility is a nuclear weapon***, either warhead dismantlement transparency or verification ***can be achieved*** through various combinations of the ten monitoring activities, with confidence that increases at higher classification levels.

The study group identified four options for discussion based on the ten monitoring activities listed above, ranging from monitoring only the warhead and component storage area (Option 1), to highly intrusive monitoring of the actual dismantlement process in the dismantlement area (Option 4). Each option is general and may be applied to the monitoring of warhead dismantlement at a U.S. dismantlement facility, to the disassembly of CSAs at the Oak Ridge Y-12 Plant, or to the monitoring of warhead dismantlement at a

Russian dismantlement facility. For illustration, the four options are stated here in terms of application to Pantex. Application to a Russian facility would require additional information concerning the Russian nuclear weapons program. The four options chosen for discussion are:

Option 1: Monitoring of warheads and components in the storage area (*Zone 4 at Pantex*) and chain-of-custody monitoring to and from the gate to the dismantlement area (*Zone 12 at Pantex*).

Option 2: Option 1 *plus* portal perimeter continuous monitoring (PPCM) of a segregated portion of the dismantlement area (*inside Zone 12 at Pantex*) dedicated to monitored dismantlement.

Option 3: Option 1 *plus* further chain-of-custody procedures to monitor warheads and components within a segregated portion of the dismantlement area (*inside Zone 12 at Pantex*) and to and from the disassembly bays and dismantlement cells (without PPCM).

Option 4: Option 3 *plus* direct observation or remote monitoring of the dismantlement process (*inside Zone 12 at Pantex*).

Each of the four options was evaluated against the following seven evaluation criteria:

- **Level of confidence**—the level of confidence that dismantlement has taken place provided by each option.
- **Negotiability**—a judgment of the relative ease with which the transparency or verification option may be accepted by the Russian Federation.
- **Inadvertent loss of classified information**—the possibility that a Russian inspector, by being present at a dismantlement facility, could either accidentally or intentionally gain access to classified information not intended to be shared with the inspectors.
- **Impact on operations**—the disruption to ongoing operations at Pantex or Y-12 unrelated to the dismantlement of excess nuclear weapons, such as stockpile surveillance and maintenance activities.
- **Operational readiness**—the time needed to be ready for Pantex or Y-12 to host inspections, including the time required for construction and physical modifications, if needed.
- **Cost to prepare for and host the first inspection**—including any physical or procedural modifications that would need to be made to prepare for and host the first inspection.
- **Routine cost of hosting each inspection**—the recurring cost of each routine inspection after the initial inspection.

ASSUMPTIONS

Several general as well as specific assumptions were made by the study group. However, it should be noted that the four options listed above were designed to be flexible enough to accommodate changes to the specific assumptions described below. If—as part of the U.S. interagency deliberations—it became necessary to change the specific assumptions so that, for example, the duration and number of inspections per year were increased, the model that was developed would be able to generate a revised analysis of the impacts of the new assumptions on the overall cost, level of confidence, etc. Thus, even though we have hypothesized for purposes of analysis that, for Options 1, 3, and 4, there would be twelve inspections per year, these assumptions can easily be varied to accommodate changes in U.S. policy.

General Assumptions

- For the purposes of this study, it is ***assumed*** that the object arriving at Pantex to be dismantled is ***actually*** a nuclear warhead.
- Warhead dismantlement monitoring procedures would only be applied to warheads declared to be *excess* to national security requirements, and no longer required as part of the existing nuclear warhead stockpile.
- Issues associated with the ***"irreversibility"*** of the fissile materials in storage and the disposition of fissile materials are beyond the scope of this study.
- The problem of the ***"initialization"*** of the size of U.S. and Russian stockpiles of warheads and fissile material is beyond the scope of this study.
- Stockpile surveillance activities and other activities required to maintain the enduring stockpile would ***not*** be subject to monitoring procedures.
- Segregated, dedicated magazines in Zone 4 at Pantex and segregated, dedicated disassembly bays and dismantlement cells in Zone 12 at Pantex will be used for the storage and dismantlement of excess warheads and components covered in a START III treaty. (Facilities represented in the graphics illustrating the options which follow are included for cost estimating purposes only. The actual magazines, bays, cells, etc. used in a warhead dismantlement monitoring regime may differ from those illustrated.)

Specific Assumptions

The following specific assumptions were used ***only*** for the purposes of generating cost estimates. A complete listing of all specific assumptions used for cost-analysis purposes is included in Appendix F.

- Options 1, 3, and 4 would allow a discrete number of inspections per year (e.g., up to 12 inspections per year).
  - Each inspection would have a relatively short duration (e.g., up to 5 working days).
  - Each inspection team would consist of a relatively small number of inspectors (e.g., up to 10).
- Options 2, 3, and 4 would be applied in the same segregated, dedicated portion of the dismantlement area (Zone 12 if implemented at Pantex).
- Option 2 would require that inspectors be continuously present at the dismantlement facility.

DESCRIPTION OF OPTIONS

Option 1: Monitored Storage

Option 1 involves declarations of the dismantlement schedule and inventories of warheads and components resulting from dismantlement as well as spot checks to confirm those declarations. Option 1 would be applied to monitoring the storage of warheads and components coming from dismantled warheads in the Zone 4 storage area at Pantex and HEU from CSAs if implemented at the Oak Ridge Y-12 Plant. This *monitored storage option* is designed to be a minimally intrusive option that includes following the warhead to the gate of the dismantlement or disassembly area (Zone 12 at Pantex) but does not provide access to the dismantlement area itself, where actual dismantlement of the warhead takes place. This option provides the lowest confidence level of all four options considered in this report that dismantlement has taken place, since the other options build upon this one. Figure 1 shows the areas in red that inspectors would have access to under Option 1 if implemented at Pantex.

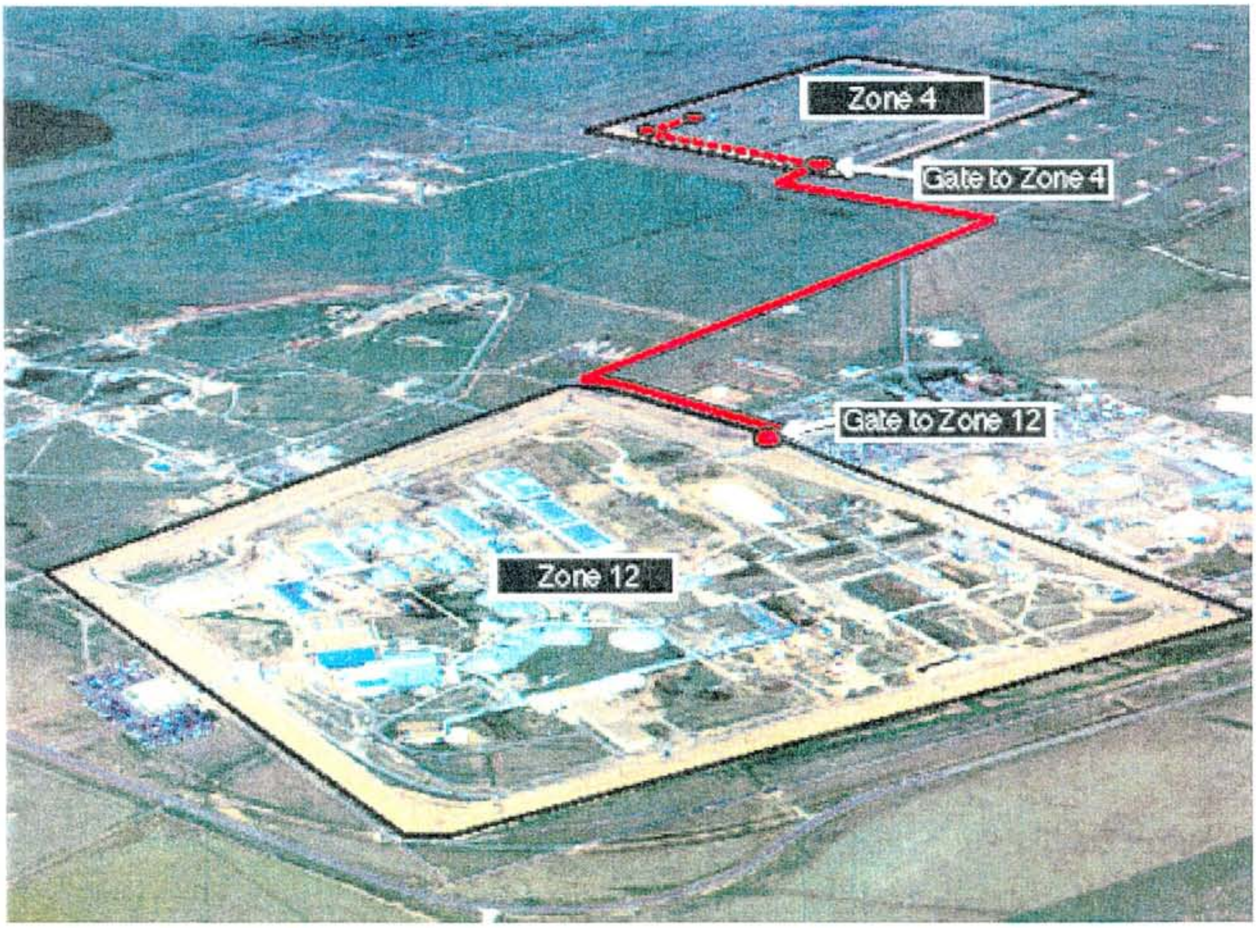


Figure 1: Pantex Access Areas Covered under Option 1.

Option 2: Option 1 *Plus* Portal Perimeter Continuous Monitoring

Option 2 is intended to produce higher confidence in dismantlement than Option 1 but without direct observation of the dismantlement process (Option 4) or the need for chain-of-custody within the dismantlement area (Option 3). In addition to monitored storage, Option 2 would establish Portal Perimeter Continuous Monitoring (PPCM) of a segregated portion of the dismantlement area (inside Zone 12 at Pantex) dedicated to monitored. The study group considered establishing PPCM around the entire dismantlement area but concluded—as did previous studies—that this would be extremely intrusive and costly because it would require that *all* items entering and leaving the dismantlement area would be subject to search. This would result in an unintentional loss of information regarding the enduring stockpile because warheads returned to Pantex and CSAs returned to Y-12 for retrofitting or testing as part of the Stockpile Stewardship Program would be subject to inspection and potential radiation measurements. Implementation of PPCM around a segregated, dedicated portion of the dismantlement area (inside Zone 12 at Pantex) would have a significant impact on current Pantex and Y-12 operations, and would require a one-time investment for facility modification of $12 million or more. Following the initial significant impact on plant operations of segregating and dedicating an area, Option 2 would provide a moderate to high level of confidence that dismantlement is taking place, depending on the classification level chosen, at a relatively low impact on normal operations both in the segregated, dedicated portion of the dismantlement area and in the remainder of the dismantlement area. Figure 2 shows the areas in red to which inspectors would have access under Option 2 if implemented at Pantex.

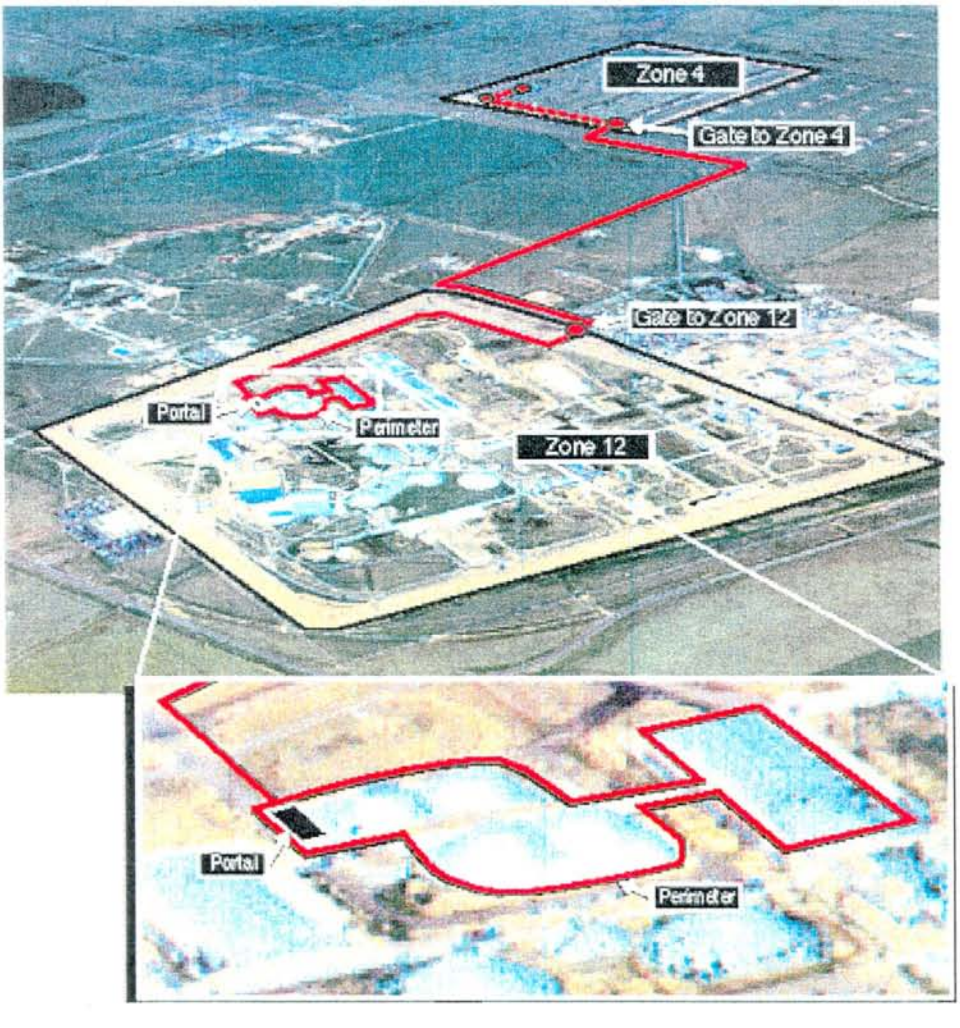


Figure 2: Pantex Access Areas Covered under Option 2.

<u>Option 3: Option 1 *Plus* Chain-of-Custody from Monitored Storage to and from the Dismantlement Bay or Cell</u>

In addition to declarations and spot checks to monitor the warhead receipt and storage area and the component storage area (as in Option 1), Option 3 provides a direct and continuous chain-of-custody from arrival and storage of the warhead at Pantex (or CSA at Y-12) in the storage area to and from dedicated dismantlement bays and cells in the dismantlement area. Option 3 does **NOT** include PPCM as does Option 2. Instead, in Option 3, the warhead can be followed up to a dedicated bay for mechanical disassembly and then to a dedicated dismantlement cell where the physics package is taken apart and the high explosive is removed from the pit (at Pantex) or to the area where CSAs are separated into components (at Y-12).

In Option 3, inspectors would have the right to sweep or sanitize the bays and cells before and after disassembly to determine there are no nuclear components or undeclared entrances and exits in the bay or cell. In addition, inspectors would have the right to examine the declared warhead or CSA in the staging area outside of the bay or cell and confirm that it is the object of inspection using radiation signatures and tags and seals. The warhead is then taken into the bay or cell to be taken apart and separated into its key parts (pit, CSA, high explosive, and other non-nuclear components), or the CSA is taken into an area without inspectors present and disassembled. When the nuclear and non-nuclear components are removed from the bay or cell, the inspectors could perform additional radiation measurements on each container leaving the cell to confirm the absence or presence of fissile material, and/or conduct radiation signature measurements to determine whether the components are actually *from* the declared warhead or CSA. Figure 3 shows the areas in red that inspectors would have access to under Option 3 if implemented at Pantex.

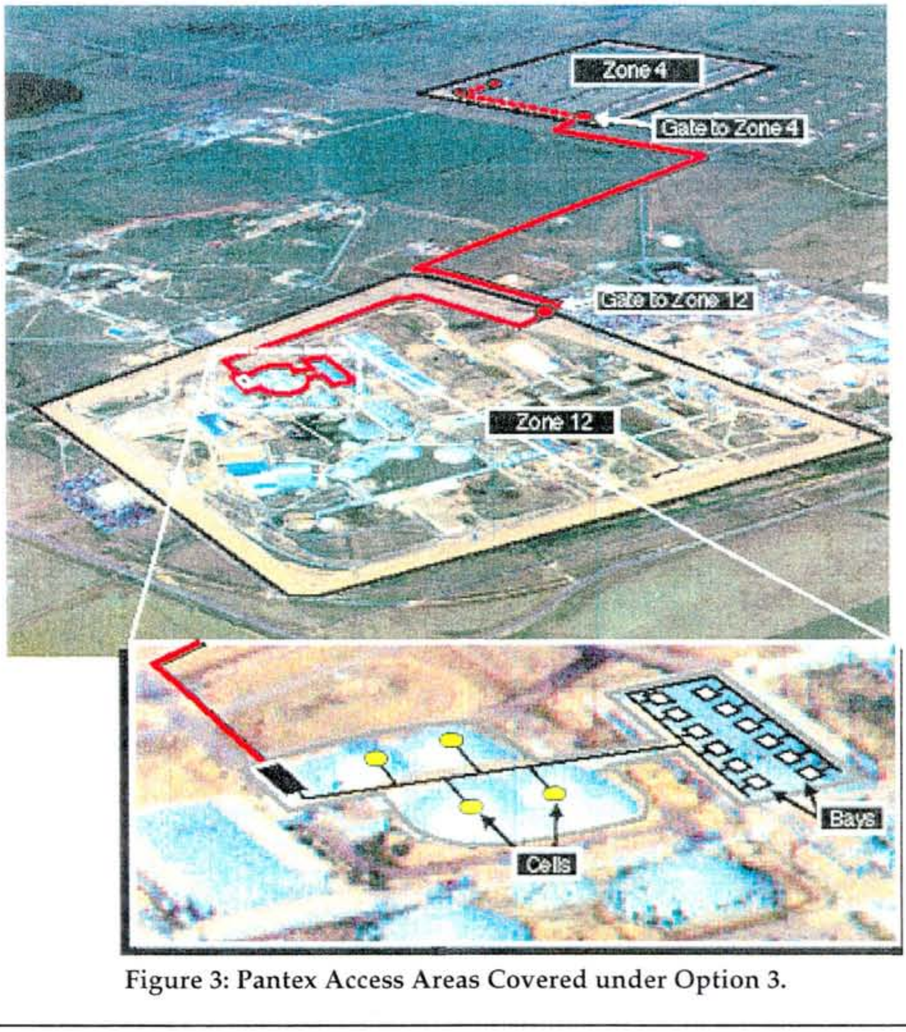


Figure 3: Pantex Access Areas Covered under Option 3.

Option 4: Option 3 *Plus* Direct Observation or Remote Monitoring of the Dismantlement Process

Option 4 includes all of the steps in Option 3 but also allows direct observation or remote monitoring of the dismantlement process in the bays and cells. In some special cases, such as the case of the gravity bombs (e.g., B61), observation of the mechanical disassembly process in a *bay* at Pantex (when the warhead is separated into three parts: front section, center section, and rear section) could be performed at the Unclassified to C/NSI level, with some masking of the disassembly process. However, for all warheads, observation of the disassembly of the physics package in a *cell* is classified as Restricted Data, unless extensive and costly masking of classified information and parts is done to allow unclassified observation of the dismantlement process. Similarly, observation of the actual disassembly of a CSA at Y-12 is classified as Restricted Data without extensive masking.

Direct observation of the dismantlement process, therefore, would generally reveal Restricted Data information and would require an Agreement for Cooperation, assuming the U.S. and the Russian Federation were willing to exchange such sensitive information with each other. However, remote observation of the dismantlement process by using a video camera could, in principle, be done at the unclassified level if classified details are masked. Figure 4 shows the areas in red to which inspectors would have access under Option 4 if implemented at Pantex.

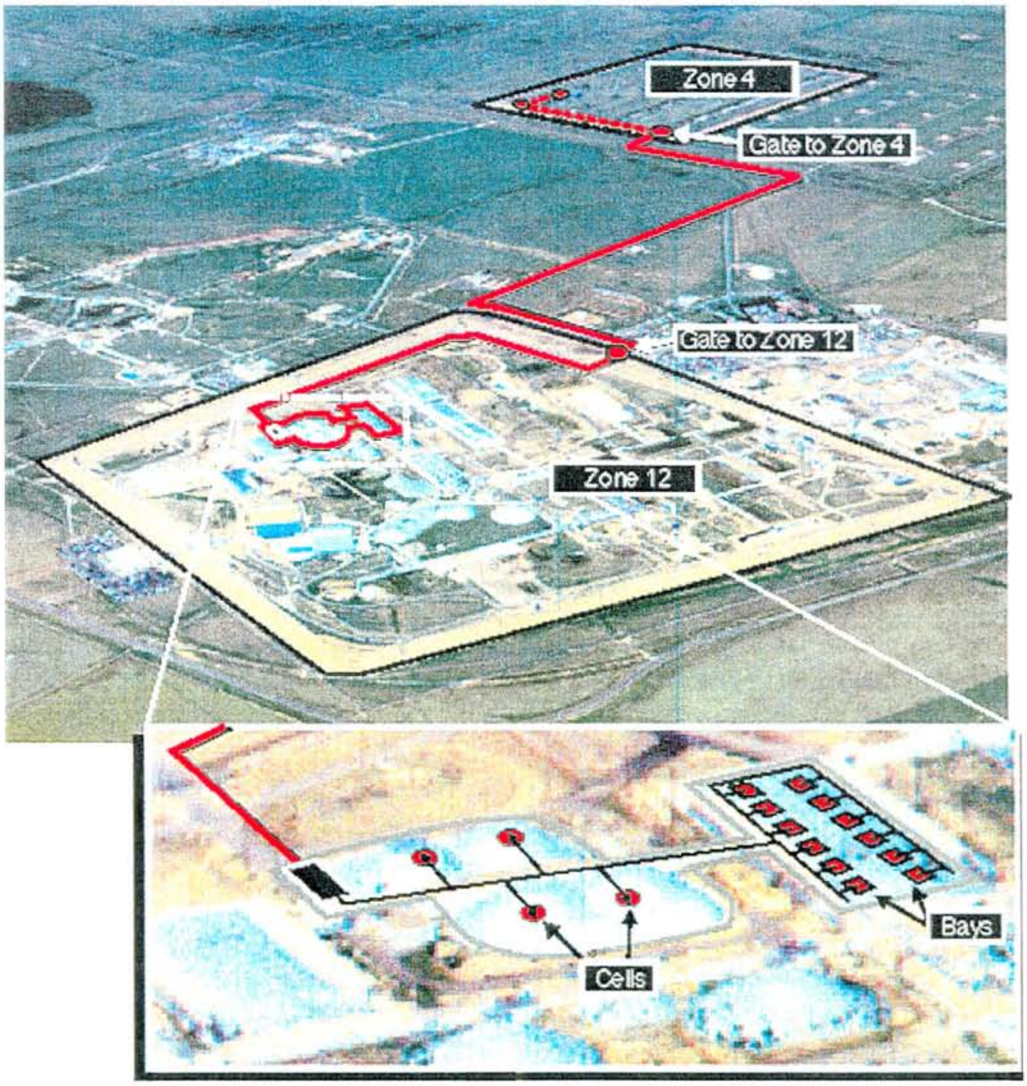


Figure 4: Pantex Access Areas Covered under Option 4.

Each of the four warhead dismantlement monitoring options was evaluated against the seven criteria previously mentioned. With the exception of three of the criteria—operational readiness, cost to prepare for the first inspection, cost of hosting routine inspections—a qualitative, as opposed to quantitative, analysis was conducted for the purposes of this report. An analysis of the other four criteria—level of confidence, negotiability, inadvertent loss of classified information, impact on operations—is essentially subjective. For criteria evaluated on a qualitative or subjective basis, the analysis includes either a low, moderate, or high rating. In some limited cases, an intermediate assessment of either low-to-moderate or moderate-to-high was used. The results of the analysis of the four dismantlement monitoring options considered in this report are summarized in Table 1.

Table 1. Summary of Options and Criteria

Option 1: Monitored storage
Option 2: Option 1 *plus* portal perimeter continuous monitoring of a portion of the dismantlement area
Option 3: Option 1 *plus* chain of custody from monitored storage to and from the dismantlement bay or cell
Option 4: Option 3 *plus* direct observation or remote monitoring of the dismantlement process in the bay or cell

		Confidence in Dismantlement	*Negotiability*	*Inadvertent Classified Information Loss*	*Impact on Operations*	*Operational Readiness* [1]	*Cost of First Inspection* [2]	*Routine Inspection Cost* [2,3]
Option 1	**C/NSI**	**Low**	**High**	**Low**	**Low**	**1 year**	**$2.5 M**	**$0.12 M**
	RD/FRD	**Moderate**	**Low–Mod.**	**Low–Mod.**	**Low**	**1 year**	**$2.5 M**	**$0.12 M**
Option 2	**C/NSI**	**Moderate**	**Low**	**Low–Mod.**	**Moderate**	**2 years**	**$12.0 M**	**N/A** [4]
	RD/FRD	**High**	**Low**	**Moderate**	**Moderate**	**2 years**	**$12.0 M**	**N/A** [4]
Option 3	**C/NSI**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**1.5 years**	**$6.5 M**	**$0.2 M**
	RD/FRD	**Mod.–High**	**Low–Mod.**	**Mod.–High**	**Moderate**	**1.5 years**	**$6.5 M**	**$0.2 M**
Option 4	**C/NSI**	**Moderate**	**Low**	**High**	**High**	**2 years**	**$6.5 M**	**$0.2 M**
	RD/FRD	**High**	**Low**	**High**	**High**	**2 years**	**$6.5 M**	**$0.2 M**

1 Operational readiness refers, for example, to the time required for construction and physical modifications. The time required for the SS-21 process would have to be incorporated into the declared dismantlement schedule.
2 Cost estimates are planning estimates only for Pantex and do not represent official estimates for budget purposes.
3 Routine inspection costs are shown for one inspection, but several such inspections would likely be performed each year.
4 Option 2 assumes permanent presence of inspectors at a cost of $5.5 million per year.

CONCLUSIONS

The following general conclusions were reached by the DOE study group:

- Any treaty involving the monitoring of nuclear warheads, nuclear warhead dismantlement, and stockpiles of fissile materials will have a significant impact on the DOE nuclear weapons complex.
  - Pantex is DOE's primary—and currently only—plant for performing warhead operations that support both the enduring stockpile and the dismantlement of excess warheads.
  - Consistent with Executive priorities, operations that support the enduring stockpile are given the highest priority while warhead dismantlements are performed in a safe, timely and efficient manner consistent with available resources.

- Both the requirement to dismantle additional warheads under a START III regime and the requirement to allow Russian inspectors to monitor, the dismantlement process will affect ongoing stockpile surveillance and maintenance activities.
  - The U.S. will therefore need to plan carefully to ensure that implementation of the START III requirement does not adversely affect the Presidential requirement to maintain a safe, secure, and reliable U.S. nuclear weapons stockpile.
- **Assuming that the item arriving at Pantex is a nuclear warhead**, either warhead dismantlement ***transparency*** or ***verification*** can be achieved by implementing the monitoring measures considered in this study.
- Determining that an item to be dismantled is ***actually*** a nuclear warhead is very difficult.
  - Radiation measurements (such as an x-ray or radiograph) of the container to confirm that the nuclear material in a storage container is in a configuration fully consistent with a nuclear warhead is highly intrusive and would reveal highly classified nuclear-weapons design information.
  - Such measurements would be too sensitive to be performed even if an Agreement for - Cooperation were in place allowing the exchange of Restricted Data and Formerly Restricted Data with Russian inspectors because such measurements would reveal possible system vulnerabilities and/or advanced design technology.
- Determining that an item to be dismantled is ***actually*** a nuclear warhead may require both chain-of-custody procedures from DoD facilities (e.g., from a delivery vehicle, deployment site, or weapons storage depot) to the dismantlement facility and the use of warhead radiation signatures, other than an x-ray or radiograph, to determine a unique template of the warhead.
- As a result of the new openness that Pantex, Y-12, and DOE have experienced over the past four years, ***transparency*** measures for monitoring warhead dismantlement can be applied at Pantex with up to a moderate level of confidence that dismantlement has taken place if implemented at the Unclassified to C/NSI level.[2]
- V***erification*** of warhead dismantlement will likely require the exchange of Restricted Data or Formerly Restricted Data under an Agreement for Cooperation in order to confirm that dismantlement has taken place.
  - However, if warhead radiation signatures and templates are successful in correlating signatures from weapons and their components, it may be possible to confirm warhead dismantlement without needing an Agreement for Cooperation.[3]
  - As in the case of the November 1996 demonstration to the Russians at Oak Ridge on classified U.S. HEU weapons components, even though the actual template generated for each weapon or component is classified, it may be possible to compare a classified radiation signature of a warhead or component to that of a classified template of an identical warhead or component in an unclassified manner.
  - This can be done by comparing ***only the relative differences*** in each template or by normalizing the results of each measurement without actually revealing the details of the classified templates.

[2] Transparency measures cannot be implemented completely on the unclassified level because all options include monitoring the movements of weapons and components. Under current classification guidelines, dates and times of movements of weapons and components are classified as C/NSI.

[3] Under START I, the U.S. and Russia exchanged C/NSI data by having the President of the United States sign the treaty, in effect giving the treaty the force of an Executive Order. A START III treaty could use a similar mechanism to exchange C/NSI without requiring an Agreement for Cooperation.

- However, there will need to be extensive red-teaming of any candidate technologies to ensure that such measurements or comparisons do not reveal classified design information and to ensure that such measurements cannot be easily spoofed.
- Should the inadvertent loss or compromise of classified warhead information lead to identification of potential vulnerabilities associated with the existing stockpile, the loss in dollars would be significant and that loss could be coupled with significant safeguards and security concerns.
- Additional analysis will need to be conducted to address the problem of "authenticating" the measurement system to have confidence that what is being measured is actually a nuclear warhead.
- One approach to addressing the "authentication" problem could include performing measurements on unclassified plutonium and highly enriched uranium shapes and displaying the unclassified templates to Russian monitors to provide confidence in the integrity of the measurement methods.
- In the case of warheads mounted on delivery vehicles, it may be possible to ameliorate the "authentication" problem by validating the template when the warhead is in the custody of the DoD.
- Additional demonstrations on actual U.S. warheads should be performed to provide further empirical data to determine whether warhead radiation signatures can be applied in a warhead dismantlement regime.[4]

• The technical readiness or maturity of the technologies that would support the monitoring of warhead dismantlement is essentially the same for all four options considered in the study because all options include the use of radiation measurements.

  - As a result, technical readiness was not a discriminating criterion included in the analysis of the options.
  - The time needed to be ready to use radiation measurement technologies, including warhead radiation signatures, is at least one to two years.

• Transparency measures for monitoring warhead dismantlement can be applied at the Unclassified to C/NSI level with up to a moderate level of confidence that dismantlement has taken place for all of the weapons types currently scheduled for dismantlement in the near term, which include the following weapons programs:

- B53	- W56
- B61, Mod 5	- W69

• To meet the Helsinki Summit requirement to establish new, lower aggregate levels of 2,000–2,500 strategic nuclear warheads, dismantlement of strategic warheads currently in the U.S. active stockpile will need to take place. This could include dismantlement of some of the following strategic warhead systems:

- B61, Mod 7 and 11	- W76
- W78	- W80
- B83	- W87
- W88	

[4] In 1988, the Nuclear Weapons Identification System (NWIS) was demonstrated on a B83 warhead at Pantex to explore the concept of confirming dismantlement by correlating the signature of the warhead with that of its components. The Controlled Intrusiveness Verification Technology (CIVET) was demonstrated on three current warhead systems at a U.S. Air Force installation in 1994.

- If additional weapon reductions include elimination of an entire warhead type (e.g., the B83), then we can still reach the same conclusion that warhead dismantlement transparency measures can be implemented at the Unclassified to C/NSI level with up to moderate confidence that dismantlement has taken place.

  - By eliminating an entire warhead type, the security concerns posed to the enduring stockpile by performing radiation measurements may be reduced because the entire type will be dismantled.
  - However, the DOE study group strongly recommends that, due to potential design commonalities in various warheads, a thorough red-team and vulnerability analysis should be conducted to ensure that the risks associated with such measurements are fully understood.

- In the event that the provisions in a START III treaty require that the dismantlement of a portion of a particular warhead type remaining in the active stockpile be monitored (e.g., dismantle 50% of the W76s but retain the other 50% of the W76s as part of the enduring stockpile), then—

  - Transparency measures can still be implemented that provide up to moderate confidence that dismantlement has taken place on the Unclassified to C/NSI level.
  - Verification procedures involving the exchange of Restricted Data or Formerly Restricted Data could only be performed on such weapon types after a thorough security and vulnerability analysis has been conducted.
  - Under the condition that warheads in a monitored dismantlement regime represent warheads in the enduring stockpile, sharing Restricted Data would significantly increase the risk that potential vulnerabilities might be unintentionally revealed.
  - Members of the DOE study group expressed serious concerns that unless such measurements were thoroughly red-teamed, information could inadvertently be released that might identify potential vulnerabilities of these systems.

- In the event that the monitoring provisions in a START III treaty require that a specific quantity of nuclear warheads be dismantled, the rate of dismantlement and the number of warheads dismantled can be monitored by all four options because the accumulated data from declarations, spot checks, and confirmatory measures would allow the number of warheads and components resulting from dismantlement to be determined.

  - However, under Option 1, the rate of dismantlement and the number of warheads dismantled can only be determined if warhead radiation signature methods are successful in correlating warheads going into the dismantlement area and components coming out. This would detect the possible introduction of pre-existing components, which might be stored inside the dismantlement area, into the dismantlement stream.
  - The confidence in the quantity of warheads dismantled increases as the number of inspections per year increases, and is highest when the permanent presence of inspectors is allowed.

- Dismantlement of a specific type of warhead can only be verified in conjunction with collateral information obtained outside of Pantex.

  - Once a weapon arrives at Pantex for dismantlement, it may be possible that Pantex can provide a declaration of the specific type of warhead and allow a unique signature or template to be made of that ***declared*** type of warhead, assuming that such templates prove to be feasible.
  - However, the combination of these two measures is not sufficient to ***confirm*** that the declared warhead is in fact a weapon of that type.
  - Determination of a specific warhead type will require that the weapon be monitored before it arrives at Pantex for dismantlement (e.g., at a point of DoD custody).

- Similarly, a determination of strategic versus tactical nuclear warheads can only be made before the warhead arrives at Pantex for dismantlement.
  - Because strategic and tactical warheads are typically distinguished by warhead type, delivery system, and employment purpose, a determination of "strategic versus tactical" is linked to when the determination of a specific warhead type is made.
  - Because a determination of a specific warhead type can only be made in conjunction with collateral information obtained outside of Pantex, a distinction between strategic and tactical can only be made when the warhead is in DoD custody.

II. CONTEXT

Before discussing in detail the factors that have changed over the past several years, it is useful to briefly summarize the conclusions contained in previous dismantlement transparency and verification studies. This dismantlement-monitoring study is not the first detailed analysis of various warhead dismantlement transparency and verification options. In fact, there is a rich history of studies addressing the issue of monitoring warhead dismantlement. The study group thought it useful to extract the key conclusions from these previous studies as a means of providing not only a background for the current study but also to ensure that any valuable conclusions previously reached are carried forward.

SUMMARY OF PREVIOUS WARHEAD DISMANTLEMENT TRANSPARENCY AND VERIFICATION STUDIES

For this report, we reviewed seven major studies published since 1990 relating to warhead dismantlement transparency and verification. Three of the studies—the President's 1991 Report to Congress on "Verification of Nuclear Warhead Dismantlement and Special Nuclear Material Controls" (the Section 3151 Report), the 1991 Joint U.S.–Russia Report on "Verifying the Dismantlement of Nuclear Warheads," and the 1993 JASON Report on "Verification of Dismantlement of Nuclear Warheads and Controls on Nuclear Materials"—scoped the larger issues of controlling all special nuclear material, accountability of U.S.–Russian nuclear material, breakout and cheating scenarios, and the ability to effectively monitor or verify activities related to the above.

The other four studies focused more closely on the impacts and issues for the DOE nuclear weapons complex if the U.S. government decided to implement a regime for warhead dismantlement monitoring and safeguarding of special nuclear material. The key conclusions from the seven studies are summarized below. For summary purposes, we have highlighted only the most relevant conclusions, but Appendix C includes a complete bibliography and summary of each study.

- Any dismantlement verification regime would involve a high risk of disclosing sensitive information, and such disclosures could reveal potential vulnerabilities of our nuclear forces or reveal weapons-design information. As a result, measures will have to be taken to keep classified information from being placed at risk. (*3151 Report*)
- Determining the initial number of warheads that a side possesses at the time of entry into force of an agreement would be an extremely difficult problem. (*3151 Report*)
- National Technical Means (NTM) are not effective at verifying dismantlement. (*3151 Report*)
- The verified destruction of the non-nuclear parts of the dismantled warheads would have little arms control significance by themselves because these parts could be reconstituted in a clandestine manner with only modest costs. (*3151 Report*)
- The most important step in the verification of dismantlement occurs at the beginning, when a weapon is first declared to be a weapon and officially entered into the system. (*JASON Study*)
- Although DOE facilities such as Pantex and Y-12 were not designed to accommodate monitoring procedures, implementation of a variety of dismantlement monitoring and cooperative measures at DOE dismantlement facilities is feasible. (*Wilson Report*)
- The use of a dedicated dismantlement facility, such as the Device Assembly Facility (DAF) at the Nevada Test Site, could reduce the disclosure of sensitive information as well as the impact on nondismantlement activities. (*Wilson Report*)

- Monitoring the accumulating inventories of nuclear components and materials would provide strong indications that warheads are being dismantled, or at least that the inventory of warheads is being reduced. The confidence provided by monitoring inventories could be relatively high and would minimize the disruption to ongoing dismantlement activities. (*Wilson Report*)

- The cost of Portal Perimeter Continuous Monitoring (PPCM) would be high because of the need for continuous onsite presence and the need to make the necessary modifications to facilities to allow for accurate flow measurements. (*Wilson Report*)

- There are significant asymmetries between the U.S. and Russian nuclear weapons programs. These asymmetries include differences in the physical size of the nuclear production and storage complexes, inventory accountability, and, perhaps most important, the fact that Russia is still producing new nuclear weapons. (*JASON Study*)

RECENT CHANGES

Many activities have taken place over the past several years that require an update of the previous warhead dismantlement transparency and verification studies. These include the beginning of START I inspections, planning for potential START II inspections, and various transparency initiatives being negotiated with the Russian Federation.

START I Inspections

Arms control in the U.S. underwent a significant paradigm shift with the signing of the Chemical Weapons Convention in January 1993 and the ratification and entry into force of the START I Treaty in December 1994. For the first time, the U.S. was willing to allow inspectors representing a foreign country into U.S. facilities. Given the long history of differences in national-security concerns between the U.S. and the Soviet Union, and between the U.S. and Russia, the START inspections have gone remarkably well. Anomalies have been encountered, but the mechanism established to deal with them—the Joint Compliance and Inspection Commission—has by and large worked well.

Under START I treaty inspections, each country is given the right to verify that the declared number of Reentry Vehicles (RVs) or Reentry Bodies (RBs) assigned to each ballistic missile system has not been exceeded. For these and other inspections in the treaty, the sides negotiated an elaborate set of confidence-building and verification measures that include data exchanges, movement notifications, pre-inspection operational and movement restrictions, and onsite inspection (specific inspection-site selection, chain of custody, and visual viewing of shrouded RV/RB sections). These measures and associated procedures established by the Services have not fully satisfied the Russians except in the case of the Peacekeeper system. For this system, the front section of the missile is removed and transported back to the maintenance facility for shroud removal and viewing preparation. Thus, the Russians have full exposure to the warhead section, albeit with the individual warheads and the mounting platform appropriately covered. For both the Minuteman III and the Trident D-5 and C-4 systems, the Russians have registered concerns over covert warhead capability because the shrouding techniques and operational procedures utilized by the Services do not afford them the full exposure to the Minuteman III and Trident missiles or the undersides of the RV/RB platforms. In all cases, the procedures and measures utilized by the U.S. are determined to be treaty-compliant and have been implemented on an unclassified basis.

START II

Following the signing of the START I Treaty on January 31, 1993, the U.S. and Russia embarked on an intense set of negotiations to reduce strategic accountable force levels below the 6,000-warhead limit established in START I. Within an 18-month period, the U.S. and Russia negotiated and signed the START II Treaty which limited accountable warheads to between 3,000–3,500. This agreement also eliminated the entire class of heavy ballistic missiles, prohibited multi-warhead land based ballistic missiles, and capped sea launched ballistic missiles at 50% of the total ballistic missiles allowed.

Anticipating rapid ratification of the START II Treaty and entry into force, the interagency conducted in early 1993 a review of what steps should follow START II. This review considered numerous options for lower strategic force levels, operational constraints on nuclear forces, objectives for the next round of discussions, and type of negotiations to be conducted. However, during this process, initial Russian concerns began to surface with START II, especially within the Duma and among anti-Yeltsin factions. Because of the uncertainty in Russian ratification, U.S. policy, as recommended by the interagency, focused on ensuring that START II was moved forward for ratification before entering into formal discussions on a follow-on START treaty.

START III

Consistent with this policy, at the March 21, 1997, Helsinki Summit, Presidents Clinton and Yeltsin issued a Joint Statement on Parameters on Future Reductions in Nuclear Forces. Specifically, Presidents Clinton and Yeltsin agreed that once START II enters into force, the U.S. and Russia will immediately begin negotiations on a START III agreement, which will include, among other things, the following basic components:

- Establishment, by December 31, 2007, of lower aggregate levels of 2,000–2,500 strategic nuclear warheads for each of the Parties; and,

- Measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads and any other jointly agreed technical and organizational measures, to promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads.

The Presidents also agreed that in the context of START III negotiations their experts will explore, as separate issues, possible measures relating to nuclear long-range sea-launched cruise missiles and tactical nuclear systems, to include appropriate confidence-building and transparency measures. Presidents Clinton and Yeltsin also agreed that the sides will consider the issues related to transparency in nuclear materials. A complete text of the Helsinki Summit Statement is provided in Appendix B.

SAFEGUARDS, TRANSPARENCY, AND IRREVERSIBILITY

At the January 1994 Summit Meeting, Presidents Clinton and Yeltsin agreed on the goal of ensuring the "transparency and irreversibility of the nuclear arms reduction process." A Joint Working Group on "Safeguards, Transparency and Irreversibility" (STI) was established in May 1994, with the mandate to build confidence and promote stability in the two countries' mutual security relationship. At their September 1994 Summit Meeting, Presidents Clinton and Yeltsin further directed their experts to pursue additional transparency and irreversibility measures and to report on their accomplishments during the summit scheduled for the spring of 1995. The Presidents also mandated that the U.S. and Russia negotiate an Agreement for Cooperation that would provide the legal basis for the exchange of classified and sensitive information necessary to support an STI regime.

In December 1994, the U.S. presented the Russians with a non-paper defining the objectives of the STI initiative and outlining the key elements of the U.S. STI approach. The December 1994 non-paper stated that the STI initiative should meet four key objectives:

- **Transparency:** *The measures that build each side's confidence in its understanding of the size of the other's stockpiles of nuclear weapons and fissile materials, and the rate of reduction in these stockpiles.*

- **Safeguards and Security:** *The measures should build each side's confidence that nuclear weapons and fissile materials are secure, and provide the information and openness needed to strengthen our mutual cooperation toward that end.*

- **Irreversibility:** *The measures should build each side's confidence that the nuclear arms reductions being carried out are irreversible, and in particular that fissile materials declared excess to military needs (including civilian weapons-usable materials) are not being used to build new nuclear weapons.*

- **Political Benefits:** *The measures should build public, legislative, and international confidence in the nuclear arms reduction process, supporting our mutual efforts to extend and strengthen the NPT regime, ratify and implement the START agreements, and consider further arms control measures.*

The key elements of the STI regime include:

- Reciprocal exchanges of detailed information on aggregate stockpiles of nuclear warheads and fissile material *(THE STOCKPILE DATA EXCHANGE AGREEMENT)*

- Mutual reciprocal inspections to confirm that ***excess*** Pu and HEU removed from nuclear weapons are not being returned to weapons *(MRI)*

- Cooperative measures to confirm the fissile material portion of the Stockpile Data Exchange Agreement *(SPOT CHECKS)*

- A cooperative arrangement to monitor warheads declared excess and awaiting dismantlement, to further confirm the dismantlement of these nuclear weapons *(LIMITED CHAIN-OF-CUSTODY)*

At the May 9–10, 1995 Summit Meeting in Moscow, Presidents Clinton and Yeltsin laid out a more detailed agenda to increase the transparency and irreversibility of the process of reducing nuclear weapons. Specifically, they agreed as follows:

- Fissile materials removed from nuclear weapons being eliminated and excess to national security will not be used to manufacture nuclear weapons;

- No newly produced fissile materials will be used in nuclear weapons;

- Fissile material from or within the civil nuclear programs will not be used to manufacture nuclear weapons;

- The U.S. and Russian Federation will negotiate agreements to increase the transparency and irreversibility of the nuclear arms reduction process that, *inter alia*, establish:

  - An exchange on a regular basis of detailed information on aggregate stockpiles of nuclear weapons, on stocks of fissile materials and on their nuclear security *(THE STOCKPILE DATA EXCHANGE AGREEMENT);*
  - A cooperative arrangement for reciprocal monitoring at storage facilities of fissile material removed from nuclear warheads and declared to be excess to national security requirements to help confirm the irreversibility of the process of reducing nuclear weapons *(MRI)*, recognizing that progress in this area is linked to progress in implementing the joint U.S.–Russian program for the fissile material storage facility at Mayak; and
  - Other cooperative measures, as necessary to enhance confidence in the reciprocal declarations on fissile material stockpiles *(SPOT CHECKS).*

In June 1995, the U.S. tabled a Stockpile Data Exchange Agreement with the Russians which proposed that each side not only declare existing inventories of weapons and fissile material but also declare the number of nuclear weapons dismantled each year since 1980 and the quantity of fissile material produced by the Parties each year since 1970 by material type, amount, category of enrichment or grade and production location. Assistant Minister of Atomic Energy Vladislav Balamutov rejected the June 1995 version due to the fact that it was too comprehensive and inconsistent with a "step-by-step" approach to transparency.

By December 1995, the two sides had nearly completed the text of the Agreement for Cooperation providing the legal basis for exchanging classified nuclear information required to implement these initiatives. However, the Russian government then called a halt to these negotiations pending an internal Russian policy review. As a result, no negotiations on STI have taken place since that time, although technical discussions on MRI were conducted in the fall of 1996. Nevertheless, it is important to note that many of the specific activities that will increase the transparency and irreversibility of the nuclear weapons reduction process, such as Mutual Reciprocal Inspections (MRI) of facilities storing fissile material removed from dismantled nuclear weapons, declarations of nuclear weapons and fissile material stockpiles, and spot checks to verify these declarations, could become the building blocks for a warhead dismantlement monitoring treaty, if they are negotiated and implemented in the near term.

MUTUAL RECIPROCAL INSPECTIONS

With regard to the first element of the STI framework, on March 16, 1994, former U.S. Secretary of Energy O'Leary and Russian Minister of Atomic Energy Mikhailov issued a Joint Statement on Inspection of Facilities Containing Fissile Material Removed from Nuclear Weapons.

The Joint Statement required that the U.S. and Russia "...conclude an agreement on the means of confirming the plutonium and highly enriched uranium inventories from nuclear disarmament." Negotiations with the Russians to implement the O'Leary–Mikhailov Joint Statement initially focused on the technical means of monitoring plutonium inventories because of the relative ease in conducting radiation measurements on pits as opposed to canned subassemblies.

Plutonium Mutual Reciprocal Inspections

Significant progress on technical discussions relating to plutonium demonstrations continued through the summer of 1994 with reciprocal familiarization visits being conducted at the U.S. Rocky Flats Plant in July 1994 and at Seversk, Russia, in August 1994. During the Rocky Flats visit, the U.S. demonstrated to the Russians an unclassified sodium iodide (NaI) radiation measurement indicating the presence of plutonium in a sealed container containing an actual pit removed from a dismantled U.S. nuclear weapon. Similarly, at Seversk, the Russians demonstrated for the U.S. delegation an unclassified radiation measurement demonstrating the presence of plutonium in a sealed container declared to contain an actual pit removed from a dismantled Russian nuclear weapon. Subsequently, meetings took place in September and October 1994 in Moscow to finalize the plutonium demonstration techniques. At both the September and October 1994 meetings, the technical experts from both countries agreed that it would be necessary to exchange some classified, Restricted Data, in order to carry out an effective transparency regime.

Discussions with the Russians on plutonium measurements continued in November 1994 with a Russian visit to the Lawrence Livermore National Laboratory and the signing of a protocol on the technical means to carry out a plutonium mutual reciprocal inspection (MRI) demonstration agreement. This protocol led to a draft plutonium MRI Demonstration Agreement which was tabled with the Russians in January 1995. The draft Pu MRI Demonstration Agreement incorporated specific radiation measurement techniques in order to determine that the contents of a sealed container are consistent in isotopics, mass, and shape with a pit removed from a dismantled nuclear weapon. Specifically, the January 1995 draft Pu MRI Agreement included the following three technical annexes:

- **Technical Annex 1:** *Radiation measurements to determine the presence and isotopics of plutonium in a sealed storage container*
- **Technical Annex 2:** *Neutron measurements to determine the approximate mass of plutonium in a sealed storage container*
- **Technical Annex 3:** *Gamma-ray scanning measurements to determine the shape and extent (size) of plutonium in a sealed storage container*

The draft Pu MRI Demonstration Agreement was discussed in February 1995 with the Russians and during the February negotiations they essentially accepted the procedural body of the draft agreement but made a counter proposal based on neutron measurements concerning the technical annex on the shape measurement (Annex 3). Formal negotiations with the Russians on the Pu MRI Demonstration Agreement have been stalled by the lack of progress of the Agreement for Cooperation. Completion of the Agreement for Cooperation is required since the technical annexes require certain classified information to be exchanged. Hence the fate of the O'Leary–Mikhailov Joint Statement and the Pu MRI Demonstration Agreement became bound up with the fate of the Agreement for Cooperation allowing the sharing of classified and sensitive information. However, technical discussions on the Pu MRI Demonstration Agreement *annexes* have continued while the U.S. and Russia discuss the issues associated with the Agreement for Cooperation at a higher level.

In September 1996, U.S. and Russian technical experts met in Moscow to continue technical discussions associated with the Pu MRI Demonstration Agreement. At the September 1996 meeting, U.S. and Russian technical experts confirmed that the technical procedures in Annex 1 (for the determination of the presence of weapons-grade plutonium) and Annex 2 (for the determination of the mass of Pu) were agreed. However, the sides also confirmed that there are differing views regarding the technical procedures in Annex 3 (for the determination of the shape). In order to evaluate the merits of the proposed Russian neutron isotropy technique and the U.S. gamma ray scanning technique, a Russian delegation, headed by Deputy Assistant Minister of the Russian Federation for Atomic Energy Nikolai Voloshin, visited the Lawrence Livermore National Laboratory in November 1996 to conduct joint measurements on unclassified plutonium sources in sealed storage containers. Based on the November 1996 LLNL meeting, the U.S. and Russian technical experts agreed that they now have sufficient technical information to evaluate the merits of the different techniques to measure the shape of plutonium in a sealed storage container. In addition, the sides agreed to meet in the near future to discuss the results of the joint measurements and work towards completing the MRI Demonstration Agreement, including a limited Agreement for Cooperation that would allow the sides to exchange only that classified data necessary for a one-time Pu MRI demonstration.

Highly Enriched Uranium Mutual Reciprocal Inspections

Because the March 16, 1994, O'Leary–Mikhailov Joint Statement also required that inventories of highly enriched uranium be monitored, the Department of Energy Office of Arms Control and Nonproliferation held a number of technical meetings, and sponsored a series of measurements, in early 1995 to determine how to conduct highly enriched uranium mutual reciprocal inspections (HEU MRI). The conclusions from these meetings were presented to the Russians in June 1995 in the form of a non-paper. The non-paper proposed two different HEU MRI regimes:

- For Canned Sub-Assemblies (CSAs) or secondaries, the use of tags and seals, the weighing of CSAs, and "chain-of-custody" techniques were proposed to track HEU in sealed storage containers.
- For other forms of HEU (metal, oxide, or right circular cylinders), measurements to determine the approximate mass and enrichment of uranium in sealed containers would be performed.

Based on this approach, in November 1995, DOE and MINATOM agreed that HEU MRI would be implemented on an unclassified level. This decision paved the way for the U.S. and Russia to conduct unclassified reciprocal familiarization visits to each other's HEU storage facilities. In November 1996, a Russian delegation visited the Oak Ridge Y-12 Plant for a highly enriched uranium transparency familiarization visit. During the Russian visit to Y-12, procedures extracted from the HEU MRI non-paper were demonstrated to the Russians to support the transparency measures associated with the U.S.–Russian HEU Purchase Agreement. Specifically, Russian experts observed a demonstration of the U.S. procedures for receiving HEU components in sealed containers from Pantex, recording the unique identifier, and weighing the sealed shipping container containing an actual HEU weapons component. Russian technical experts also observed radiation measurements being performed on U.S. HEU weapons components in sealed storage containers to confirm the presence of HEU. Two types of radiation measurements were demonstrated to the Russians on actual HEU weapons components from dismantled U.S. nuclear weapons. First, the U.S. demonstrated portable sodium iodide (NaI) non-destructive assay equipment to confirm the presence of HEU in a sealed storage container holding a HEU weapon component removed from a dismantled U.S. nuclear weapon. Second, the U.S. side successfully demonstrated, on sealed storage containers holding HEU weapons components removed from dismantled U.S. nuclear weapons, the Nuclear Weapon Identification System (NWIS) to confirm that the contents of a sealed storage container containing a U.S. HEU weapon component are identical to the contents of another sealed storage container containing a similar HEU component.

In December 1996, U.S. technical experts visited Seversk (Tomsk-7) for a reciprocal familiarization visit. In particular, the Russians demonstrated a sodium iodide (NaI) radiation measurement to measure the enrichment of a Russian HEU weapons component from a dismantled Russian nuclear weapon in a sealed storage container.

HEU PURCHASE AGREEMENT TRANSPARENCY MEASURES

On February 18, 1993, the U.S. signed an agreement with Russia to purchase up to 500 metric tons of highly enriched uranium from dismantled former Soviet nuclear weapons. The HEU Government-to-Government Agreement also required that transparency measures be implemented in the U.S. and Russia to provide confidence that the arms control and nonproliferation objectives of the Agreement were met. Specifically, transparency measures were required to provide confidence that:

- Highly enriched uranium was extracted from dismantled Russian nuclear weapons;
- Highly enriched uranium was blended down to low enriched uranium in Russia; and,
- Low enriched uranium shipped to the United States was fabricated into fuel assemblies for use in commercial power reactors.

To date, fifteen technical transparency annexes that govern the monitoring activities at U.S. and Russian facilities have been signed over the course of five Transparency Review Committee meetings. At the fifth session of the Transparency Review Committee in Moscow in December 1996, the Russians agreed to significantly expand U.S. monitoring activities at the three Russian facilities subject to the Agreement.

As a result, at the Siberian Chemical Enterprise (SChE) at Seversk, U.S. technical experts currently have the right to:

- observe HEU weapons components in sealed containers, that are shipped to Seversk from Russian dismantlement facilities, being received and stored
- request and observe nondestructive assay (NDA) measurements being performed on sealed containers of Russian HEU weapons components to independently confirm the enrichment of uranium
- request and observe NDA measurements being performed on sealed containers of HEU metal shavings from weapons components
- request and observe NDA measurements being performed on HEU oxide containers prior to shipment to the Russian blending facilities at Novouralsk and Zelenogorsk.
- obtain copies of relevant shipping and material control and accounting documentation.

Thus, the U.S. currently has the right to routinely observe *unclassified* radiation measurements being performed on HEU weapons components in sealed containers at Seversk. The NDA equipment is commercially available Canberra equipment that includes a sodium iodide detector. The U.S.-supplied NDA equipment has been licensed and certified for use at Seversk by Russian authorities. Such unclassified radiation measurements on HEU weapons components could be an important element or building block of a warhead dismantlement transparency or verification regime.

PANTEX PLANT MEDIA DAY

One of the most significant changes that has taken place over the past several years is the cultural change with regard to openness at the Pantex Plant. Prior to 1993, Pantex was very limited in its public declarations of functions and missions. However, because of former Secretary of Energy O'Leary's openness initiative, Pantex significantly changed its relationship with the public in 1993. Since 1993, Pantex has conducted an annual event called "Media Day," where members of the press are invited to tour the facility and are briefed on plant operations. In 1994, Media Day became "International Media Day" and representatives from all U.S. national broadcast and print media as well as representatives from the foreign media were invited to participate. In addition to Media Day, Pantex has also conducted public tours of limited areas of the plant. These public tours were conducted weekly from January 1993 until October 1996 for the public who were citizens of the United States. In September 1995, Pantex also had its first ever family day where family members of Pantex workers were invited to visit the plant.

During Media Day, tours are given of a linear accelerator facility, gas analysis laboratory, Zone 4, a bay and a cell in Zone 12, the high-explosive firing site, the DOE Transportation Safeguards Division Pantex operations, and a windshield tour of the facility. However, it is important to note that current regulations require that normal operations at Pantex be shut down during such tours. During these tours the media are presented information on and have access to unclassified information related to:

- Radiographic procedures used to check the condition of weapon components before disassembly
- Leak-check procedures, also used to check the condition of weapon components
- Several different types of weapons trainers
- Representative steps in the disassembly of a weapon, using a weapon trainer
- Pit packaging
- A demonstration of the Stage Right system for storage of pits in Zone 4

AGREEMENT FOR COOPERATION

One of the other most significant changes over the past few years is that the United States and Russia now have the legal mechanism by which to exchange sensitive and classified information for the purpose of arms control and nonproliferation. In 1994, Congress acknowledged the difficulty imposed on further transparency and arms control agreements by the necessity to discuss classified, and in particular Restricted Data, information. As a result, Congress amended the Atomic Energy Act of 1954 to allow the reciprocal sharing with a treaty partner, under an Agreement for Cooperation, of Restricted Data information for the purpose of arms control and nonproliferation. An Agreement for Cooperation has yet to be completed with the Russian Federation. However, the possibility for such an agreement in itself has significantly altered the possible approaches to warhead dismantlement transparency and verification.

SUMMARY

All of these recent activities in the arms control policy arena contributed to the decision to undertake the current study of the options for warhead dismantlement monitoring and their effect on the DOE weapons complex. The three most significant changes that have taken place over the past several years are:

- *unclassified* radiation measurements are routinely performed on Russian HEU weapons components in sealed containers as part of the expanded HEU transparency measures;
- the greatly increased level of openness in U.S. dismantlement activities at the Pantex Plant; and,
- a new legal mechanism to exchange classified information to support arms control and nonproliferation initiatives with the Russian Federation.

As a result of these changes, an update of previous warhead dismantlement monitoring studies was required in order to prepare the U.S. for a possible warhead dismantlement monitoring regime as part of a START III treaty.

III. DESCRIPTION OF THE U.S. DISMANTLEMENT PROCESS

A. FACILITIES

This study focuses only on the DOE facilities primarily involved in nuclear warhead dismantlement: the Pantex Plant and the Y-12 facility. A brief description of the facilities relevant to the dismantlement process is provided below. In addition, a brief description of the Device Assembly Facility (DAF) at the Nevada Test Site is also included. Although the DAF does not currently perform dismantlement activities, it could be used as a dedicated dismantlement facility in the future as a means of minimizing the impact on ongoing operations at the Pantex Plant.

PANTEX PLANT

The Pantex Plant is located approximately 17 miles east of Amarillo, Texas. It is operated for DOE by the Mason & Hanger Corporation. The Pantex Plant is the only U.S. facility currently authorized for the disassembly of nuclear warheads. In addition to nuclear warhead disassembly, the Pantex Plant is responsible for several other operations involving warheads, including:

- High Explosive (HE) development, fabrication (processing, machining, and subassembly) and disposal;
- warhead assembly and stockpile rebuilds;
- new material and stockpile surveillance testing;
- Joint Test Assembly preparation; and
- stockpile maintenance.

In addition there are non-DOE activities that occur at Pantex. Currently, warhead throughput at Pantex is approximately 118 warheads per month or about 1,400 warheads per year for dismantlement plus additional warhead throughput for other activities.

The Pantex Plant consists of two key areas: Zone 4 West (hereafter referred to as Zone 4), which contains facilities and operations for the storage and inspection of both warheads and pits, and Zone 12 South (hereafter referred to as Zone 12) which contains the facilities and operations required for nuclear warhead production, testing, maintenance, and dismantlement. Zone 12 North is a support area and is not relevant to this discussion. Figure 5 shows an aerial view of Zone 4 and Zone 12. A schematic of Zone 4 is shown in Figure 6, and a schematic of Zone 12 is shown in Figure 7. For warhead dismantlement the key operations occur in those areas labeled as "weapon assembly, disassembly, and test areas," "HE to pit assembly," and "SNM staging." The buildings involved in these key operations are known as disassembly bays and dismantlement *cells* (the latter are also known as "gravel gerties"). A layout of a typical bay and cell is shown in Figures 8 and 9, respectively. In general, operations involving conventional high explosives, such as the removal of the high explosive from the pit, occur in the cells; other mechanical assembly and disassembly operations occur in the bays.

Figure 5: Aerial View of Zone 4 and Zone 12 at the Pantex Plant.

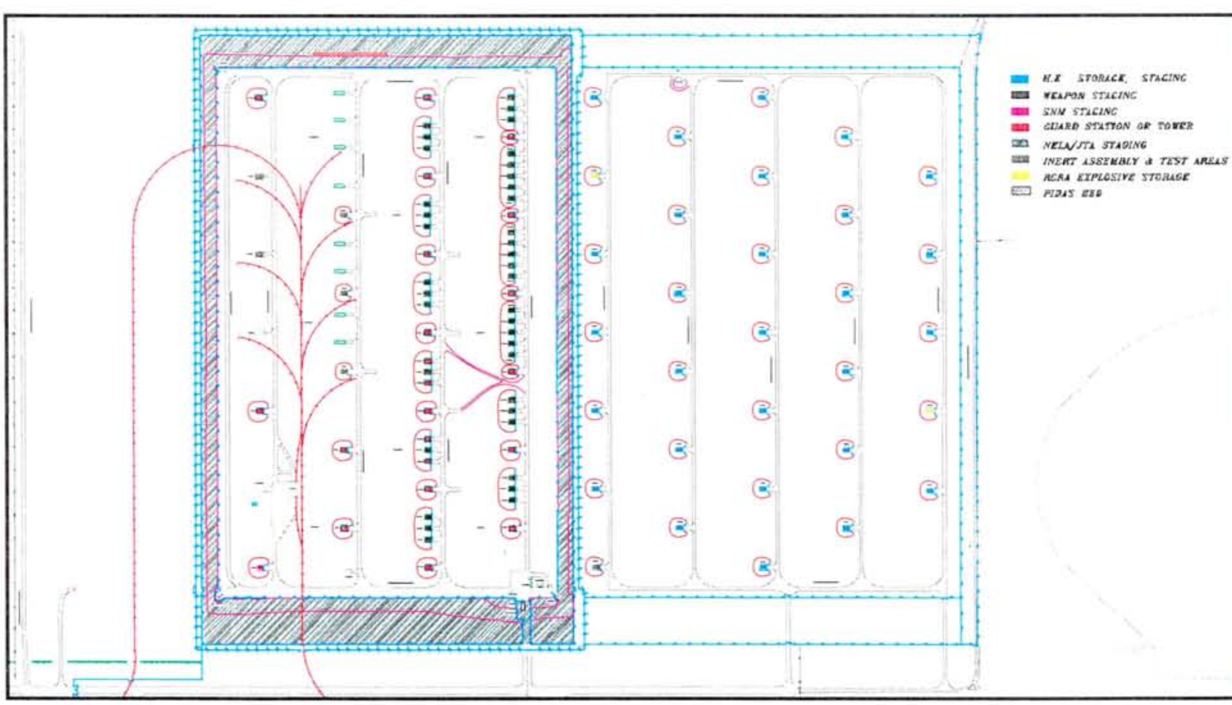


Figure 6: Schematic of Zone 4 at the Pantex Plant.

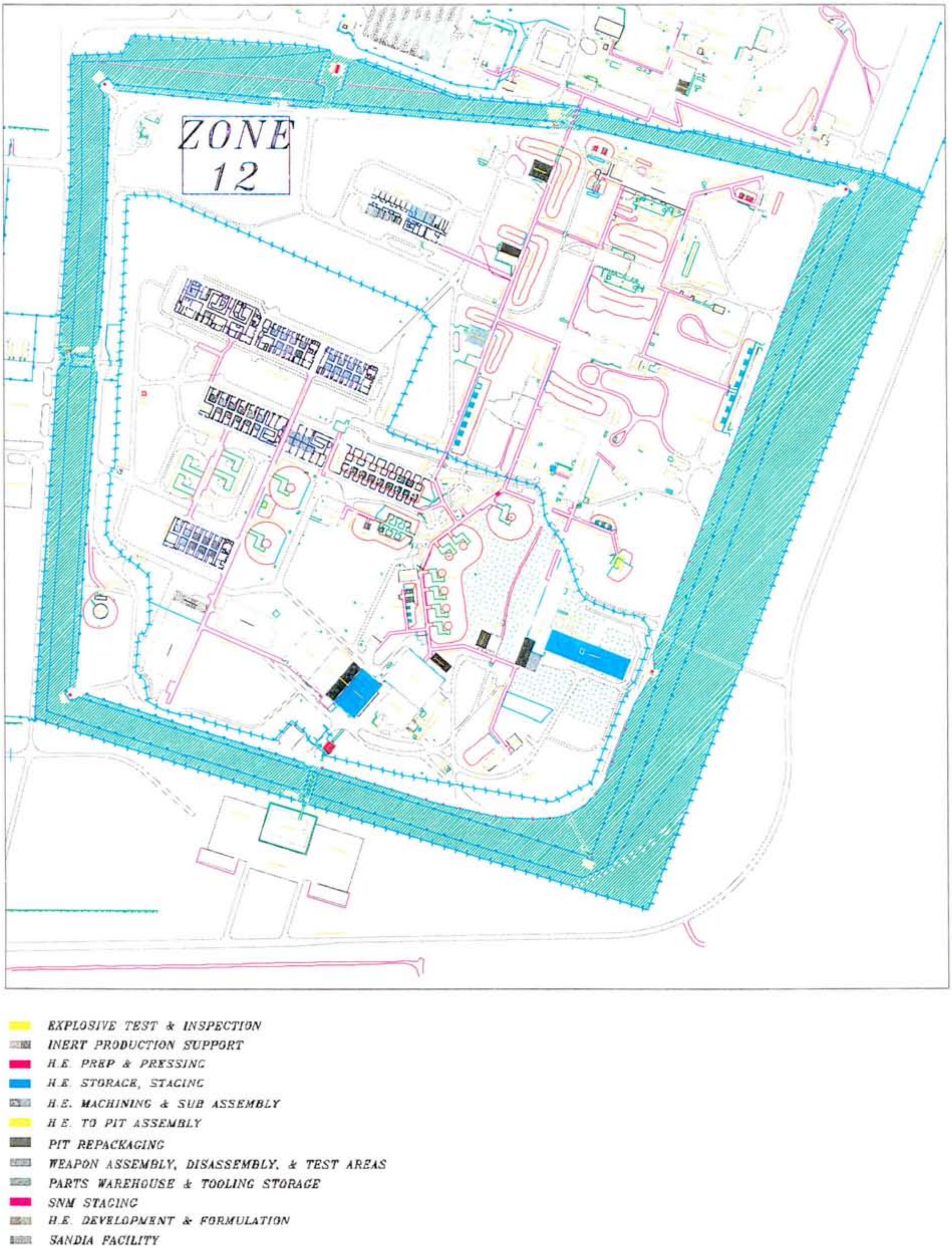


Figure 7: Schematic of Zone 12 at the Pantex Plant.

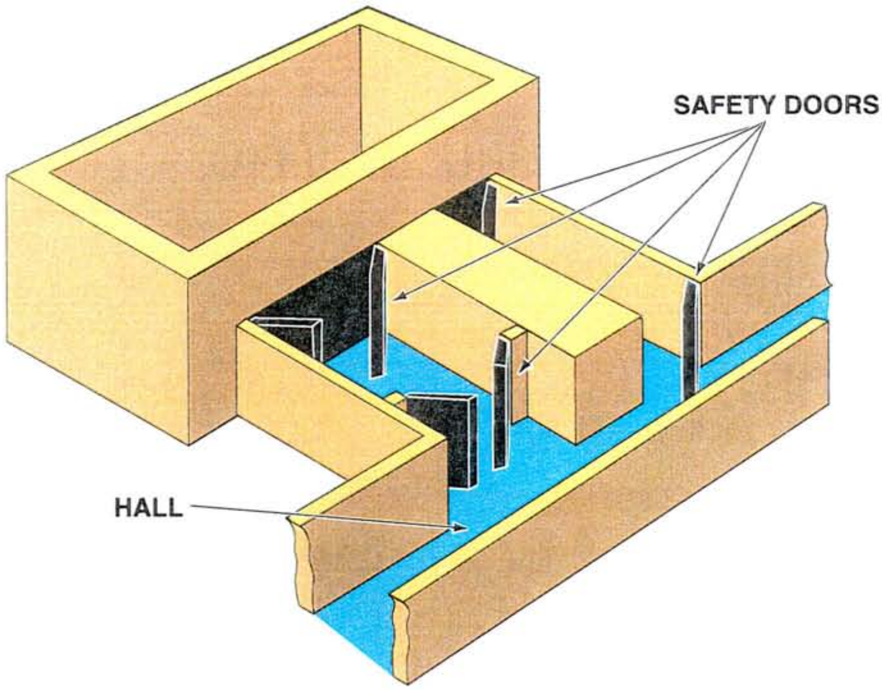


Figure 8: Layout of a Typical Disassembly Bay in Zone 12 at Pantex.

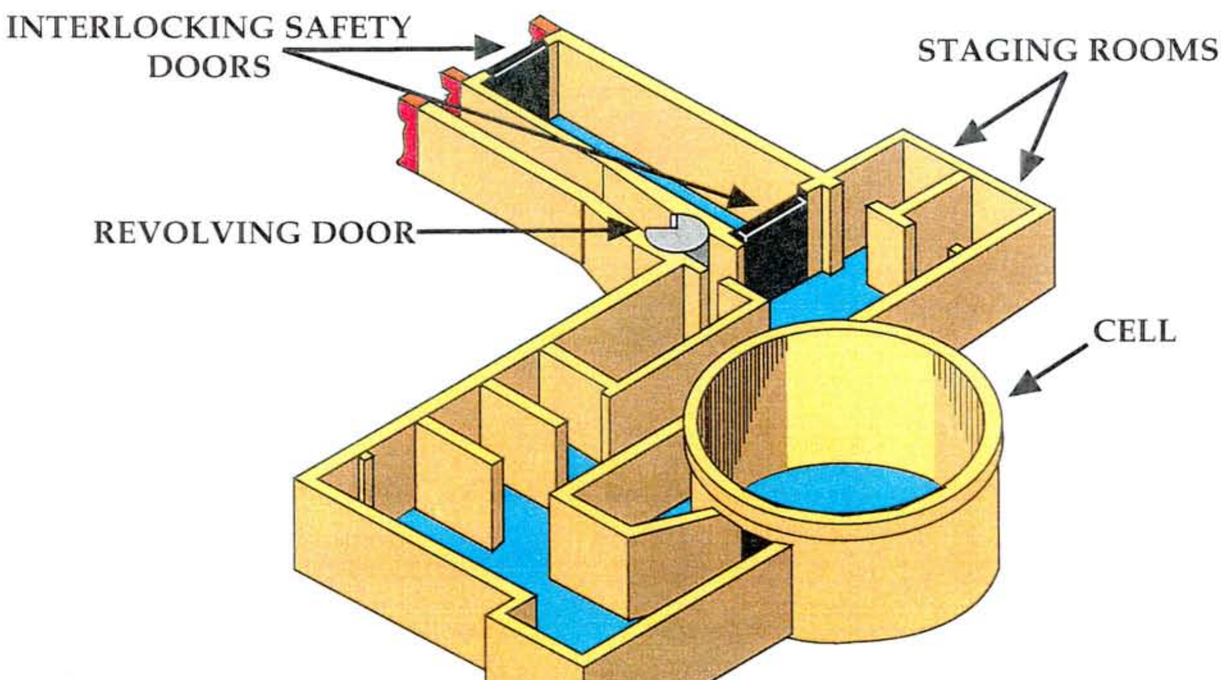


Figure 9: Layout of a Typical Dismantlement Cell in Zone 12 at Pantex.

While the layout of Zone 12 shows separate bays, cells, and other buildings, all these facilities are connected by enclosed hallways (commonly called "ramps"). Once inside the facility, it appears to be much like a single large building with various rooms.

There are 13 cells and 60 bays, all located in the southern portion of Zone 12. In addition, Zone 12 has SNM staging facilities and a loading dock for transferring weapons, components and materials in and out of Zone 12. Zone 4 is a staging area for weapons and components, consisting of 61 storage magazines of various types and a shipping and receiving building.

From a monitoring standpoint a number of facts concerning Pantex are important:

- Bays and cells are scattered throughout Zone 12, and dismantlement activities share space with other activities. It would greatly facilitate the monitoring process to isolate these facilities from others in which non-dismantlement activities occur.

- Dismantlement of warheads does not take place one at a time in serial fashion. Warheads are "campaigned" throughout the disassembly and dismantlement areas in Zone 12, with several warheads in various stages of disassembly and dismantlement in the bays and cells at any one time. This could make it necessary to use tags, seals, and radiation signature methods to track the dismantlement of individual warheads through the process.

- For explosive safety reasons, bays and cells have limited personnel access. In cells the limits are 8 operators and 8 observers; in bays the limits are 6 operators and 4 observers.

- Bays, cells, and connecting ramps do not contain a large amount of excess space for conducting monitoring procedures.

- Nuclear material is currently staged/stored in a number of different buildings.

Y-12 PLANT

The Y-12 facility is located in Oak Ridge, Tennessee. It is operated for DOE by Lockheed Martin Energy Systems. The Y-12 Plant is the only U.S. nuclear weapons facility authorized for the disassembly of nuclear warhead Canned SubAssemblies (CSAs), also known as secondaries. In addition to disassembly of CSAs removed from nuclear weapons, the Y-12 Plant has many other nuclear warhead missions, including:

- Highly Enriched Uranium (HEU) fabrication of complex components and assemblies;

- Safe and secure storage of nuclear materials;

- National Repository for non-irradiated HEU;

- Sole supplier of lithium hydride and lithium deuteride fabricated components; and

- Stockpile surveillance testing, evaluation, and assessment of warhead components.

In addition, there are non-DOE activities ongoing at the Y-12 Plant. Currently, disassembly throughput at Y-12 is approximately 22 disassemblies per month or about 260 disassemblies per year, plus additional stockpile stewardship activities. As with the Pantex Plant, disassembly activities, which comprise the largest share of the current Y-12 plant work, occur in the same buildings as assembly activities.

The Y-12 Plant includes three key facilities related to disassembly. The Nuclear Material Safeguarded Shipping and Storage Facility, Building 9720-5, is where retired warhead CSAs are received from Pantex. Building 9720-5 is also the facility principally utilized for long-term storage of HEU material. Building 9204-2E contains facilities and operations required for nuclear weapons component production, testing, storage, and disassembly. The 9212 complex contains facilities and operations used to convert HEU metal shapes into unclassified right circular annular cylinders. These cylinders are the configuration used for long term storage of HEU at the Y-12 Plant.

All disassembly activities at Y-12 occur within the area of the plant designated as the Western Exclusion Area. This area, located at the western end of the Y-12 reservation, is surrounded by a Perimeter Intrusion Detection and Assessment System (PIDAS), and entry is restricted and controlled through security portals. All activities associated with nuclear material occur within the boundaries of the Western Exclusion Area. The layout shown in Figure 10 highlights the major Y-12 facilities where disassembly and related activities occur.

All Y-12 operations associated with the disassembly of retired subassemblies from dismantled weapons have been consolidated into Building 9204-2E. Disassembly and inspection activities at Y-12 associated with the DOE Stockpile Quality Evaluation and Surveillance Program occur in Building 9204-4.

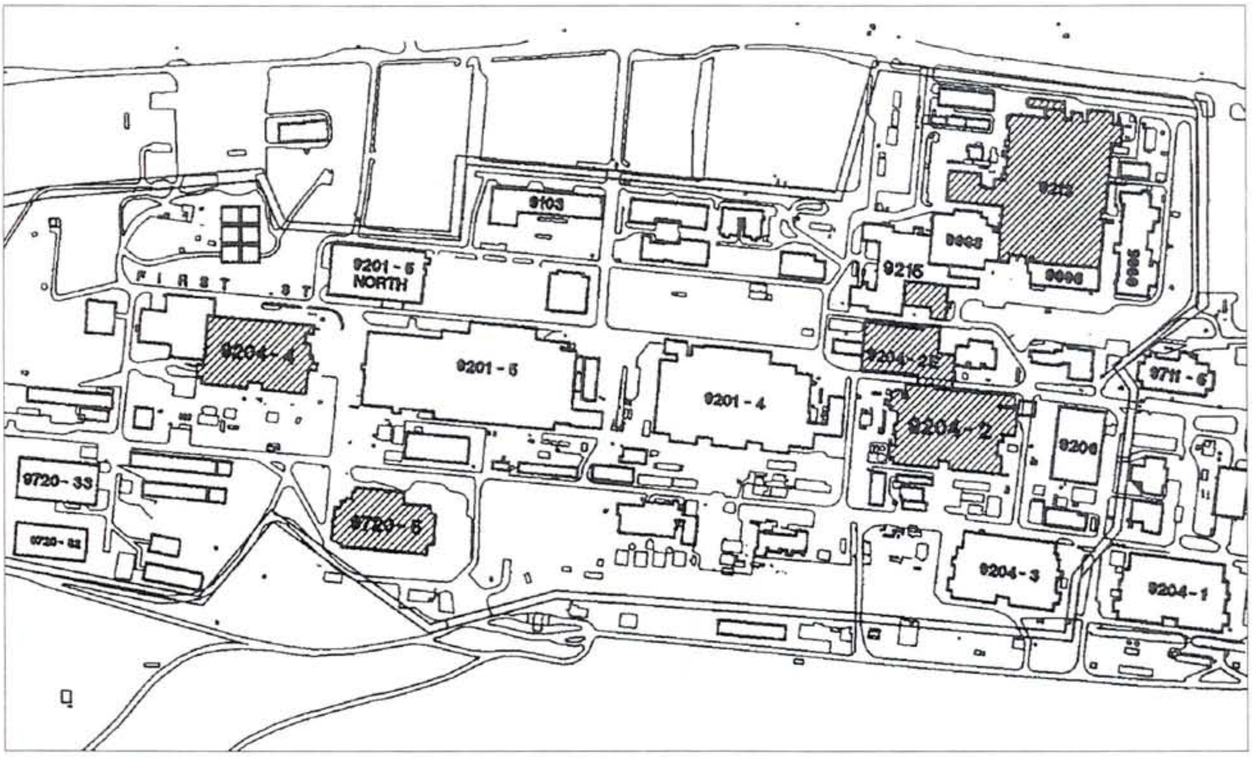


Figure 10: Diagram of the Oak Ridge Y-12 Plant.

DEVICE ASSEMBLY FACILITY

The Device Assembly Facility (DAF) is located in Area 6 at the Nevada Test Site (NTS), approximately 90 miles northwest of Las Vegas, Nevada. Prior to signature of the Comprehensive Test Ban Treaty (CTBT), the primary purpose of the DAF was to consolidate the LANL and LLNL Nuclear Test Device Assembly Operations in a single location at the NTS to provide optimum security features and provide structures that meet DOE Safety Standards for the assembly of nuclear and high-explosive materials.

The current status of the DAF includes:

- Five (5) cells of gravel gertie design to minimize release of radioactive contamination in the event of a high-explosive detonation;
- Five (5) staging bunkers with a single door for personnel and equipment (minimal processing utilities are available);
- Four (4) high bays with interlocking blast doors for personnel, and blast security doors for equipment;
- Three (3) assembly bays with interlocking blast doors for personnel and blast security doors for equipment;
- Two (2) radiography bays, with interlocking personnel and equipment doors, and areas for control equipment, film reading, a darkroom, and a processing space lab;
- Two (2) shipping and receiving bays with a loading dock and hydraulic leveling platform in place;
- Two (2) decontamination areas.

The DAF is not yet fully operational to perform nuclear explosive operations. The requirements to start up a facility such as the DAF include an approved Final Safety Analysis Report (FSAR), Nuclear Explosive Safety Studies (NESS), Environmental Assessment (EA), the successful completion of an Operational Readiness Review (ORR), and possibly, a security Inspection and Evaluation (I&E). The DAF is scheduled to have its DOE Operational Readiness Review in the Summer of 1997.

As a whole, the NTS offers considerable assets for supporting nuclear weapon dismantlement activities at the DAF. The DAF includes both bays and cells (gravel gerties) which are essential for performing dismantlement activities. Figure 11 shows the DAF at NTS.

In order to fully evaluate the cost, impact, and schedule issues associated with using DAF to support START III dismantlement and transparency activities, DOE will undertake a more detailed analysis of the DAF as part of a follow-on study to this report.

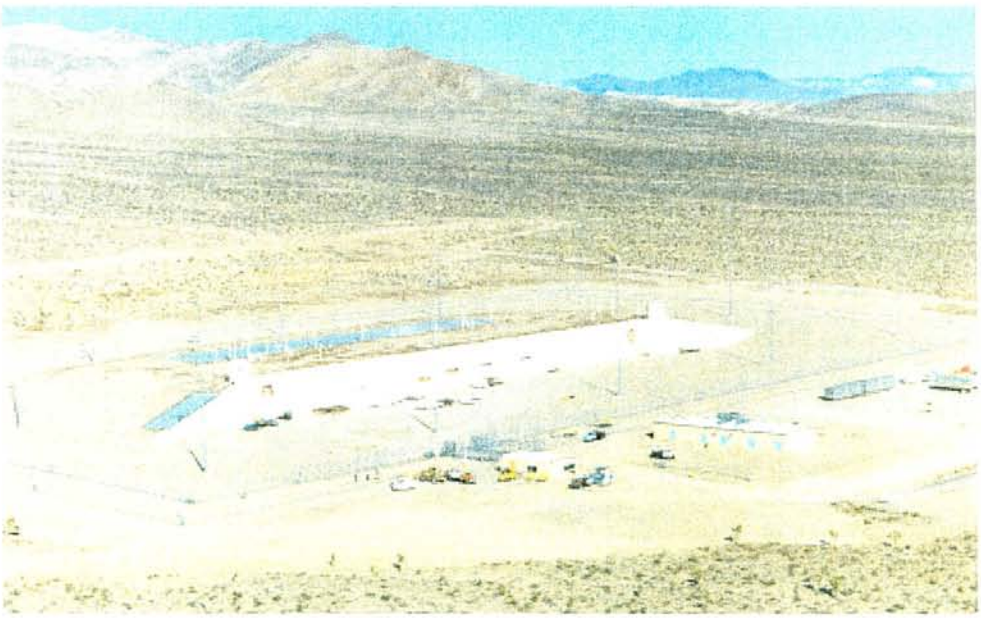


Figure 11: The Device Assembly Facility at the Nevada Test Site.

B. DISMANTLEMENT PROCESS

Dismantlement is commonly defined as the separation of the high-explosive materials from the fissile materials. More generally, dismantlement is a part of a four-step process of retirement, return, disassembly of weapons, and disposal of nuclear warhead components. The retirement of a nuclear warhead by DoD is an administrative action. During retirement, weapons may be moved from one DoD facility to another for interim DoD storage. Eventually, retired weapons are returned to the Pantex Plant by the DOE Transportation Safeguards Division (TSD) in DOE-owned and operated Safe Secure Trailers (SSTs). Weapons returned to Pantex go through a change of custody from DoD to DOE at the time they are picked up at a DoD facility. Once at the Pantex Plant, retired weapons are disassembled and the resulting components and materials are disposed of either at the Pantex Plant or at one of the other DOE nuclear weapons complex facilities, contract vendors, or DoD. The discussion of the dismantlement process below focuses on the current disassembly process that occurs at Pantex (for warheads) and at the Y-12 facility (for CSAs).

Appendix D provides a flow diagram of the dismantlement steps at Pantex for the B-61 and the W-56. It also includes a further breakdown of the major dismantlement steps for gravity bombs (weapons such as the B-61) and for reentry vehicles (weapons such as the W56). For simplicity, we have only provided an overview of the major dismantlement steps below.

DISMANTLEMENT AT PANTEX

Warhead Staging Prior to Disassembly

Retired weapons arriving at Pantex are taken to the plant's staging area in Zone 4, where custody is transferred from TSD to the plant's operating contractor, Mason & Hanger Corporation. These weapons are placed in one of the magazines until they are transferred to Zone 12 for disassembly. Zone 4 is a Material Access Area (MAA) with associated levels of security protection.

Safeguards Inspection

Within 72 hours of arrival at Pantex, gamma spectrometry and/or neutron detection verification of each warhead is performed by the Safeguards Confirmation Measurements Section of the Safeguards Department either in Zone 4 or in Zone 12. If the procedure is done in Zone 12, it is typically done in one of the linear accelerator (LINAC) facilities.

Security Inspection and Radiography

Some weapons having security features must be taken to a special facility, a gravel gertie set aside for performing the necessary operations prior to dismantlement. These inspections involve extremely sensitive aspects of warhead operation and are only accessible to limited personnel. Following these security inspections, weapons are sent to one of five LINAC facilities for radiographic safety inspection to determine the status of the weapons and components (e.g., positions of switches, the status of valves and other electro-explosive devices, the integrity of components and sub-components, and the detection of any cracks which might have developed in the high explosive). Currently, two LINAC facilities are devoted full time (one shift) to supporting dismantlement activities.

Mechanical Disassembly

The next step in the disassembly process is to move the warhead to a bay for disassembly. Mechanical disassembly includes:

- Removal from the shipping container;
- Removal of non-nuclear components (tail fins, parachute canister, pre-flight packages, etc.);
- Removal of the AF&F (arming, fusing, and firing) component;
- Removal of tritium containers (if not already performed); and
- Removal of the nuclear explosive physics package.

This is not an all-inclusive list, and not all weapons have all of these components. There are typically 2 to 4 bays associated with mechanical disassembly operations for each warhead program. However, some older warhead types lacking modern safety features are disassembled completely in the gravel gerties, where more hazardous dismantlement steps are usually performed.

Disassembly of the Nuclear Explosive Physics Package

When mechanical disassembly is complete (i.e., when the physics package consisting of the nuclear components and high explosives has been removed), the physics package is moved to a gravel gertie for "dismantlement" (i.e., separation of the high explosive from the nuclear components). When the high explosive and the nuclear components are separated, the warhead ceases to exist for accounting purposes (and for nuclear explosive safety purposes), and the nuclear components are accounted for individually from that point forward.

Component Staging

When the physics package disassembly is complete, the nuclear components are staged in several buildings in Zone 12 and the magazines in Zone 4 until they are returned to other DOE nuclear weapons complex facilities. Radioisotopic Thermal Generators (RTGs) are transported to the Los Alamos National Laboratory, tritium containers are transported to the Savannah River Site in Aiken, South Carolina, and CSAs are transported to the Y-12 Plant in Oak Ridge, Tennessee.

Pits are currently being stored in Zone 4 at Pantex in both modified Richmond magazines and Steel Arch Construction (SAC) magazines. Currently a total of 26 magazines are used for the storage of pits, and up to 425 pits may be stored in each of the modified Richmond magazines. In response to personnel radiation exposure considerations, the physical protection in and around these magazines has been upgraded to allow for extended physical inventory periods of 18 months. Generally only one or two magazines undergo physical inventory each month, requiring approximately one eight hour shift to inventory each magazine. As part of the physical inventory each item (and its tags and seals) within a magazine can be visually inspected by remote cameras, and bar codes are automatically read from a shielded fork lift as part of the Stage Right inventory system. In addition, a statistically significant population of items are selected from the population of containers within the one to three magazines selected for physical inventory during the month, and Pantex performs confirmatory NaI radiation measurement on these items to complement the container accounting described above.

Disposal

All other parts removed from dismantled warheads are categorized, disfigured, and/or rendered unusable (if required to satisfy classification and/or nonproliferation concerns), and then staged for disposal through appropriate waste streams. These efforts require significant portions of 6 warehouses at Pantex (more than 14,000 square meters). Of particular note are the high explosive components, removed from the nuclear explosive physics package, which are presently destroyed by open-air burning.

Observations on the Pantex Dismantlement Process

From the standpoint of monitoring dismantlement, several observations regarding the process described above are worth mentioning:

- The process is not uniform, varying considerably from one warhead type to another.
- The process occurs in a number of different buildings.
- The process takes considerable time. HE removal alone can take a day or longer per warhead for certain warhead types.
- Some level of monitoring by international inspectors is possible at the unclassified or Confidential/ National Security Information level at each major step of the dismantlement process.
- More confidence in dismantlement verification could be gained by the exchange of limited amounts of Restricted Data or Formerly Restricted Data with the inspecting party, if the legal mechanism for doing so (an Agreement for Cooperation) were in place.

DISASSEMBLY AT Y-12

Component Staging Prior to Disassembly

Retired warhead CSAs are shipped from Pantex to Y-12 by DOE's TSD in SSTs. These subassemblies are delivered to the Nuclear Material Safeguarded Shipping and Storage Facility, Building 9720-5. Depending on storage space availability, some CSAs may be moved to another storage facility to await disassembly. All of these facilities are located in MAAs.

Safeguards Inspection

Within 24 hours of receipt, shipments of CSAs are subjected to a transfer check, which consists of confirmation of shipping container or item count, validation of tamper-indicating device (TID) integrity, and identification.

Within 72 hours of receipt, shipments are subjected to material confirmatory measurements by non-destructive assay (gamma ray spectral measurements by multi-channel analyzer) and by gross weight checks.

Transfer to Storage Containers

CSAs removed from dismantled nuclear weapons arrive at Y-12 in containers specially designed and certified. After unloading into an MAA, some CSAs are unpacked and transferred to in-plant storage containers. Empty shipping containers are refurbished, re-certified, and are returned to the Pantex Plant for reuse.

Disassembly Operations

Per disassembly schedules, CSAs are moved to the Building 9204-2E disassembly area. Disassembly activities include:

- Unpacking from the storage or shipping container;
- Disassembly of CSAs using lathes, special disassembly tooling, presses, hand tools, and mechanical disassembly devices;
- Accountability measurements consisting of assay checks, part number verification, and part weight verification;
- Packing of nuclear material for interim storage or transport for melting and casting; and
- Processing and packaging of non-fissile classified and unclassified components.

Disassembly operations and the total duration of the disassembly process differ for each warhead type. Some CSAs are completely disassembled in one day and other, more complicated, CSAs may require several days for complete disassembly.

Component Staging after Disassembly

Following disassembly, nuclear material is assayed, verified for weight and part number identification, and entered into the Y-12 plant's accountability system. HEU is loaded into specially designed containers (birdcages) for interim storage within vaults, and eventually transported to the Building 9212 MAA for melting and casting.

Other materials are handled in various ways depending on part configuration, classification, material type, and contamination level. Depleted uranium parts are assayed, verified for weight and part number, and marked with white paint to prevent potential misidentification in later processing. Depleted parts are placed in tote-pans with lids and are moved out of the MAA to await further processing. Components manufactured from lithium compounds are checked by health physics technicians for potential contamination with enriched uranium. Contaminated and uncontaminated components are packaged separately into plastic bags and into 55-gallon metal drums.

After casting, HEU is packaged into sealed metal cans which are placed in interim storage or moved to the MAAs for long-term storage in one of the three concrete-encased tube vaults, each having a storage capacity of 40 metric tons of (approximately 93% enriched) HEU or into Modular Storage Vaults (MSVs), each having an HEU storage capacity of approximately 1.9 metric tons in a 5-layer configuration.

C. U.S. DISMANTLEMENT SCHEDULE

Table 2. U.S. Dismantlements Completed.

Fiscal Year	Programs Completed	Associated Delivery Vehicles	Total Dismantlements
1989	W-45	Terrier, Bullpup B	1,208
1990	None	N/A	1,154
1991	B43, B54, W44, W50, W85	USN Tactical, Davy Crockett, ASROC, Pershing I, Pershing II	1,595
1992	B28, W33	USN Tactical, 8" AFAP	1,856
1993	None	N/A	1,556
1994	None	N/A	1,369
1995	B57, W71*, W68, W70	ASW Depth Bomb, Spartan, Poseidon C-3, Lance	1,393
1996	W48, B61-0	155 mm AFAP, Strategic Bomb	1,064
Total			11,195

* The quantity dismantlement of W71 units was completed in 1995.

Table 3. U.S. Dismantlement Schedule.

Fiscal Year	Programs Completed	Associated Delivery Vehicles	Total Dismantlements
1997	B61-2, W55, W71**	Tactical Bombs, SUBROC, Spartan	944*
1998	TBD	TBD	1,319*
1999	TBD	TBD	418*
2000	TBD	TBD	150*
Total			2,827*

* Dismantlements scheduled according to the current Long Range Planning Assessment.
** A single W71 unit remained until 1997.

Table 4. Remaining Warhead Programs.

Status	Warhead Type	Associated Delivery Vehicles
In Dismantlement	B61-5	Tactical Bombs
*Scheduled for Dismantlement**	W69	SRAM
	W79	8" AFAP
	B53*	Strategic Bombs
	W56*	Minuteman II
Canceled Programs	W82	155 mm AFAP
	W89	SRAM II
	B90	ND/SB
	W91	SRAM T
*Enduring Stockpile***	W62**	Minuteman III
	W84**	GLCM
	B61-3***, 4***, 7, 10, 11**	Tactical & Strategic Bombs
	W76**	Trident I
	W78**	Minuteman III
	W80**	SLCM/ALCM
	B83**	Strategic Bombs
	W87**	Peacekeeper/Minuteman III
	W88**	Trident II

* Scheduled for dismantlement in the current Long Range Planning Assessment.
** Potentially subject to monitored dismantlement under START III.
*** A portion of the B61-3 and B61-4 units have been retired and will be dismantled.

Table 5. Time Required for Dismantlement.

Warhead Type	Status	Process Time,[1] person hours	Cycle Time,[2] 8 hr. shifts	Throughput,[3] Units/month
B61-5	In dismantlement	29.4	1.5	14 - 15
W69	Scheduled for dismantlement	55.2	2.8	7 - 8
W79	Scheduled for dismantlement	165.2	8.6	2 - 3
B53[4]	Scheduled for dismantlement	175	9	2 - 3
W56[4]	Scheduled for dismantlement	120	6.5	3 - 4
W62[4]	Enduring Stockpile	95	5	4 - 5
W84[4]	Enduring Stockpile	160	8.5	2 - 3
B61-3, 4, 7, 10, 11[4]	Enduring Stockpile	30	1.5	14 - 15
W76[4]	Enduring Stockpile	60	3	7 - 8
W78[4]	Enduring Stockpile	70	3.5	6 - 7
W80[4]	Enduring Stockpile	60	3	7 - 8
B83[4]	Enduring Stockpile	90	5	4 - 5
W87[4]	Enduring Stockpile	95	5	4 - 5
W88[4]	Enduring Stockpile	85	4.5	4 - 5

Notes:

1. Process time is the actual hands-on dismantlement time in person hours, with no down time for breaks, waiting for transfer of parts between bays and cells, etc. Under the Pantex Reader, Worker, Checker system, a minimum of 3 technicians are involved at each step of the dismantlement process.
2. Cycle time is the time required for dismantlement including breaks, waiting for transfers between bays and cells, etc. For the purposes of this report cycle time is measured in 8 hour shifts of 3 technicians each. With no lost time for breaks, transfer between bays and cells, etc., 24 hours of process time would require 1 shift of cycle time.
3. For the purposes of this report, throughput assumes one dedicated dismantlement cell, one warhead system in dismantlement at a time, and one shift per day, 5 days per week.
4. Dismantlement time required for these systems has been estimated.

IV. MONITORING ACTIVITIES AND TECHNOLOGIES

Before embarking on a discussion of the various dismantlement monitoring options, it will be useful to discuss the activities and technologies which can be used as the building blocks of these options. This chapter presents various monitoring activities and technologies that may be useful to the dismantlement monitoring process. The next chapter will then discuss dismantlement options that may be constructed from these activities.

In undertaking this report it is necessary to limit the types of technologies that will be considered. This report takes the position that dismantlement monitoring will be an on-site activity. For this reason, no consideration has been given to monitoring techniques such as National Technical Means (NTM) which played such a large part in the negotiations of the START I and II Treaties. This is appropriate since the small size of the Treaty Limited Items (TLIs) which are relevant to a warhead dismantlement treaty (nuclear warheads, and warhead components) greatly reduces the usefulness of NTM alone for monitoring treaty compliance. This was also a fundamental conclusion of the President's Report to Congress (the 3151 Report), and the JASON Report (see Appendix C).

As a further constraint on the technologies considered in this report, it was decided to limit consideration to technologies that could be fielded within a year of the completion of a dismantlement treaty. This is not to imply that all of the technologies described below are in a monitoring-ready condition, but that experimental work has been carried out in these areas and prototype systems have been developed and tested.

DECLARATIONS

Declarations form the basis of any warhead dismantlement monitoring regime. Declarations consist of statements, made by the host country, concerning some aspect of its nuclear weapons program. These can range from numbers of warheads available to the host (e.g., "the U.S. has 2750 warheads of a given type"), to information about schedules (e.g., "the U.S. intends to dismantle 27 warheads a week during September"), to information on storage (e.g., "there are 19 individual warheads components, removed from dismantled nuclear warheads, in a particular magazine at Pantex"). Of particular interest for dismantlement monitoring would be declarations of the numbers of warheads declared excess to national needs, declarations of warheads transported to Pantex, declarations of dismantlement rates, declarations of the movement of warheads from Zone 4 to Zone 12 for dismantlement, and declarations of the movement of pits from Zone 12 to Zone 4 or of canned subassemblies from Zone 12 to the Y-12 Plant after dismantlement. These declarations could be unclassified, classified at the Confidential National Security Information (C/NSI) level, or classified at the Restricted Data or Formerly Restricted Data (RD/FRD) level, depending on the content of the declarations and the legal constraints on sharing classified information with the treaty partner.

The declarations will be based on the existing inventory and processing record systems at Pantex and Y-12. It will be necessary to develop the process by which the data to be declared is extracted from the existing record systems. It is anticipated that the overall activity of declarations and data exchanges will be simple, with relatively modest impact and cost. Included within the area of declarations will be the question of process flow initiation. The dismantlement of each individual warhead type at Pantex occurs in a unique manner, with a material flow through the various cells and bays that is specific to that system. It will be necessary to develop specific briefings for inspectors before they can begin to understand and monitor the dismantlement of individual warhead types.

SPOT CHECKS

Declarations are a necessary part of any dismantlement monitoring regime, but are not by themselves sufficient to confirm dismantlement. One method of improving the credibility of declarations is by the introduction of

Spot Check inspections to confirm the declarations. Spot Checks are usually taken to mean the application of random inspections at a few locations to confirm the contents of a set of declarations. These inspections can employ various levels of intrusiveness, from the audit of records to simple item accounting, to verifying unique identifiers on storage containers, to radiation measurements such as those proposed for radiation signatures or MRI inspections. For dismantlement monitoring Spot Checks would be applied in the warhead and component storage areas to confirm that the contents of the magazines matched the declarations.

Whatever the level of intrusiveness, Spot Checks usually imply that the inspection method is only applied at a subset of the possible inspection locations or containers at any one time, but that the locations and containers are chosen by the inspecting party. This is in contrast to methods to be described later in which the inspecting party would apply the same techniques to every item of inspection. At the beginning Spot Checks provide a moderate level of confidence, but with continued application, the level of confidence rises considerably as the statistics improve.

REMOTE MONITORING

Remote monitoring activities for dismantlement monitoring refers to the application of various containment and surveillance technologies to give a level of confidence that events have or have not occurred without the actual presence of inspectors. Cameras are traditionally used to monitor storage areas or perimeters. These can be coupled with anti-intrusion image storage units or satellite links to send the images in real time to remote locations. Tags and seals of various kinds also fall into this area. These can be applied to storage buildings or to individual storage containers to indicate if the items have been tampered with, or to assure the lack of intrusion. Application of such techniques would allow the inspectors to follow the dismantlement activities by watching the movement of warheads and components in and out of the storage area, even when they are not present at the facility.

In order for a remote monitoring system to provide credible information, it would have to be tamper protected. Such systems have been designed and installed to assist the International Atomic Energy Agency (IAEA) in monitoring safeguarded fissile materials. Additional confidence would be offered by systems which were data authenticated and included additional sensors such as motion or seismic sensors and proximity sensors. The major cost of this activity is for equipment and site preparation. This activity should involve minimal impact and inspection cost.

Remote monitoring can be thought of as an extension of surveillance which allows visual images to be seen at a different, perhaps distant location. Currently the U.S. and Russia have a demonstration project to study the application of remote monitoring to spent fuel storage facilities. This project is a joint venture between the Kurchatov Institute and the U.S. Argonne National Laboratory (West). As a result of this project, real-time images of the spent fuel storage facilities at each location are available at the other facility.

A significant question in the remote monitoring area is the ability of tags and seals to either indicate tampering or to assure non-intrusion. Most currently used systems are good enough to always indicate tampering, if one has sufficient time to examine the tag or seal. For current systems used on small containers, such as the ALR8 or AT400 containers, schemes to defeat the containers themselves may be more of a concern than schemes to defeat the tags and seals.

For larger structures, such as the magazines in Zone 4, current systems may be more effective, but again one must consider other scenarios for entry into the structure. The U.S. government has sponsored a wealth of red teaming activities in the general area of tags and seals. Before using these techniques for dismantlement monitoring it would be necessary to evaluate this knowledge in view of the specific applications of interest.

CHAIN-OF-CUSTODY

Chain-of-custody is a technique to provide continuous monitoring of the existence or presence of an accountable item. Chain of custody demonstrates that an unaltered or uninterrupted custody or control of an item has been maintained by the owner or inspector, depending on the monitoring protocol, that provides confidence that deceptions have not been introduced. Specific technologies utilized are tamper indicating devices (TIDs) such as tags and seals, radiation signature measurements, remote monitoring technologies, and direct observation.

In the case of warhead dismantlement monitoring, chain-of-custody implies that the inspectors would begin to observe the warhead early in the dismantlement flow, at the entrance to Zone 4 at Pantex, or when the warhead is accepted for custody by DOE, or even when it is removed from the delivery vehicle, deployment site, or storage depot at a DOD facility. Through the use of unique identifiers, tags and seals, radiation measurements, and/or physical accompaniment of the Treaty Limited Items and direct observation, the inspectors would be able to follow the exact warhead through the dismantlement procedure to the dismantlement bay or cell at Pantex. Following the actual dismantlement, the inspectors would be allowed to follow the nuclear components to their storage location pending final disposition, either in Zone 4 at Pantex or at the Y-12 facility in Oak Ridge.

The level of intrusiveness that accompanies chain-of-custody depends on the types of measurements that the inspectors are allowed to see and do, and the types of records that they have access to. These measurements could range from reading the unclassified unique identifiers that are already on all U.S. warheads, to unclassified radiation measurements such as the measurement done during reception of CSAs at the receiving facility at Y-12. More intrusive measurements would include the confirmation measurements currently done within 72 hours of reception at Pantex and Y-12, MRI-like measurements, or the types of measurements described below in the discussion of radiation "signature" methods. The ultimate in chain-of-custody would include having the inspectors observe the actual dismantlement, either remotely or directly.

At Pantex, chain-of-custody can be confined to Zone 4, Zone 4 plus the portal of Zone 12, or can be extended all the way to the dismantlement cell and back. Chain of custody within Zone 12 would not be a linear process, since the warhead typically moves back and forth between different dismantlement bays and cells during the course of dismantlement. This non-linear flow is different for each warhead type. The study group concluded, however, that it would be possible to do a chain-of-custody at the C/NSI level but that would not reveal Restricted Data or Formerly Restricted Data. Such a chain-of-custody could extend all the way to the dismantlement cell and back to the storage areas, even though it would be costly and highly intrusive. Coupling such a chain-of-custody with radiation measurements or finger-printing techniques would allow inspectors to follow a warhead and its components from its retirement through dismantlement to storage pending the final disposition of the fissile material.

PORTAL PERIMETER CONTINUOUS MONITORING

PPCM refers to a system for inspecting every item that passes into or out of a specific area. For this activity to be effective, the inspecting party must control all of the access portals to the facility of interest. This usually involves either remote monitoring or actual visual inspection of the entire fence line (or perimeter) surrounding the facility to be monitored. All traffic into and out of the facility is then directed through a single portal, or a small number of portals. The inspectors have the right to stop and examine any item passing through the portal that is big enough to contain a TLI. For warhead dismantlement monitoring, such inspections could be classified or unclassified, depending on the level of information which can be shared with the inspectors.

PPCM is usually thought of as a system that limits the intrusiveness of monitoring TLIs. This is generally true for treaties like START and INF, where the TLIs are very large and can only be contained in a very heavy truck or a rail car. In a dismantlement treaty scenario however, PPCM would be extremely intrusive, because some Treaty Limited Items, e.g., certain nuclear warhead components resulting from dismantlement, could be quite small, and would easily fit in a car trunk, a glove compartment, or under a coat. For a Portal Perimeter Continuous Monitoring regime to be effective it would require permanent presence of an inspection team at the facility being monitored, or the use of remote monitoring techniques. PPCM for small Treaty Limited Items also requires a very thorough initialization procedure to ensure that no items have been sequestered within the monitored area that can be used to mock up the items of inspection and spoof the inspections.

PPCM can be either classified or unclassified, depending on the measurements that the inspectors are allowed to carry out. An unclassified, but still highly intrusive, scenario can be constructed in which the inspectors monitor all items large enough to contain a TLI, but using measurements that only reveal the presence of fissile material.

There are also significant considerations in applying PPCM to an area where many different warhead operations are performed, such as Zone 12 at Pantex. PPCM is only meaningful if all traffic in and out of the area is subject to search and documentation. If all of Zone 12 at Pantex or all of the Western Exclusion Area at Y-12 were placed under PPCM this would subject all refabrication, refurbishing, and retrofit activities for the enduring stockpile to inspections. This would adversely affect the DOE's ability to fulfill the Presidential requirement to maintain a safe, secure, reliable stockpile.

Therefore, the PPCM option would only be viable at Pantex if PPCM is applied to a portion of Zone 12 which is segregated from the rest of Zone 12 and dedicated to the dismantlement of warheads covered by the treaty. By declaration, no dismantlement of warheads covered by the treaty would occur in the rest of Zone 12, and therefore the rest of Zone 12 would not be subject to PPCM. This dedicated dismantlement zone would have to be segregated from the remainder of Zone 12 by a security perimeter sufficient to demonstrate to the inspectors that there was no potential for material to enter the zone other than by the monitored portals. The dedicated portion of Zone 12 would have to be initialized by a thorough one-time search to confirm that the area contains no warheads or components. This would be done, for example, to ensure that there was no clandestine stockpile of pits already stored in the PPCM area for use in a spoofing scenario.

A similar segregated portion of the Y-12 Western Exclusion Area could be established for the monitored disassembly of TLI canned subassemblies. Applying PPCM to a segregated and dedicated dismantlement zone for TLI would mean that every warhead or CSA going into the dedicated zone would be dismantled, and no warheads would come out of the dedicated zone at Pantex, or CSAs out of the dedicated zone at Y-12. No components would go into the dedicated zone at either Pantex or Y-12, and every component coming out of the dedicated zone would be from a dismantled TLI warhead or canned subassembly. By making radiation fingerprint measurements on the warheads, canned subassemblies, and components it may be possible to identify a particular type of component with a particular type of warhead. This coupled with careful record keeping would provide the confirmation that warheads are being dismantled.

It was estimated for the purpose of making cost estimates that this segregated portion of Zone 12 could include 1 linear accelerator radiography bay, up to 11 mechanical disassembly bays, and up to 4 dismantlement cells at Pantex. A segregated portion of Y-12 subject to PPCM would be less extensive. The preparation and initialization of the segregated dismantlement zones would be relatively costly. This monitoring activity would require permanent presence or very effective remote monitoring.

SWEEPING OF THE BAY OR CELL BEFORE AND AFTER DISMANTLEMENT

Sweeping of the bay and cell is defined as allowing the inspectors to search the bay or cell before dismantlement to determine that there are no nuclear warheads (or CSA if implemented at Y-12) or nuclear components present before dismantlement, and no undeclared portals by which nuclear components or nuclear warheads could enter or exit the bay or cell. The inspectors would then examine the declared warhead in the staging bay outside of the bay or cell and determine that it is an actual TLI warhead, or a specific TLI warhead, using fingerprint measurements and TIDs. The warhead is then taken into the bay or cell to be separated into components (pit, canned subassembly, HE, and non-nuclear components) in the absence of the inspectors. When nuclear components (pit and canned subassembly) in sealed containers are removed from the cell, the inspectors perform radiation measurements or fingerprint measurements in the staging bay outside of the cell, and apply TIDs to the containers. The inspectors then search the cell to determine that no nuclear components remain in the cell. Chain-of-custody could then be applied to verify that the components are placed in monitored storage.

Dismantlement in a swept bay or cell would allow the inspectors to verify that specific components came from a specific warhead, by ruling out other possibilities. This activity is the extension of the chain-of-custody into the dismantlement bay or cell itself, and would be extremely valuable if the monitoring of dismantlement of specific warheads was required. It could be classified or unclassified depending on the measurements permitted inside the bay or cell, and the degree of masking that is done before the inspectors enter the bay or cell.

DIRECT OBSERVATION OR REMOTE MONITORING OF THE DISMANTLEMENT PROCESS IN A BAY OR CELL

Actual observation of the dismantlement process, whether done remotely or directly, would produce the highest confidence that dismantlement is taking place. Routine use of this activity could be appropriate if a very high level of confidence in dismantlement is required as part of a true verification regime. Direct observation or remote observation of dismantlement could also be performed on a limited basis, for example, if the inspectors wanted to "guarantee" that a component came from a specific warhead so that a template for radiation signature measurement could be developed, or to resolve an "ambiguity" in the dismantlement process.

In order to perform this activity a dismantlement cell would have to be specially prepared to protect information that is not intended to be shared with the inspectors. The inspectors would then observe the dismantlement process either by going into the cell or through the use of remote monitoring techniques such as closed circuit television (CCTV). Because of the critical nature of the components and processes being observed, the prevention of inadvertent disclosure of sensitive information in this activity would be very difficult.

However, an opportunity for unclassified direct or remote observation of the dismantlement process may be presented by the Pantex SS-21 (Seamless Safety for the 21st Century) dismantlement process, which makes extensive use of specialized tooling and carefully prescribed operations to ensure safety in the dismantlement process. It might be possible to mask the most sensitive aspects of the dismantlement process by building sufficient visual shielding into the SS-21 tooling to allow the presence of inspectors in the dismantlement cell during dismantlement. With careful red-teaming and extensive security review of this approach, it could be possible to allow direct observation or remote monitoring of the dismantlement process in the bays and cells without revealing Restricted Data to the inspectors. The SS-21 process currently has no provisions for protecting the classified information that might be revealed during the dismantlement process. Although it seems simple to incorporate measures to protect classified information, only a thorough review of the needed measures, and their impact on the safety of the dismantlement process, will reveal the feasibility of incorporating those measures into the SS-21 process.

MONITORING OF NON-NUCLEAR COMPONENTS

While earlier studies concluded that monitored destruction of non-nuclear parts of dismantled warheads would, by itself, have little arms control significance, the study group which prepared this report concluded that the monitoring of non-nuclear components can add to the preponderance of evidence that functional nuclear warheads are being dismantled and that a proper disposition process is in place for all major nuclear warhead components. Verified destruction of non-nuclear major components may increase confidence that a particular type of warhead has been dismantled and that a country's capability to regenerate those warheads has been made more difficult. Monitoring of non-nuclear components includes the physical and administrative tracking of components as they are removed from the warheads and rendered inoperable or destroyed, and could include the use of video equipment or direct observation.

For this study non-nuclear components are defined as those components from nuclear warheads that do not have bulk quantities of fissile material. Therefore, non-nuclear components include warhead components that could be radioactive or contaminated by radioactive material due to proximity to nuclear components. Also included in this category are major nonnuclear components (MC) of the nuclear warhead that are required for it to function as a weapon system. The following categories of MC are considered non-nuclear for this study:

- HE in all forms that are part of a nuclear warhead, including detonators
- Radiation cases and channels
- Reentry vehicle aero-shells
- Nuclear initiators, neutron generators, and tritium storage containers
- AF&F sets, including all components associated with the HE initiation train; radar fuse, impact fuse, RTGs, batteries, etc.

Depending on the warhead type, other non-nuclear components may be identified as items which would be significant to monitor. Monitoring the disposition of non-nuclear components can be accomplished with a reasonable amount of workplace and procedural modifications. Since a significant number of the non-nuclear components are unclassified in U.S. systems, shrouding techniques and administrative procedures could prevent the loss of sensitive information. For example, for one of the warhead types currently undergoing dismantlement, the Pantex nuclear warhead dismantlement process has been broken into twenty major steps. Eighteen of these steps (90% of dismantlement operations) involve tasks and operations that fall into the non-nuclear category.

RADIATION SIGNATURES

The use of radiation signatures is applicable to several of the monitoring activities including spot checks, chain-of-custody, portal perimeter continuous monitoring, and sweeping of a bay or cell before and after dismantlement. Radiation signature techniques involve measurements of the radiation emitted from a warhead before dismantlement, and from the components following dismantlement. If these signals can be correlated, one can obtain increased confidence that dismantlement is taking place without having to intrude within the dismantlement area.

There are two distinct types of radiation signature measurements: intrinsic and induced.

In passive (intrinsic) measurements, one makes use of the spontaneous radiation emitted by the nuclear materials before and after dismantlement to produce the needed correlations. In active (induced) measurements, one interrogates the warhead, and perhaps the components, with an external radiation source, and attempts to correlate the resulting induced radiation patterns.

Templates

For many of the radiation signature schemes it may be necessary to employ a template-matching approach to analyze the data. Templates may be applied in two ways. In the first approach one originally accumulates, by some means, a series of authenticated radiation signatures or "templates" describing the various different warhead and component types. Then during inspections the signature obtained is compared to the library of templates that is available to the inspectors, and it is determined which warhead type or component type matches the radiation signature of the item being inspected.

In the second method one obtains the templates as the radiation signatures from the first unit to be dismantled and the components removed from it, and then compares the radiation signatures for all similar units to these templates to determine whether they are the same as the first unit of that declared type.

In many cases the information contained in the templates is classified, which restricts the utility of these methods. However, it may be possible to ***compare*** a radiation signature to a classified template without revealing classified information, by displaying to the inspectors only a "Yes" or "No" answer to the question "Does this radiation signature match the template?"

Radiation Signature Technologies

A detailed description of warhead radiation signature technologies is provided in Appendix E. Several examples of radiation signature techniques that may have utility for dismantlement monitoring are discussed below:

- **Gamma Ray Spectral Measurements**: The Sandia Remote Monitoring System (RMS) is currently in use at the Pantex facility for domestic safeguards purposes. This system measures the gamma ray spectrum from a pit, both in the warhead configuration and after dismantlement. The NaI spectrum is then binned into a low resolution spectrum which is used to distinguish various component types. This is a totally passive system, and can be carried out in a portable configuration. Both the high and low resolution spectra taken with systems like the RMS are classified.

- **Controlled Intrusiveness Verification Technology (CIVET):** CIVET consists of a set of hardware, software, and procedures designed for the purpose of permitting an inspecting party to perform a high-confidence inspection while at the same time providing assurance to the inspected party that sensitive data are not revealed to the inspector. In the CIVET high-resolution gamma-ray spectroscopy (HRGS) system, the hardware was especially designed to minimize the opportunity for clandestine data storage or transmission, and the software was developed to perform all data acquisition, spectrum data analysis, peak data computation, and template comparison functions with minimal operator input, and to display verification conclusions containing no sensitive or classified information.

- **Nuclear Weapons Identification System (NWIS):** NWIS has been under development for several years at Oak Ridge, and has been applied with success at the Y-12 facility. The system has proven particularly useful for CSAs, which are resistant to gamma ray spectral techniques because of the low intrinsic radiation signal from HEU. In the NWIS system one interrogates the item being inspected with a ^{252}Cf neutron source which is built into an ionization chamber. Thus one has an exact time for the birth of the neutrons used for the interrogation. The system then measures the correlations in arrival time between this counter and several neutron or gamma detectors placed around the object being inspected, or between any two of the detectors. In all, the system generates 19 correlations, some of which show very high sensitivity to small changes in the warhead configurations. Even though the actual template generated by NWIS for each warhead or component is classified, the results of NWIS can be displayed on the unclassified level by comparing only the differences from each template or by normalizing the results of each measurement. While this normalizing technique was used effectively during the Russian demonstration at Y-12 in November 1996, the question of the classification of NWIS signals will need to be further investigated to ensure that no warhead design information can be extracted from the signals.

V. WARHEAD DISMANTLEMENT MONITORING OPTIONS

In considering the various transparency and verification options, many of the monitoring concepts for warhead dismantlement are largely facility independent. That is, the options might employ, for example, monitoring of receiving areas, storage areas, or disassembly areas, which in general terms would be common to any dismantlement facility. It is the *implementation* of the options which would be facility specific. The following discussion is written in terms of implementation of warhead dismantlement monitoring activities at Pantex. The application of the options discussed below to the monitoring of warhead dismantlement at Russian facilities is outside the scope of this report. An in-depth analysis of the impact of a warhead dismantlement monitoring regime on the Y-12 Plant should be conducted as part of the implementation plan for warhead dismantlement transparency, as detailed in Appendix G.

The activities and technologies described in Chapter IV are building blocks from which various options for the monitoring of warhead dismantlement can be constructed. Four potential warhead dismantlement monitoring options have been constructed from these building blocks, with the intention of spanning the range of intrusiveness, level of confidence, and impact on facility operations consistent with meeting the objective of monitoring warhead dismantlement.

The four options chosen for discussion are as follows:

- **Option 1:** Monitoring of warheads and components in the storage area (*Zone 4 at Pantex*) and chain-of-custody monitoring to and from the gate to the dismantlement area (*Zone 12 at Pantex*).

- **Option 2:** Option 1 ***plus*** portal perimeter continuous monitoring (PPCM) of a portion of the dismantlement area (*inside Zone 12 at Pantex*) dedicated to dismantlement of TLI warheads.

- **Option 3:** Option 1 ***plus*** further chain-of-custody procedures to monitor warheads and components within the dismantlement area (*inside Zone 12 at Pantex*), to and from the disassembly bays and cells (without PPCM).

- **Option 4:** Option 3 ***plus*** direct observation or remote monitoring of the dismantlement process (*inside Zone 12 at Pantex*).

The four options selected for analysis are shown in more detail in Table 6. Many other scenarios formed from combinations of the activities and technologies discussed in the previous chapter are possible in support of warhead dismantlement monitoring. However, the study group found the range of options summarized above to provide a convenient framework for discussing the costs and benefits of minimally intrusive through highly intrusive monitoring scenarios.

After carefully considering the details of current Pantex operations, the study group concluded that all of the activities and technologies discussed in Chapter IV can be applied either at the Unclassified to C/NSI or RD/FRD level, with varying effectiveness depending on the classification level chosen for each activity. Each of the options summarized above can be implemented at the C/NSI level if a General Security of Information Agreement (GSOIA) or Executive Order permits the exchange of NSI with the treaty partner, or at the RD or FRD level if an Agreement for Cooperation (AFC) permitting the exchange of such information is in place with the inspecting party. The confidence gained by the monitoring activities contained in Options 1-4 is generally greater at higher classification levels. The intent of the study group is that each activity be implemented at the classification level determined by a balance of level of confidence, intrusiveness, and cost consistent with legal constraints on the exchange of classified information at the time of the inspection.

Table 6. Options for Monitoring Dismantlement.

Option 1 = Monitored storage
Option 2 = Portal perimeter continuous monitoring of a dedicated portion of Zone 12
Option 3 = Chain-of-custody from storage to and from the dismantlement bay or cell
Option 4 = Direct observation or remote monitoring of dismantlement in the bay or cell

Activity	*Option 1*	*Option 2*	*Option 3*	*Option 4*
Declarations of dismantlement schedules and inventories	Yes	Yes	Yes	Yes
Spot checks of weapon and component storage in Zone 4	Yes	Yes	Yes	Yes
Remote monitoring of weapon and component storage in Zone 4	Yes	Yes	Yes	Yes
Chain of custody of warheads and components from Zone 4 to Zone 12 gate	Yes	Yes	Yes	Yes
Portal perimeter continuous monitoring of a segregated portion of Zone 12	No	Yes	No	No
Chain of custody of warheads and components within Zone 12	No	No	Yes	Yes
Sweeping of bay or cell before and after dismantlement	No	No*	Yes	No
Direct or remote observation of dismantlement in the bay or cell	No	No	No	Yes
Chain of custody of nuclear components from Zone 12 gate back to Zone 4	Yes	Yes	Yes	Yes
Monitoring of non-nuclear components following dismantlement	Yes	Yes	Yes	Yes

*One-time sweeping of the entire dedicated portion of Zone 12 is required at initialization of Portal Perimeter Continuous Monitoring.

A detailed discussion of each of the options considered in Table 6 follows. The descriptions of the options given in this chapter represent possible scenarios for implementation of the four options chosen for discussion. Many other choices are possible for the details of the options presented here. The descriptions which follow are intended to be representative of the possible choices for each option, and to stimulate discussion of the possibilities for monitoring of warhead dismantlement.

OPTION 1. MONITORED STORAGE

Activity	Option 1
Declarations of dismantlement schedules and inventories	Yes
Spot Checks of weapon and component storage in Zone 4	Yes
Remote monitoring of weapon and component storage in Zone 4	Yes
Chain of custody of warheads and components from Zone 4 to Zone 12 gate	Yes
Portal perimeter continuous monitoring of a segregated portion of Zone 12	No
Chain of custody of warheads and components within Zone 12	No
Sweeping of bay or cell before and after dismantlement	No
Direct or remote observation of dismantlement in the bay or cell	No
Chain of custody of nuclear components from Zone 12 gate back to Zone 4	Yes
Monitoring of non-nuclear components following dismantlement	Yes

Option 1 Goal

Option 1 is designed to be a minimally intrusive monitoring method. Option 1 involves monitoring the storage of warheads and components coming from dismantled warheads in the Zone 4 storage area at Pantex, and HEU from CSAs if implemented at the Oak Ridge Y-12 Plant. This *monitored storage option* is designed to be a minimally intrusive option that includes following the warhead to the gate of the dismantlement or disassembly area (Zone 12 at Pantex), but does not provide access to the dismantlement area itself, where actual dismantlement of the warhead takes place. As such, even with the use of classified declarations and the implementation of warhead radiation signatures to correlate the signature of the warhead with that of its components, this option would provide the lowest level of confidence of all the options considered that dismantlement has taken place. Figure 12 shows the areas at Pantex that would be covered under Option 1.

A meaningful procedure for monitoring of warhead staging and storage depends strongly on a reliable method for establishing the fingerprint of a warhead and the resulting components, or of tracking them with high confidence from an authenticated origin (e.g., from DoD custody). Chain-of-custody and fingerprinting radiation measurements are therefore important parts of monitored storage.

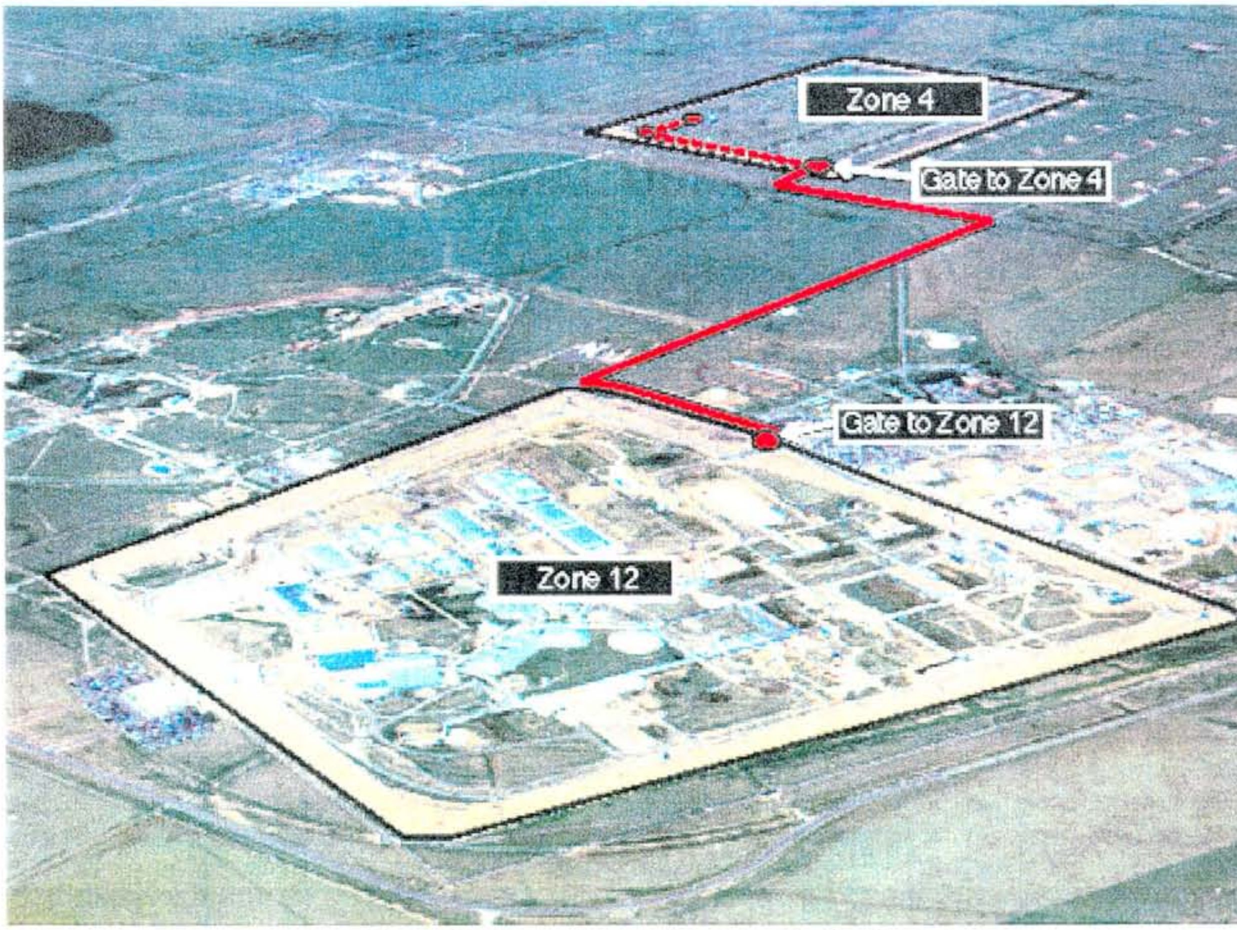


Figure 12: Pantex Access Areas for Option 1.

Option 1 Pantex Monitoring Procedure Summary

- Pantex segregates magazines for TLI warheads scheduled for monitored dismantlement and pits removed from dismantled TLI warheads
- Inspectors are permitted to make independent confirmatory radiation measurements on containers in each TLI magazine
- Inspectors are allowed to observe the unloading of SSTs containing TLI warheads arriving at Pantex for dismantlement
- Inspectors are allowed to observe the loading and unloading of transport trucks carrying TLI warheads from Zone 4 to Zone 12 and TLI pits from Zone 12 to Zone 4
- Chain-of-custody of TLI warheads scheduled for dismantlement is carried only to the gate of Zone 12 in Option 1
- Chain-of-custody of TLI warhead components removed from dismantled TLI warheads begins at the gate of Zone 12 in Option 1
- Chain-of-custody of non-nuclear components removed from dismantled TLI warheads begins at the gate of Zone 12 in Option 1

Detailed Description of Option 1 at Pantex

Option 1 begins with a declaration from Pantex that identifies the location of every TLI at Pantex (i.e., in a storage magazine in the segregated, dedicated portion of Zone 4, in Zone 12, or in transit). In particular, this declaration includes the bar-code, seal number, warhead type or pit type, warhead serial number or part number, magazine, and location within the magazine for every TLI warhead and pit from a TLI warhead stored within the dedicated portion of Zone 4. Pits and other nuclear components within TLI warheads staged in the dedicated portion of Zone 4 and in the dismantlement process in Zone 12 will also be identified. Under Option 1 such items will only be subject to monitoring when they are within Zone 4 (within a warhead or as a separated pit) or during transfer between Zone 4 and Zone 12. Because the dismantlement of each warhead type is unique, a part of the declaration process will be a special briefing for the inspectors detailing the specific dismantlement process for the warheads of interest.

For Zone 4 monitoring of stored pits, the inspectors will have the right to observe the opening of the magazine and watch the real-time video and bar code data returned from each container as the Stage Right inventory system moves down the aisle of the magazine. In addition, the inspectors will be allowed to randomly select containers to be removed from the magazine for a fingerprint measurement, which could involve template matching to the extent required by the classification level at which the inspection can be performed, subject to legal constraints on the exchange of classified information.

The inspectors may perform as many fingerprint measurements as possible during the time allowed by the treaty on items selected by the inspectors, in order to confirm that they contain TLIs. During the first few visits the statistics resulting from a small number of measurements will provide a relatively modest level of confidence. However, as inspections continue, the overall level of confidence in the inventory will increase as the statistics improve. During the initial inspection, the inspectors will be permitted to place a remote monitoring camera on the magazine. In this manner the inspectors can obtain a record of the activities that take place in the magazine while they are not present between inspections.

In addition to these pit measurements, the inspectors would have the right to inspect magazines that contain TLI warheads being staged for dismantlement. The inspectors may perform fingerprint measurements on as many TLIs as the time allowed by the treaty permits. The inspectors may require that measurements be performed in a measurement room which will be constructed or identified within Zone 4 in order to reduce background signals from adjacent warheads. A remote monitoring camera would also be placed on the TLI warhead storage magazine to record activities between inspections.

In order to complete Option 1 as a credible monitoring system, and in order to monitor the rate of dismantlement, the inspectors would be allowed to install remote monitoring containment and surveillance equipment on magazines containing TLIs. This would be designed to ensure that undeclared material movements do not occur. These requirements may be fulfilled by installing tamper indicating video monitoring systems at the door to each magazine, motion detectors, etc.

Remote monitoring equipment installed in Zone 4, and direct observations during inspections will provide an opportunity for the inspectors to observe the unloading at Zone 4 of SSTs containing TLI warheads arriving at Pantex for dismantlement, and the loading and unloading in Zone 4 of transport trucks carrying TLI warheads scheduled for dismantlement and pits removed from them moving between Zone 4 and Zone 12, to confirm that activities are consistent with the declared dismantlement schedule. Information transfer concerning Pantex operations involving non-TLIs should be kept to a minimum.

For the purposes of this study, the radiation signature measurements used in Option 1 are assumed to include MRI-type measurements (presence of plutonium, mass, shape) on excess materials if RD can be exchanged with the inspectors, or measurements restricted to determining the presence or absence of plutonium and HEU if Restricted Data cannot be exchanged. Unclassified or C/NSI confirmatory radiation measurements of fissile material under Option 1 would be far more limited, such as a confirmation of the presence of plutonium in a storage container without revealing isotopic, shape, or mass information.

OPTION 2. PORTAL PERIMETER CONTINUOUS MONITORING OF A DEDICATED PORTION OF ZONE 12

Activity	Option 2
Declarations of dismantlement schedules and inventories	Yes
Spot checks of weapon and component storage in Zone 4	Yes
Remote monitoring of weapon and component storage in Zone 4	Yes
Chain of custody of warheads and components from Zone 4 to Zone 12 gate	Yes
Portal perimeter continuous monitoring of a segregated portion of Zone 12	Yes
Chain of custody of warheads and components within Zone 12	No
Sweeping of bay or cell before and after dismantlement	No*
Direct or remote observation of dismantlement in the bay or cell	No
Chain of custody of nuclear components from Zone 12 gate back to Zone 4	Yes
Monitoring of non-nuclear components following dismantlement	Yes

* One-time sweeping of the entire dedicated portion of Zone 12 is required at initialization of PPCM.

Option 2 Goal

The goal of Option 2 is to increase the confidence in dismantlement above that obtained in Option 1 by adding Portal Perimeter Continuous Monitoring to the Option 1 activities. That is, all traffic, whether by vehicle or by foot, entering and exiting the segregated portion of the dismantlement area would be subject to inspection in Option 2.

Detailed Description of Option 2 at Pantex

Chain-of-custody and monitored storage (Option 1) techniques are used in Option 2 in order to add confidence that no TLIs are illicitly moving in and out of the area dedicated to dismantlement of TLIs. Chain-of-custody between Zone 4 and the segregated portion of Zone 12 would be included as described in Option 1, but in Option 2 there would be no chain-of-custody within the portion of Zone 12 dedicated to monitored dismantlement of TLIs. Figure 13 shows the areas at Pantex impacted by Option 2.

The study group considered PPCM around all of Zone 12 but found, as did previous studies, that this would be extremely intrusive. For PPCM to be meaningful, all items, vehicles, and personnel entering and leaving Zone 12 would have to be subject to search by the inspectors. This could result in unintentional loss of information regarding the active enduring stockpile.

Option 2 as considered in this report includes portal perimeter continuous monitoring of a segregated portion of Zone 12 dedicated to monitored dismantlement. Setting up such a dedicated dismantlement sub-section of Zone 12 would have a significant impact on current Pantex operations, and require a one-time investment in facility modification of $12 million or more and increased ongoing operational costs, as discussed in Appendix F.

By dedicating part of Zone 12 to dismantlement of TLI warheads, intrusiveness into the overall Pantex operations can be reduced. Conceptually one part of Zone 12 could be placed under PPCM and dedicated for dismantlement monitoring, while the remainder of Zone 12 continued to operate as at present. For example, segregation for dismantlement could include cells 12-98-1, 12-98-2, 12-98-3, and 12-98-4, and all bays in building 12-84 west of Ramp 12-R-84, which includes 11 disassembly cells and an x-ray LINAC, as indicated schematically in Figure 13. These cells and bays are all co-located in the southwest section of Zone 12. Operations on non-TLI warheads, such as surveillance operations for the enduring stockpile, could then proceed in the remaining part of Zone 12 with minimal impact from these monitoring measures.

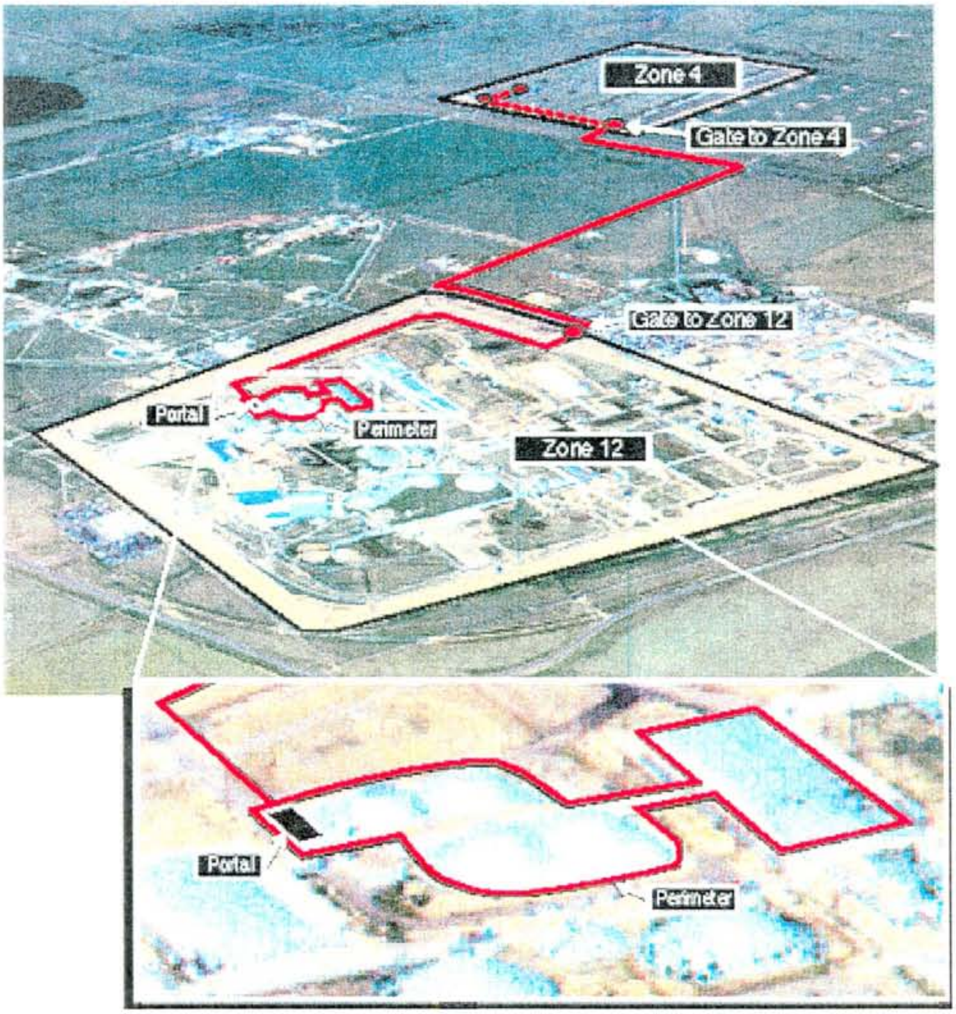


Figure 13: Pantex Access Areas for Option 2.

Option 2 Pantex Monitoring Procedure Summary

- Option 1 procedures are applied in Zone 4 and upon any transfers between Zone 4 and Zone 12.
- The dedicated portion of Zone 12 must be swept one time at the inception of PPCM to ensure that a stockpile of components does not exist inside the facility prior to long-term operation of the portion of Zone 12 subject to PPCM.
- Inspection points should be established on the boundary of the area of Zone 12 dedicated to dismantlement.
  - These points are to be placed in such a way that all traffic in and out of the dedicated portion of Zone 12 is channeled through inspection stations.
  - Adequate provisions must be made to ensure that parts of the perimeter closed to traffic are fenced off or otherwise sealed, and that these fences have not been breached.

  - This might be accomplished through the use of remote monitoring devices, or by permanent presence.

- Option 1 monitoring procedures apply to components exiting through the Zone 12 portal and returning to Zone 4 or Y-12.

- PPCM inspections for Option 2 may be carried out in one of two ways:

  - All vehicles and pedestrian traffic passing through the checkpoints around the dedicated portion of Zone 12 may be inspected for TLIs or components. This may be done with physical inspections and/or radiation measurements that have been discussed above in the context of monitored storage (Option 1). While this method yields the highest confidence, it could also impact plant operations significantly.

  - Inspections of pedestrians, packages, and vehicles passing through the checkpoints around the dedicated portion of Zone 12 may be conducted at random using the same methods. This strategy would reduce the impact on plant operations somewhat, but would also provide a lower level of confidence that movements of TLIs inconsistent with treaty restrictions are not being undertaken.

OPTION 3. CHAIN-OF-CUSTODY FROM STORAGE TO AND FROM DISMANTLEMENT BAY OR CELL

Activity	Option 3
Declarations of dismantlement schedules and inventories	Yes
Spot checks of weapon and component storage in Zone 4	Yes
Remote monitoring of weapon and component storage in Zone 4	Yes
Chain of custody of warheads and components from Zone 4 to Zone 12 gate	Yes
Portal perimeter continuous monitoring of a segregated portion of Zone 12	No
Chain of custody of warheads and components within Zone 12	Yes
Sweeping of bay or cell before and after dismantlement	Yes
Direct or remote observation of dismantlement in the bay or cell	No
Chain of custody of nuclear components from Zone 12 gate back to Zone 4	Yes
Monitoring of non-nuclear components following dismantlement	Yes

Option 3 Goal

The goal of Option 3 is to make the fullest possible use of chain-of-custody techniques in place of PPCM. In addition to monitoring the warhead receipt area and component storage area as in Option 1, Option 3 provides a direct and continuous chain-of-custody from arrival and storage of the warhead at Pantex (or CSA at Y-12) in the storage area to and from dedicated dismantlement bays and cells in the dismantlement area. Option 3 does **NOT** include PPCM as does Option 2. Instead, in Option 3 the warhead can be followed up to a dedicated bay for mechanical disassembly and then to a dedicated dismantlement cell where the physics package is taken apart and the high explosive is removed from the pit (at Pantex), or to the area where the CSA is disassembled (at Y-12).

In Option 3, inspectors would have the right to sweep or sanitize the bays and cells both before and after disassembly to determine that there are no nuclear components or undeclared entrances and exits in the bay or cell. In addition, inspectors would have the right to examine the declared warhead or CSA in the staging area outside of the bay or cell and confirm that it is the object of inspection using fingerprint measurements and tags and seals. The warhead is then taken into the cell to be taken apart and separated into its key parts (pit, CSA, high explosive, and other non-nuclear components), or the CSA is taken into an area without inspectors present and disassembled. When the nuclear and non-nuclear components are removed from the bay or cell, the inspectors could perform additional radiation measurements on each container leaving the cell to confirm the absence or presence of fissile material, and/or conduct radiation signature measurements to determine whether the components are actually from the declared warhead or CSA. It might not be feasible to perform radiation measurements in the bay or cell staging areas. The feasibility of such measurements will depend on the size of the equipment involved, the time require for the measurement, and the number of persons involved in the measurement activity. Figure 14 shows the areas at Pantex impacted by Option 3.

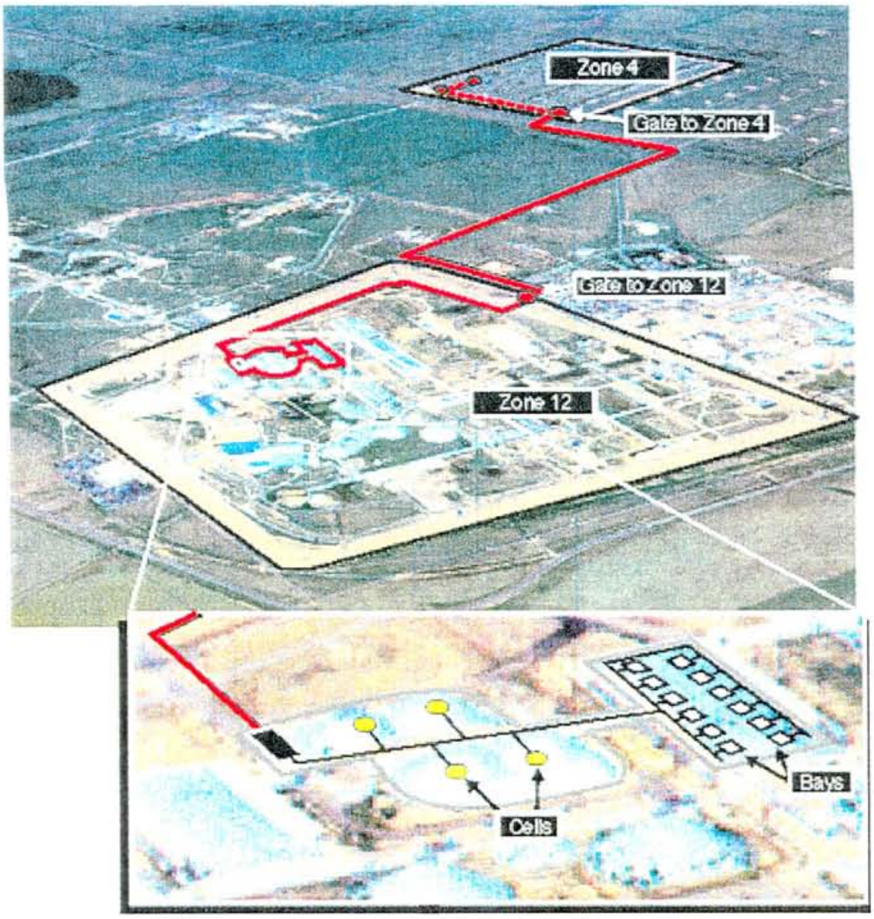


Figure 14: Pantex Access Areas for Option 3.

Option 3 Pantex Monitoring Procedure Summary

Warheads scheduled for dismantlement are brought to Pantex by SST. Warheads are staged in magazines in Zone 4, until they are transferred to Zone 12 for dismantlement. Within Zone 12, warheads scheduled for dismantlement are staged temporarily until they are transferred to a bay or cell for dismantlement. A particular warhead may be transferred to and from several bays or cells during the course of dismantlement, as successive stages of dismantlement are performed. After dismantlement is complete, pits are returned to Zone 4 for storage and the canned subassemblies to the Y-12 plant for disassembly.

The steps under Option 3 in taking a warhead from delivery at Pantex through the dismantlement process to final storage of components are as follows:

- Option 1 procedures are applied in Zone 4 and upon any transfers between Zone 4 and Zone 12.
- The inspectors are provided with a schedule of the TLI warheads to be delivered to Pantex over the next month and when they are to arrive.
- An SST carrying items declared to be TLI warheads scheduled for dismantlement arrives at Pantex Zone 4.
- The SST is opened and unloaded in the presence of the inspectors.
- Radiation or fingerprint measurements, using template matching as required by the classification level at which the inspection is being performed, are made to determine that the declared items are warheads and that they are the declared TLI warheads.
- The inspectors apply TIDs to the TLI warheads or to the containers containing the TLI warheads.
- Each TLI warhead is then taken to temporary storage in a magazine in Zone 4 until it is to be dismantled.
- Based on a schedule supplied to the inspectors as part of the declarations, a TLI warhead is taken from Zone 4 to Zone 12 to be dismantled, using Option 1 monitoring procedures to track the TLI warhead from Zone 4 storage to the Zone 12 portal.
- At the time the TLI warhead is scheduled for transfer from staging in Zone 4 to Zone 12 for disassembly, the inspectors are permitted to "sweep" the transport vehicle prior to loading and to check the seals/tags (TIDs) on the TLI warhead or warhead container.
- Radiation or fingerprint measurements can again be taken and compared with prior measurements or templates, according to the classification level at which the inspection is being conducted.
- The inspectors track the transport vehicle to the Zone 12 portal as in Option 1.
- In Option 3, the inspectors escort the TLI warheads from the Zone 12 portal to a temporary staging area in Zone 12.
- TIDs and/or remote monitoring techniques are applied to TLI warheads in temporary staging in Zone 12 pending dismantlement.
- When a TLI warhead is ready for dismantlement the TLI warhead is transferred from the staging area to a bay or cell for dismantlement.
- The inspectors have the right to verify TIDs at the staging area prior to transfer.
- Chain-of-custody extends along dedicated pathways between the temporary staging areas and the dismantlement bays or cells by the use of remote monitoring devices, by inspection of TIDs, and/or by escort of the TLI warhead by the inspectors to the bay or cell.
- The inspectors search each bay or cell before the TLI warhead is moved into the bay or cell to determine that there are no nuclear warheads, nuclear components, or undeclared portals in the bay or cell.

- The inspectors examine the TLI warhead in the staging area outside of each bay or cell which the TLI warhead enters, and determine that it is a TLI warhead using fingerprint measurements and TIDs, using template matching as required by the classification level of the inspection.
- The TLI warhead is taken into the bay or cell to be separated into components (i.e., dismantled).
- The inspectors do not observe the dismantlement process itself in Option 3.
- Radiation or fingerprint measurements are performed on all containers entering or leaving each bay or cell in which dismantlement of TLI warheads is declared to occur, in order to determine whether they contain TLI warheads or components.
- When nuclear components in containers are removed from the bay or cell, the inspectors perform radiation or fingerprint measurements in the staging area outside of the bay or cell to determine that they are from the declared TLI warhead, using template matching as required by the classification level of the inspection, and apply TIDs to the containers.
- The inspectors monitor the chain-of-custody using the techniques described above for Option 1 as the nuclear components are shipped to Zone 4 (pits) or Y-12 (CSAs) for storage pending ultimate disposition.
- The inspectors have the right to track nonnuclear components removed from the bay or cell to storage or final disposition using TIDs, escort of nonnuclear components, and/or remote monitoring.
- The inspectors search the bay or cell after the components are removed to determine that no separated nuclear components remain in the bay or cell and that the TLI warhead (or the portion that remains at this stage of dismantlement) is or is not present in the bay or cell.
- Since the same TLI warhead may have dismantlement operations performed in several bays or cells, if the TLI warhead or an undismantled portion of it is still present in the bay or cell, this process is repeated as required as the TLI warheads move between bays and cells and to and from temporary staging in Zone 12.
- Option 1 monitoring procedures apply to components exiting through the Zone 12 portal and returning to Zone 4 or Y-12.

OPTION 4. DIRECT OBSERVATION OR REMOTE MONITORING OF DISMANTLEMENT

Activity	Option 4
Declarations of dismantlement schedules and inventories	Yes
Spot checks of weapon and component storage in Zone 4	Yes
Remote monitoring of weapon and component storage in Zone 4	Yes
Chain of custody of warheads and components from Zone 4 to Zone 12 gate	Yes
Portal perimeter continuous monitoring of a segregated portion of Zone 12	No
Chain of custody of warheads and components within Zone 12	Yes
Sweeping of bay or cell before and after dismantlement	No
Direct or remote observation of dismantlement in the bay or cell	Yes
Chain of custody of nuclear components from Zone 12 gate back to Zone 4	Yes
Monitoring of non-nuclear components following dismantlement	Yes

Option 4 Goal

Option 4 is intended to provide the highest level of confidence that a TLI warhead brought to Pantex for dismantlement is in fact dismantled. To achieve this level of confidence, Option 4 uses direct observation or remote monitoring of dismantlement in the bays and cells in addition to chain-of-custody (Option 3) and storage monitoring (Option 1) procedures. Figure 14 shows the access areas covered under Option 4.

Option 4 Pantex Monitoring Procedure Summary

In direct observation or remote monitoring of dismantlement the inspector has the ability to see, either visually or through suitably authenticated video equipment, the activities involved in dismantling the TLI warhead and its physics package. Thus the chain-of-custody approach of Option 3 is extended into the bay or cell in Option 4. Also involved in this process are means of checking before and after dismantlement that treaty limited items (TLIs) enter and leave the dismantlement process. The loss of information through the observation process could be controlled by limiting the quality of the view given the inspectors through various means such as controlling the resolution of optical devices, restricting the field of view, or careful masking.

Option 4 is similar to Option 3, but allows the direct or remote observation of the dismantlement process in the bays or cells at the Unclassified to C/NSI or RD/FRD level, depending on the level of information which can be exchanged with the inspecting party. When combined with the rigorous chain of custody of warheads from staging in Zone 4 to the dismantlement bay or cell and for components from the bay or cell back to storage in Zone 4 or at Y-12 developed in Option 3, Option 4 provides the highest confidence in dismantlement of any of the options considered in this study. It is also the most intrusive.

If performed at the RD/FRD level, it would require an Agreement for Cooperation allowing the exchange of RD and FRD, and the willingness to include very sensitive warhead design information in such an exchange. Option 4 would use all of the steps described in Option 3, except sweeping of the bay or cell prior to dismantlement, which would be superfluous if the inspectors had direct visual access to the bay or cell during dismantlement. In addition, it would add the following step after the warhead is introduced into a bay or cell for dismantlement:

- The dismantlement process in the bays or cells is observed by inspectors, either by the use of remote monitoring or by going into the bays or cells and visually observing the dismantlement process in person.

The access areas for Option 4 are the same as for Option 3, except that access to the bays and cells is allowed during the dismantlement in Option 4, as indicated schematically in Figure 15.

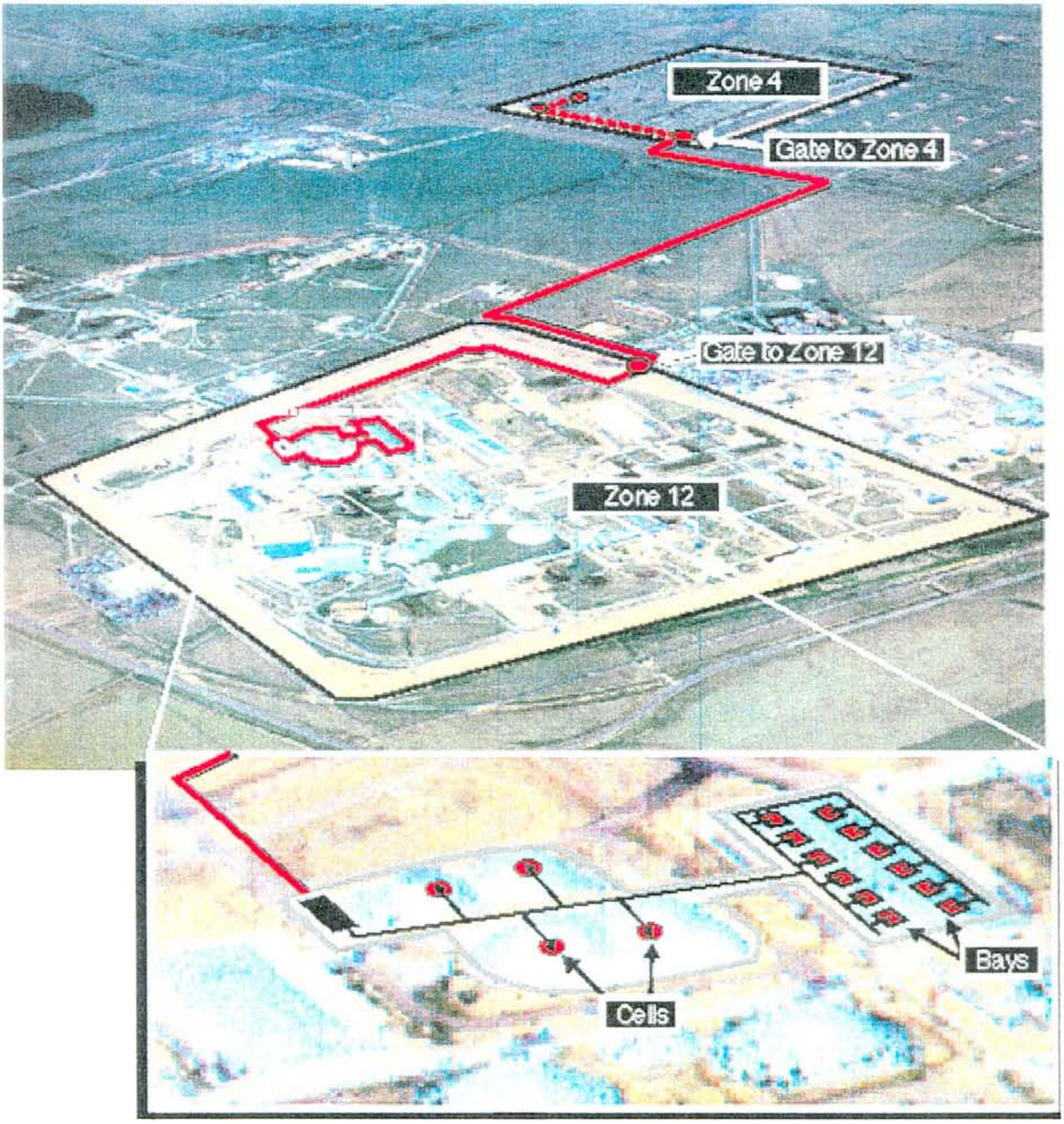


Figure 15: Pantex Access Areas for Option 4.

The confidence in dismantlement provided by direct observation or remote monitoring of dismantlement in the bays or cells at Pantex, or by direct observation or remote monitoring of disassembly in the disassembly areas at Y-12, is such that variants of Option 4 deleting one or more of the activities included in Option 3 could also provide a high level of confidence in the warhead dismantlement process.

VI. EVALUATION OF OPTIONS

In order to determine the relative merit of the options for warhead dismantlement monitoring, a set of criteria with which to evaluate these options was developed. After considerable discussion, the study group established the following seven criteria with which to evaluate the four dismantlement monitoring options:

- Level of Confidence
- Negotiability
- Inadvertent Loss of Classified Information
- Impact on Operations
- Operational Readiness
- Cost to Prepare for and Host the First Inspection
- Routine Cost of Hosting Each Inspection

These criteria cover the major points in determining the applicability of the various options to the problem of warhead dismantlement monitoring. A brief discussion of each of the evaluation criteria considered in this study follows.

A. DESCRIPTION OF EVALUATION CRITERIA

Level of Confidence

The first evaluation criterion is the level of confidence that dismantlement has taken place produced by each option. The level of confidence that a particular monitoring option provides that warhead dismantlement is actually occurring depends on the level of information obtained from that particular option and the ease with which that option can be spoofed. Short of direct observation or remote monitoring of dismantlement (Option 4), evaluation of confidence levels will always be somewhat subjective. However, the extended continuous application of any monitoring regime would result in an accumulation of data amenable to statistical analysis.

Negotiability

Negotiability is a judgment of the relative ease with which the transparency or verification option may be accepted by the Russian Federation. The evaluation of this criterion was based on knowledge of what the Russians have been willing to negotiate in recent agreements. Based on this experience, some elements of a monitoring regime, such as use of radiation measurements, may be easier to negotiate as part of a START III treaty, since they are already an accepted element of other U.S.-Russian agreements. However, some elements may be more difficult, such as continuous presence of inspectors and the exchange of sensitive nuclear weapons design information (such as Restricted Data), which the Russians have strongly resisted in previous negotiations. Exchange of such information would require an Agreement for Cooperation, and negotiation of such an Agreement could affect the time required for implementation of a warhead dismantlement monitoring regime.

Inadvertent Loss of Classified Information

Each of the monitoring options discussed in the previous chapter can be conducted at the C/NSI or RD/FRD levels. The sharing of NSI with foreign inspectors could be accomplished under a General Security of Information Agreement or Executive Order. Under START I the treaty itself served as the instrument allowing the exchange of NSI. RD or FRD can only be shared with another country under an Agreement for Cooperation. In 1994 Congress amended the Atomic Energy Act of 1954 to allow an Agreement for Cooperation to be concluded with another country for the purpose of arms control and nonproliferation or for the verification of a treaty. Such an Agreement for Cooperation is under negotiation with the Russian Federation, but has not yet been concluded.

If the legal mechanism for the exchange of classified information were in place with the treaty partner, classified information could be exchanged as a result of the declarations that are a necessary part of each option, or during the monitoring process itself. Classified information could be exchanged in the form of written information related to dismantlement process descriptions, written records of process activities or inventories of warheads and components, or data obtained from measurements performed during spot checks, chain of custody radiation measurements, or portal perimeter monitoring inspections, etc. Classified information could also be exchanged by visual observation of classified aspects of the dismantlement facility, classified warheads and components, and classified activities during the dismantlement process.

It is important to distinguish between this intentional sharing of classified information and the unintentional, inadvertent loss of information not intended to be shared with the inspectors. Even the least intrusive monitoring options will have inspectors present at the U.S. dismantlement facilities, Pantex and Y-12. This presence, by its very nature, provides the possibility for the inspectors to gain classified information, either accidentally or by intentional acts of the inspectors. When inspectors are allowed access to an area that is used to perform classified operations or store classified material, or to observe a classified operation such as warhead dismantlement, the chance for the inadvertent disclosure of classified information exists. Inadvertent classified information loss could be limited by a thorough Red Team assessment of the proposed measures, extensive training of escorts and careful preparation of areas containing classified information for inspection.

Impact on Operations

The financial cost of altering operations at Pantex and Y-12 to accommodate warhead dismantlement monitoring activities is included in the cost analysis in Appendix F. However, it is important to consider the effect of the inspections in terms of the impact on all operations at the sites. It is anticipated that the major impact on operations will occur at Pantex, where inspections have the potential to affect not only the disassembly of warheads covered by a treaty, but activities related to maintaining the U.S. enduring stockpile as well. Therefore, the U.S. will need to plan carefully to ensure that implementation of the START III requirement does not adversely affect the Presidential requirement to maintain a safe, secure, and reliable nuclear weapons stockpile. The impact on Y-12 operations of warhead dismantlement monitoring may be less than at Pantex, depending on the rate of disassembly of canned subassemblies at the time a treaty enters into force. As with inadvertent loss of classified information, it is difficult to quantify the impact on operations.

Operational Readiness

Operational readiness refers to the time that it would take to actually implement each warhead dismantlement monitoring option. It includes any facility modification or new construction which might be required, developing software to produce the appropriate declarations from the Pantex and Y-12 data bases, conducting the applicable nuclear weapon safety and security studies, training of site personnel, etc. The metric used for the evaluation of the operational readiness of each option is the time required, following entry into force of a monitoring agreement, to prepare a site to receive the first inspection. New construction to support the permanent presence of inspectors, as assumed for Option 2, is estimated to require two years from authorization of such construction. Direct or remote observation of dismantlement, as in Option 4, would require changes in the SS-21 (Seamless Safety for the 21st Century) procedures, which would also require a minimum of two years. Similarly, beginning dismantlement for a warhead type currently in the enduring stockpile would require at least two years for the SS-21 process before dismantlement could begin. However, the time period required for the SS-21 process, which is needed for every new type of warhead to be dismantled, would be built into the dismantlement schedule, and therefore is not included in the estimate of the time needed to be operationally ready for inspections.

Cost

The evaluation criteria applied to the warhead dismantlement monitoring options include the cost to prepare for and host the first inspection, including any physical or procedural modifications that would need to be made to prepare for and host the first inspection, and the routine cost of hosting each inspection—the recurring cost of each routine inspection after the initial inspection has taken place. The approach taken in this study to estimate the costs for each option was to use the Inspection Cost Analysis Model (ICAM). ICAM was developed by the DOE Office of Arms Control and Nonproliferation to assist in the planning and design of on-site inspection regimes and has been used extensively to prepare for Russian visits to DOE facilities, including the recent Russian visit to the Oak Ridge Y-12 Plant in November 1996. For the purposes of this study, both Pantex and Y-12 provided the necessary input data needed for ICAM to generate the cost estimates for each option. A detailed discussion of the cost analysis methodology for the warhead dismantlement monitoring options is included in Appendix F to this report.

B. ANALYSIS OF OPTIONS

Each of the warhead dismantlement monitoring options was evaluated against the seven criteria previously mentioned. With the exception of three of the criteria—operational readiness, cost to prepare for the first inspection, cost of hosting routine inspections—a qualitative, as opposed to quantitative, analysis was conducted for the purposes of this report. An analysis of the other four criteria—level of confidence, negotiability, inadvertent loss of classified information, impact on operations—is essentially subjective. For criteria evaluated on a qualitative or subjective basis, the analysis includes either a low, moderate, or high rating. In some limited cases, an intermediate assessment of either low-to-moderate or moderate-to-high was used. The results of the analysis of the four dismantlement monitoring options considered in this report are summarized in Table 7 at the end of this section. A brief discussion of the evaluation of each of the options individually is provided below.

Option 1. Monitored Storage

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness	Cost of First Inspection	Routine Inspection Cost*
Option 1	C/NSI	Low	High	Low	Low	1 year	$2.5 M	$0.12 M
	RD/FRD	Moderate	Low–Mod.	Low–Mod.	Low	1 year	$2.5 M	$0.12 M

* Routine inspection costs are shown for one inspection, but several such inspections would likely be performed each year.

Option 1 is designed to have the least effect on the operations of the Pantex and Y-12 facilities. Monitoring activities at Pantex are limited to Zone 4 and up to the gate to Zone 12. Activities at Y-12 are limited to the receipt and storage areas for secondaries in building 9720-5 and to monitoring the right circular cylinders of HEU in tube vaults in building 9720-5. As a result of these limitations, the impact on Pantex and Y-12 operations is minimal, but Option 1 only provides a low level of confidence that warhead dismantlement is taking place at the C/NSI level, and a moderate level of confidence that warhead dismantlement is taking place if implemented at the RD/FRD level.

At the RD/FRD level, MRI-like measurements would be conducted in Option 1 on components in storage in Zone 4 coming from dismantled nuclear warheads. Since the MRI-like measurements will confirm that the contents of a sealed storage container are consistent in mass, isotopics, and shape with plutonium removed from dismantled nuclear warheads, the level of confidence increases over time from low to moderate as the quantity of components being monitored increases, if Option 1 is implemented at Pantex at the RD/FRD level.

The negotiability of the C/NSI version of Option 1 is high since it corresponds to a regime very close to those suggested by the Russians in other contexts. Negotiability falls to moderate or low for the RD/FRD version. In the past the Russians have shown a marked aversion to exchanging sensitive weapons design information and RD. However even with this reluctance to exchange RD the Russians would probably find a classified Option 1 preferable to any of the more intrusive options.

Because Option 1 is limited only to Zone 4 and terminates at the gate to Zone 12, the inadvertent loss of classified information is considered to be low at the C/NSI level. The possibility of loss of information increases to moderate at the RD/FRD level due to the possible loss of design information while making classified radiation signature measurements. The inadvertent loss of information as a result of radiation measurements being performed on warheads and components can be minimized by thoroughly red-teaming the proposed measurements in advance.

At all levels, the time needed for operational readiness is estimated to be only one year for Option 1. It is estimated that approximately six months are needed to generate the required declarations of warheads and components as well as the delivery and dismantlement schedules. However, up to one year is required to perform the necessary red-teaming activities, including the security and vulnerability analysis. Since Option 1 is confined to Zone 4 the impact on operations was considered to be low.

Option 2. Portal Perimeter Continuous Monitoring of a Dedicated Portion of Zone 12

		Confidence in Dismantlement	*Negotiability*	*Inadvertent Classified Information Loss*	*Impact on Operations*	*Operational Readiness*	*Cost of First Inspection*	*Routine Inspection Cost*
Option 2	C/NSI	Moderate	Low	Low–Mod.	Moderate	2 years	$12.0 M	N/A*
	RD/FRD	High	Low	Moderate	Moderate	2 years	$12.0 M	N/A*

* Option 2 assumes permanent presence of inspectors at a cost of $5.5 million per year.

Option 2 provides increased confidence that dismantlement is taking place without providing access to Zone 12 or allowing direct observation or remote monitoring of the actual dismantlement process. A highly effective regime of portal perimeter monitoring gives the inspection team the ability to monitor everything that enters or leaves the segregated area in Option 2. In addition, the segregated area of Zone 12 would be initialized by inspectors who are allowed to sweep the dedicated portion of Zone 12 one time at the inception of PPCM to ensure that a clandestine stockpile of components does not exist inside the dedicated area.

After initialization, the level of confidence that warhead dismantlement is taking place within this area is then tied directly to the intrusiveness of the measurements that the inspectors are allowed to make at the portal. Even when the inspectors are restricted to unclassified measurements, such as monitoring only the presence of weapons-grade plutonium and highly enriched uranium in warheads entering the portal and in containers exiting the portal, combining these measurements with the cumulative information gained from Option 1 produces a moderate level of confidence in Option 2 that warheads are being dismantled. At the RD/FRD level, by using MRI-like measurements to determine the isotopics, mass, and shape of the pits, the level of confidence increases over time from moderate to high as the quantity of components being monitored increases.

Since PPCM requires the continuous presence of inspectors at the Pantex facility, the likelihood of the inadvertent loss of classified information is higher in Option 2 than for Option 1. Thus the likelihood of the inadvertent loss of classified information in Option 2 is low-to-moderate at the C/NSI level. This is due to the fact that, depending on the measures taken to minimize the loss of classified information, observation at the portal may reveal information concerning stockpile activities, such as retrofits or stockpile maintenance. Segregating a dedicated portion of Zone 12 would considerably reduce the risk of such inadvertent information loss. As with Option 1, the possibility of the inadvertant loss of additional classified information increases to moderate at the RD/FRD level due to the possibility of the loss of design information in the radiation signatures measurements. The probability of information loss is no higher in Option 2 than in options which introduce inspectors within the Zone 12 perimeter on a regular basis, such as Options 3 and 4.

Option 2 would have a larger impact on operations at Pantex than does Option 1 since a dedicated or segregated area within Zone 12 would need to be established. However, once the segregated area of Zone 12 is functional, the remaining activities at Pantex could continue in a relatively unimpeded manner. After segregation is complete, activity at Pantex can develop into a new "normal," with monitored dismantlement taking place in the segregated area and regular stockpile surveillance operations taking place in the rest of Zone 12. Thus, the impact on Pantex operations for all classification levels is considered to be moderate for Option 2, once the one-time transition to a dedicated dismantlement area for TLIs is accomplished.

Significant physical modifications of Zone 12 would be required to implement Option 2. Specifically, construction to segregate a portion of Zone 12, including the need to construct a fence around the segregated area, and the need to adjust internal routings within Zone 12, would be required. It is estimated that it would take up to two years to implement these physical modifications at Pantex.

Since the Russians have been very reluctant in the past to negotiate agreements which include permanent presence, the negotiability of Option 2 is considered to be low. Even though the Russians have agreed to such permanent presence arrangements previously, both at Votkinsk (now in Ukraine) for INF and at Novouralsk for the HEU purchase agreement, these negotiations were very difficult and required high-level intervention at the secretarial level on several occasions in order to ensure that the commitments to have permanent presence were implemented. It is anticipated that negotiating permanent access at the relevant Russian dismantlement facilities, which are considered to be among their most sensitive facilities, would likely be rejected by the Russian government, particularly by the Foreign Service Bureau (FSB).

Option 3. Chain-of-Custody from Storage to and from Dismantlement Bay or Cell

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness	Cost of First Inspection	Routine Inspection Cost*
Option 3	C/NSI	Moderate	Moderate	Moderate	Moderate	1.5 years	$6.5 M	$0.2 M
	RD/FRD	Mod.–High	Low–Mod.	Mod.–High	Moderate	1.5 years	$6.5 M	$0.2 M

* Routine inspection costs are shown for one inspection, but several such inspections would likely be performed each year.

In addition to monitoring the weapons receipt area and component storage area as in Option 1, Option 3 provides a direct and continuous chain-of-custody from arrival and storage of the warhead at Pantex (or CSA at Y-12) in the storage area to and from dedicated dismantlement bays and cells in the dismantlement area. Both before and after disassembly and dismantlement, inspectors have the right to sweep the bay and cell to ensure that there are no clandestine components in either the bays or cells. In some limited cases (such as during disassembly of the B-61s), inspectors would be allowed to observe the mechanical disassembly at the unclassified level in the dedicated bays with some minor shrouding of classified components. In addition, before a warhead enters the bay or cell, inspectors would have the right to perform radiation signature measurements to ensure that the warhead entering the bay or cell is the same warhead that left Zone 4.

Following dismantlement, inspectors would have the right to conduct radiation measurements to correlate the signature of the components exiting the cell to that of the warhead that entered the bay or cell.

In both Option 1 and Option 3, the warhead and the components resulting from its dismantlement are followed through a limited chain of custody—to and from the entrance to the dismantlement area in Option 1, and to and from the dismantlement bay or cell in Option 3—and the available monitoring methods (e.g., radiation measurements, tags and seals) are much the same. The key difference between Option 1 and Option 3 is the ability of the inspectors, in Option 3, through sweeping of the bay or cell, to confirm that pre-existing components which might be stored inside the dismantlement facility are not inserted into the dismantlement stream. This addition to the preponderance of evidence indicating that dismantlement is taking place increases the confidence in dismantlement in Option 3 relative to Option 1.

Because inspectors would have access to Zone 12, Option 3 presents a higher risk of the inadvertent loss of classified information. Even with careful training of escorts and technical staff, as well as careful red teaming and attention to pathways and routings, it is estimated that the risk of inadvertent loss of information at all classification levels for Option 3 would be at least moderate. Again considering the higher risk associated with RD signature measurements the level of risk of information loss may rise to high for the RD/FRD level implementation of Option 3.

The types of measurements the inspectors are allowed to conduct as well as the level of information contained in the various declarations would depend on the classification level for Option 3. As a result of the recent openness initiatives and declassification rulings, monitoring of warhead dismantlement can be performed at the Unclassified to C/NSI level with a moderate level of confidence through the use of chain-of-custody and radiation measurement techniques. At the RD/FRD level, the level of confidence that dismantlement has taken place is considered to be moderate-to-high for Option 3.

It is estimated that about 1-1/2 years would be needed to operationally prepare Pantex to implement Option 3 because segregation of bays and cells, and possibly some physical construction, would be needed.

Similar to Option 2, Option 3 would have an initial impact on operations at Pantex because a dedicated or segregated area within Zone 12 would need to be established. However, once the segregated area of Zone 12 is functional, the remaining activities at Pantex can continue in a relatively unimpeded manner. Thus, the impact on Pantex operations for all classification levels is also considered to be moderate for Option 3.

Negotiability of Option 3, the relative ease of having the Russians accept this option, ranges from moderate for the Unclassified to C/NSI level to low-moderate for the RD/FRD level. Although the Russians would probably not want to allow U.S. inspectors in the Russian dismantlement areas they might find this option preferable to permanent presence.

Option 4. Direct Observation or Remote Monitoring of Dismantlement

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness	Cost of First Inspection	Routine Inspection Cost*
Option 4	C/NSI	Moderate	Low	High	High	2 years	$6.5 M	$0.2 M
	RD/FRD	High	Low	High	High	2 years	$6.5 M	$0.2 M

* Routine inspection costs are shown for one inspection, but several such inspections would likely be performed each year.

Option 4 provides the highest level of confidence that nuclear warheads are being dismantled. However, it also results in the highest degree of intrusiveness. Option 4 encompasses all of the procedures in Option 3, with the exception that since there will be direct observation or remote monitoring of the dismantlement process, it is not necessary to sweep the bays and cells before and after dismantlement in Option 4.

Since inspectors are allowed direct observation or remote monitoring of the actual dismantlement procedure, the possibility of the inadvertent release of classified information is high for Option 4 at all classification levels. This is particularly the case if remote viewing of the dismantlement process by television camera is conducted at the unclassified level. Although it is technically possible to distort the view enough to conceal the classified aspects of the dismantlement process, a thorough security review would need to be performed to ensure that the aggregate information revealed as a result of remote viewing of the dismantlement process is in fact unclassified.

The operational readiness of Option 4 is estimated to be approximately 2 years in order to implement any facilities modifications, such as installation of the remote monitoring equipment, as well as the training of dismantlement technicians. Also, it is estimated to take up to 1 year to conduct a thorough security review and fully assess the risk of allowing direct observation or remote monitoring of the actual dismantlement process. Finally, the impact on dismantlement operations at Pantex would be high because Option 4 allows direct observation of the disassembly and dismantlement process, which could affect operations in the bays and cells. Such intrusive monitoring could adversely impact both the process time and cycle time required to dismantle each warhead (see Table 5), which in turn would reduce the overall dismantlement rate at Pantex.

Negotiability of Option 4 is considered low for either classification level, given the anticipated Russian desire to protect sensitive warhead design information.

Table 7 presents a complete summary of the evaluation of the four options at the various classification levels.

<u>**Table 7. Evaluation of Warhead Dismantlement Monitoring Options**</u>

Option 1: Monitored storage
Option 2: Option 1 Plus Portal Perimeter Continuous Monitoring of a portion of Zone 12
Option 3: Option 1 Plus Chain-of-Custody from monitored storage to and from the dismantlement bay or cell
Option 4: Option 3 Plus Direct Observation or Remote Observation of the dismantlement process in the bay or cell

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness [1]	Cost of First Inspection [2]	Routine Inspection Cost [2,3]
Option 1	C/NSI	Low	High	Low	Low	1 year	$2.5 M	$0.12 M
	RD/FRD	Moderate	Low–Mod.	Low–Mod.	Low	1 year	$2.5 M	$0.12 M
Option 2	C/NSI	Moderate	Low	Low–Mod.	Moderate	2 years	$12.0 M	N/A[4]
	RD/FRD	High	Low	Moderate	Moderate	2 years	$12.0 M	N/A[4]
Option 3	C/NSI	Moderate	Moderate	Moderate	Moderate	1.5 years	$6.5 M	$0.2 M
	RD/FRD	Mod.–High	Low–Mod.	Mod.–High	Moderate	1.5 years	$6.5 M	$0.2 M
Option 4	C/NSI	Moderate	Low	High	High	2 years	$6.5 M	$0.2 M
	RD/FRD	High	Low	High	High	2 years	$6.5 M	$0.2 M

[1] Operational readiness refers, for example, to the time required for construction and physical modifications. The time required for the SS-21 process would have to be incorporated into the declared dismantlement schedule.
[2] Cost estimates are planning estimates only for Pantex and do not represent official estimates for budget purposes.
[3] Routine inspection costs are shown for one inspection, and several such inspections would likely be performed each year.
[4] Option 2 assumes permanent presence of inspectors at a cost of $5.5 million per year.

VII. CONCLUSIONS AND RECOMMENDATIONS

The Helsinki Summit statement issued by Presidents Clinton and Yeltsin underscored the increased interest in further nuclear warhead reductions beyond START and START II as well as the need to monitor nuclear warhead inventories, nuclear warhead dismantlement, and fissile materials resulting from warhead reductions. In anticipation of such a potential agreement requiring further warhead reductions and the monitoring of warhead dismantlement, the DOE Office of Arms Control and Nonproliferation commissioned a technical study in the Fall of 1996 to determine what transparency and verification options could be implemented at DOE facilities to monitor warhead dismantlement.

GENERAL CONCLUSIONS

The following general conclusions were reached by the DOE study group:

- Any treaty involving the monitoring of nuclear warheads, nuclear warhead dismantlement, and stockpiles of fissile materials will have a significant impact on the DOE nuclear weapons complex.
  - The Pantex Plant is the DOE's primary, and currently only, plant for performing warhead operations that support both the enduring stockpile and the dismantlement of excess warheads.
  - Consistent with Executive priorities, operations that support the enduring stockpile are given the highest priority while warhead dismantlements are performed in a safe, timely and efficient manner consistent with available resources.
  - Both the requirement to dismantle additional warheads under START III and the requirement to allow Russian inspectors to monitor the dismantlement process will impact on-going stockpile surveillance and maintenance activities.
  - The U.S. will therefore need to plan carefully to ensure that implementation of the START III requirement does not adversely impact the Presidential requirement to maintain a safe, secure, and reliable U.S. nuclear weapons stockpile.

- **Assuming that the item which arrives at Pantex is a nuclear warhead,** both warhead dismantlement ***transparency*** and ***verification*** can be achieved by implementing the monitoring measures considered in this report.

- Determining that an item to be dismantled is ***actually*** a nuclear warhead is very difficult.
  - Radiation measurements, such as an x-ray or radiograph of the container, to confirm that the nuclear material in a storage container is in a configuration fully consistent with a nuclear warhead would be highly intrusive and would reveal highly classified nuclear warhead design information.
  - Such measurements would be too sensitive to be performed even if an Agreement for Cooperation was in place allowing the exchange of Restricted Data and Formerly Restricted Data with Russian inspectors because they could reveal potential system vulnerabilities and/or advanced design technology.

- Therefore, determining that an item to be dismantled is ***actually*** a nuclear warhead may require both the use of chain-of-custody procedures from Department of Defense facilities (e.g., from a delivery vehicle, deployment site, or weapons storage depot) to the dismantlement facility and the use of warhead radiation signatures, other than an x-ray or radiograph, to determine a unique template of the warhead.

- The study group identified ten (10) key activities listed below that could be used as part of a warhead dismantlement monitoring regime.
  - They are general in nature and may be applied to the monitoring of warhead dismantlement at a U.S. dismantlement facility (either Pantex or the Device Assembly Facility), to the disassembly of CSAs at the Oak Ridge Y-12 Plant, or to the monitoring of warhead dismantlement at a Russian dismantlement facility.
- The ten monitoring activities are:
  - Declarations of dismantlement schedules, warheads, and components resulting from the dismantlement process;
  - Spot checks of the warhead receipt and storage areas and component storage areas to confirm the declarations, including the use of radiation signatures of the warheads and components *(Zone 4 at Pantex);*
  - Remote monitoring of the warhead receipt and storage areas and component storage areas *(Zone 4 at Pantex);*
  - Chain-of-custody of warheads and components from the storage areas to the dismantlement areas *(from Zone 4 to the gate of Zone 12 at Pantex);*
  - Portal Perimeter Continuous Monitoring (PPCM) to inspect every item that passes into and out of a segregated portion of the dismantlement area *(inside Zone 12 at Pantex);*
  - Chain-of-custody of warheads and components within the dismantlement area *(inside Zone 12 at Pantex);*
  - Sweeping or sanitizing a disassembly bay or dismantlement cell periodically before and after dismantlement *(inside Zone 12 at Pantex);*
  - Remote monitoring or direct observation of the dismantlement process (e.g., during the disassembly of the physics package and during the removal of the high explosive from the pit) *(inside Zone 12 at Pantex);*
  - Chain-of-custody of nuclear components from the dismantlement areas to the component storage areas after dismantlement has occurred *(from the gate of Zone 12 back to Zone 4 at Pantex);*
  - Monitoring of the disposition of the non-nuclear components of the weapon, such as the high explosive and warhead electronics, after dismantlement has occurred.
- After careful consideration of the details of current Pantex and Y-12 operations and as a result of the significant cultural changes regarding openness at the Department of Energy and at the Pantex and Y-12 Plants in the past four years, the study group concluded that all of the monitoring activities listed above could be applied at either the ***Unclassified to Confidential National Security Information (U to C/NSI)*** level or at the ***Restricted Data (RD)/Formerly Restricted Data (FRD)*** level.
  - The monitoring activities cannot be completely implemented on the unclassified level because some of the activities include monitoring the movement of weapons and components, which itself is classified as C/NSI.
  - The study group also concluded that the level of confidence gained in each monitoring activity would depend critically on which classification level was chosen, with higher classification levels generally yielding higher confidence in warhead dismantlement.
- Based on the ten monitoring activities listed above, four options were considered with varying level of confidence in dismantlement and intrusiveness.
  - **Option 1:** Monitoring of warheads and components in the storage area *(Zone 4 at Pantex)* and chain-of-custody monitoring to and from the gate to the dismantlement area *(Zone 12 at Pantex).*
  - **Option 2:** Option 1 *plus* portal perimeter continuous monitoring of a segregated portion of the dismantlement area *(inside Zone 12 at Pantex)* dedicated to dismantlement of treaty related weapons.

- **Option 3:** Option 1 *plus* further chain of custody procedures to monitor warheads and components within a segregated portion of the dismantlement area *(inside Zone 12 at Pantex)* and to and from the disassembly bays and dismantlement cells (without PPCM).
- **Option 4:** Option 3 *plus* direct or observation or remote monitoring of the dismantlement process *(inside Zone 12 at Pantex).*

- Each of the four options was evaluated against the following seven evaluation criteria:

  - **Level of confidence**—the level of confidence that dismantlement has taken place provided by each option.
  - **Negotiability**—a judgment of the relative ease with which the transparency or verification option may be accepted by the Russian Federation.
  - **Inadvertent loss of classified information**—the possibility that a Russian inspector, by being present at a dismantlement facility, could either accidentally or intentionally gain access to classified information not intended to be shared with the inspectors.
  - **Impact on operations**—the disruption to on-going operations at Pantex or Y-12 not related to the dismantlement of excess nuclear weapons, such as stockpile surveillance and maintenance activities.
  - **Operational readiness**—the time needed to be ready for Pantex or Y-12 to host inspections, including the time required for construction and physical modifications, if needed.
  - **Cost to prepare for and host the first inspection**—including any physical or procedural modifications that would need to be made to prepare for and host the first inspection.
  - **Routine cost of hosting each inspection**—the recurring cost of each routine inspection after the initial inspection has taken place.

- The results of the analysis of the four dismantlement monitoring options are summarized below in Table 8.

Table 8: Summary Matrix of Options and Criteria.

Option 1: Monitored storage
Option 2: Option 1 *plus* portal perimeter continuous monitoring of a portion of the dismantlement area
Option 3: Option 1 *plus* chain of custody from monitored storage to and from the dismantlement bay or cell
Option 4: Option 3 *plus* direct observation or remote monitoring of the dismantlement process in the bay or cell

		Confidence in Dismantlement	Negotiability	Inadvertent Classified Information Loss	Impact on Operations	Operational Readiness [1]	Cost of First Inspection [2]	Routine Inspection Cost [2,3]
Option 1	C/NSI	Low	High	Low	Low	1 year	$2.5 M	$0.12 M
	RD/FRD	Moderate	Low–Mod.	Low–Mod.	Low	1 year	$2.5 M	$0.12 M
Option 2	C/NSI	Moderate	Low	Low–Mod.	Moderate	2 years	$12.0 M	N/A[4]
	RD/FRD	High	Low	Moderate	Moderate	2 years	$12.0 M	N/A[4]
Option 3	C/NSI	Moderate	Moderate	Moderate	Moderate	1.5 years	$6.5 M	$0.2 M
	RD/FRD	Mod.–High	Low–Mod.	Mod.–High	Moderate	1.5 years	$6.5 M	$0.2 M
Option 4	C/NSI	Moderate	Low	High	High	2 years	$6.5 M	$0.2 M
	RD/FRD	High	Low	High	High	2 years	$6.5 M	$0.2 M

[1] Operational readiness refers, for example, to the time required for construction and physical modifications. The time required for the SS-21 process would have to be incorporated into the declared dismantlement schedule.
[2] Cost estimates are planning estimates only for Pantex and do not represent official estimates for budget purposes.
[3] Routine inspection costs are shown for one inspection, but several such inspections would likely be performed each year.
[4] Option 2 assumes permanent presence of inspectors at a cost of $5.5 million per year.

SPECIFIC CONCLUSIONS

The following specific conclusions were reached by the DOE study group:

- As a result of the new openness that Pantex, Y-12, and DOE have experienced over the past four years, ***transparency*** measures for monitoring warhead dismantlement can be applied at Pantex with up to a moderate level of confidence that dismantlement has taken place if implemented at the Unclassified to C/NSI level.[1]

- ***Verification*** of warhead dismantlement will likely require the exchange of Restricted Data or Formerly Restricted Data under an Agreement for Cooperation in order to confirm that dismantlement has taken place.

  - However, if warhead radiation signatures and templates are successful in correlating signatures from weapons and their components, it may be possible to confirm warhead dismantlement without needing an Agreement for Cooperation.[2]
  - As in the case of the November 1996 demonstration to the Russians at Oak Ridge on classified U.S. HEU weapons components, even though the actual template generated for each weapon or component is classified, it may be possible to compare a classified radiation signature of a warhead or component to that of a classified template of an identical warhead or component in an unclassified manner.
  - This can be done by comparing ***only the relative differences*** in each template or by normalizing the results of each measurement without actually revealing the details of the classified templates.
  - However, there will need to be extensive red-teaming of any candidate technologies to ensure that such measurements or comparisons do not reveal classified design information and to ensure that such measurements cannot be easily spoofed.
  - Should the inadvertent loss or compromise of classified weapon information lead to identification of potential vulnerabilities associated with the existing stockpile, the loss in dollars would be significant and that loss could be coupled with significant safeguards and security concerns.
  - Additional analysis will need to be conducted to address the problem of "authenticating" the measurement system to have confidence that what is being measured is actually a nuclear weapon.
  - One approach to addressing the "authentication" problem could include performing measurements on unclassified plutonium and highly enriched uranium shapes and displaying the unclassified templates to Russian monitors to provide confidence in the integrity of the measurement methods.
  - In the case of warheads mounted on delivery vehicles, it may be possible to ameliorate the "authentication" problem by validating the template when the warhead is in the custody of the DoD.
  - Additional demonstrations on actual U.S. warheads should be performed to provide further empirical data to determine whether warhead radiation signatures can be applied in a warhead dismantlement regime.[3]

---

[1] Transparency measures cannot be implemented completely on the unclassified level because all options include monitoring the movements of weapons and components. Under current classification guidelines, dates and times of movements of weapons and components are classified as C/NSI.

[2] Under START I, the U.S. and Russia exchanged C/NSI data by having the President of the United States sign the treaty, in effect giving the treaty the force of an Executive Order. A START III treaty could use a similar mechanism to exchange C/NSI without requiring an Agreement for Cooperation.

[3] In 1988, the Nuclear Weapons Identification System (NWIS) was demonstrated on a B83 warhead at Pantex to explore the concept of confirming dismantlement by correlating the signature of the warhead with that of its components. The Controlled Intrusiveness Verification Technology (CIVET) was demonstrated on three current warhead systems at a U.S. Air Force installation in 1994.

- The technical readiness or maturity of the technologies that would support the monitoring of warhead dismantlement is essentially the same for all four options considered in the study because all options include the use of radiation measurements.
  - As a result, technical readiness was not a discriminating criterion included in the analysis of the options.
  - The time needed to be ready to use radiation measurement technologies, including warhead radiation signatures, is at least one to two years.
- Transparency measures for monitoring warhead dismantlement can be applied at the Unclassified to C/NSI level with up to a moderate level of confidence that dismantlement has taken place for all of the weapons types currently scheduled for dismantlement in the near term, which include the following weapons programs:

- B53	- W56
- B61, Mod 5	- W69

- To meet the Helsinki Summit requirement to establish new, lower aggregate levels of 2,000–2,500 strategic nuclear warheads, dismantlement of strategic warheads currently in the U.S. active stockpile will need to take place. This could include dismantlement of some of the following strategic warhead systems:

- B61, Mod 7 and 11	- W76
- W78	- W80
- B83	- W87
- W88	

- If additional weapon reductions include elimination of an entire warhead type (e.g., the B83), then we can still reach the same conclusion that warhead dismantlement transparency measures can be implemented at the Unclassified to C/NSI level with up to moderate confidence that dismantlement has taken place.
  - By eliminating an entire warhead type, the security concerns posed to the enduring stockpile by performing radiation measurements may be reduced because the entire type will be dismantled.
  - However, the DOE study group strongly recommends that, due to potential design commonalities in various warheads, a thorough red-team and vulnerability analysis should be conducted to ensure that the risks associated with such measurements are fully understood.
- In the event that the provisions in a START III treaty require that the dismantlement of a portion of a particular warhead type remaining in the active stockpile be monitored (e.g., dismantle 50% of the W76s but retain the other 50% of the W76s as part of the enduring stockpile), then—
  - Transparency measures can still be implemented that provide up to moderate confidence that dismantlement has taken place on the Unclassified to C/NSI level.
  - Verification procedures involving the exchange of Restricted Data or Formerly Restricted Data could only be performed on such weapon types after a thorough security and vulnerability analysis has been conducted.
  - Under the condition that warheads in a monitored dismantlement regime represent warheads in the enduring stockpile, sharing Restricted Data would significantly increase the risk that potential vulnerabilities might be unintentionally revealed.

  - Members of the DOE study group expressed serious concerns that unless such measurements were thoroughly red-teamed, information could inadvertently be released that might identify potential vulnerabilities of these systems.

- In the event that the monitoring provisions in a START III treaty require that a specific quantity of nuclear warheads be dismantled, the rate of dismantlement and the number of warheads dismantled can be monitored by all four options because the accumulated data from declarations, spot checks, and confirmatory measures would allow the number of warheads and components resulting from dismantlement to be determined.

  - However, under Option 1, the rate of dismantlement and the number of warheads dismantled can only be determined if warhead radiation signature methods are successfull in correlating warheads going into the dismantlement area and components coming out. This would detect the possible introduction of pre-existing components, which might be stored inside the dismantlement area, into the dismantlement stream.
  - The confidence in the quantity of warheads dismantled increases as the number of inspections per year increases, and is highest when the permanent presence of inspectors is allowed.

- Dismantlement of a specific type of warhead can only be verified in conjunction with collateral information obtained outside of Pantex.

  - Once a weapon arrives at Pantex for dismantlement, it may be possible that Pantex can provide a declaration of the specific type of warhead and allow a unique signature or template to be made of that ***declared*** type of warhead, assuming that such templates prove to be feasible.
  - However, the combination of these two measures is not sufficient to ***confirm*** that the declared warhead is in fact a warhead of that type.
  - Determination of a specific warhead type will require that the warhead be monitored before it arrives at Pantex for dismantlement (e.g., at a point of DoD custody).

- Similarly, a determination of strategic versus tactical nuclear warheads can only be made before the warhead arrives at Pantex for dismantlement.

  - Because strategic and tactical warheads are typically distinguished by warhead type, delivery system, and employment purpose, a determination of "strategic versus tactical" is linked to when the determination of a specific warhead type is made.
  - Because a determination of a specific warhead type can only be made in conjunction with collateral information obtained outside of Pantex, a distinction between strategic and tactical can only be made when the warhead is in DoD custody.

RECOMMENDATIONS/PROPOSED NEXT STEPS

- An analysis of potential warhead dismantlement monitoring procedures at DoD facilities should be conducted.

  – Such a study should identify potential monitoring procedures that could be implemented at various stages of DoD custody of the warhead, including:

    -- When the warhead is on the delivery vehicle and during the time of removal of the warhead from the delivery platform

    -- When the warhead is at a storage depot or other storage location where retired warheads are stored prior to being picked up by SSTs for transportation to the DOE dismantlement facility.

    -- Particular attention should also be addressed to the appropriate starting point for chain-of-custody procedures for gravity bombs and cruise missiles since they are typically not loaded on their delivery platforms and are usually stored or staged in a location separate from the delivery system.

- A study should be undertaken to identify and evaluate options for warhead dismantlement monitoring that could be implemented in the Russian nuclear weapons complex.

  – Such a study should necessarily address the issues associated with the significant asymmetries between the U.S. and Russian nuclear weapons complex and particularly the fact that whereas Pantex is currently the only active U.S. dismantlement facility, Russia has at least four dismantlement facilities.

- A more in-depth ***quantitative*** analysis should be performed of all the options presented in this report. For each of the four options, this analysis should quantitatively evaluate, to the maximum extent possible, the inadvertent loss of information, impact on operations, and confidence level associated with each option.

- A more in-depth cost analysis should be performed of the existing four warhead dismantlement monitoring options.

  – The revised cost analysis should include budget quality estimates that are approved by both the DOE Albuquerque Operations Office and the Office of the Assistant Secretary for Defense Programs.

- An in-depth analysis should be performed of the feasibility of incorporating measures for protecting classified information into the SS-21 process.

  – This analysis should include a thorough review of potential measures for protecting classified information and their impact on the safety of the dismantlement process.

- An in-depth analysis of the advantages and disadvantages of warhead radiation signatures should be conducted.

  – Specifically, additional demonstrations on a variety of actual U.S. weapons and their components should be conducted to determine the utility of warhead radiation signatures as part of a potential dismantlement monitoring regime.

  - To this end, the most promising warhead dismantlement monitoring technologies—the NWIS, gamma ray spectral measurements, gamma-neutron threshold measurements, multiplicity fingerprint measurements, and the CIVET—should first be tested on U.S. warheads currently undergoing dismantlement and subsequently on U.S. warheads which could be subject to monitored dismantlement under a START III treaty.
  - Each of the technologies should be extensively red-teamed to ensure that such measurements do not reveal classified information and to ensure that such measurements cannot be easily spoofed.
  - A peer review group should be established to evaluate the utility of radiation signature technologies and make recommendations on whether warhead radiation signatures can be used in a warhead dismantlement monitoring regime.

- An in-depth analysis should be conducted to evaluate the security and vulnerability issues associated with performing *any* radiation measurements on nuclear warheads and/or components, regardless of whether the measurements are classified or unclassified.

  - Particular attention should be focused on evaluating security and vulnerability issues associated with performing classified radiation measurements on those warhead types that could conceivably be pertially dismantled under START III and still remain as part of the enduring stockpile.

- An in-depth analysis should be performed to fully evaluate the cost, schedule, and impact issues associated with the use of a dedicated dismantlement facility such as the DAF at the Nevada Test Site.

  - The analysis of the use of the DAF should include an evaluation of the same seven criteria used in this report for analyzing the various options so that a relative comparison can be made of all the options.

- An in-depth analysis should be conducted regarding the construction of a new dedicated dismantlement facility specifically designed to incorporate transparency or verification measures.

  - The analysis of the possible use of a new dismantlement facility should include an evaluation of the seven criteria conducted in this report so that a relative comparison can be made of all the options.

- A separate in-depth analysis of the impact of a warhead dismantlement monitoring regime on the DOE Oak Ridge Y-12 Plant should be conducted.

- An analysis of various "irreversibility" options should be conducted to determine what transparency measures can be implemented at Pantex and Y-12 to promote, as required by the Helsinki Summit statement, "...the irreversibility of deep reductions including the prevention of a rapid increase in the number of warheads."

  - This analysis should include recommendations on whether irreversibility requires that material from dismantled nuclear warheads be stored in forms other than components (e.g., converted into ingots, or oxide).

- A detailed implementation plan is provided in Appendix G that includes a summary of the actions required within the Department of Energy to fully evaluate the issues associated with implementing a warhead dismantlement monitoring regime in the U.S. nuclear weapons complex.

APPENDICES

APPENDIX A

LIST OF PARTICIPANTS

DOE
WARHEAD DISMANTLMENT
STUDY GROUP

LIST OF PARTICIPANTS

Andrew J. Bieniawski, Jr., Chairman
Office of Arms Control and Nonproliferation

James F. Morgan, Study Group Leader
Lawrence Livermore National Laboratory

Mark Percival, Executive Secretary
DynMeridian

Michael J. Newman, Technical Editor
Office of Arms Control and Nonproliferation

Office of Nonproliferation and National Security:

Office of Arms Control and Nonproliferation (NN-40)

Andrew J. Bieniawski, Jr.
Michael J. Newman

Office of Research and Development (NN-20)

Michael F. O'Connell
David Spears

Office of Safeguards and Security (NN-51)

William J. Desmond, Jr.
Kelly Coady
Christos M. Makris
Joseph Rivers

Office of Declassification (NN-52)

Richard Comerford
Vinh Le

Office of Defense Programs:

Office of Nuclear Weapons Management (DP-22)

Martin J. Schoenbauer
Jim Kapsales

Office of Technical and Environmental Support (DP-45)

Joseph Woods
Nicholas A. Paradisio

DOE Amarillo Area Office

Ronnie Pierce

Pantex Plant

Leigh Bratcher
George West

Y-12 Plant

George Cobham
Alex Reidy

Lawrence Livermore National Laboratory

Jim Morgan
Tom Gosnell
Gerald Kiernan

Los Alamos National Laboratory

Chad Olinger
Jared Dreicer
Charles Nakhleh
Bill Stanbro

Pacific Northwest National Laboratory

James L. Fuller

Sandia National Laboratories

Martha Charles
Dusty Rhoades
Max Sandoval

DynMeridian

Mark Percival
Daria Antonucci

APPENDIX B

TEXT OF THE HELSINKI SUMMIT STATEMENT

THE WHITE HOUSE

Office of the Press Secretary
Helsinki, Finland

For Immediate Release

March 21, 1997

JOINT STATEMENT ON PARAMETERS ON FUTURE REDUCTIONS IN NUCLEAR FORCES

Presidents Clinton and Yeltsin underscore that, with the end of the Cold War, major progress has been achieved with regard to strengthening strategic stability and nuclear security. Both the United States and Russia are significantly reducing their nuclear forces. Important steps have been taken to detarget strategic missiles. The START I Treaty has entered into force, and its implementation is ahead of schedule. Belarus, Kazakstan and Ukraine are nuclear-weapon free. The Nuclear Non-Proliferation Treaty was indefinitely extended on May 11, 1995 and the Comprehensive Nuclear Test Ban Treaty was signed by both the United States and Russia on September 24, 1996.

In another historic step to promote international peace and security, President Clinton and President Yeltsin hereby reaffirm their commitment to take further concrete steps to reduce the nuclear danger and strengthen strategic stability and nuclear security. The presidents have reached an understanding on further reductions in and limitations on strategic offensive arms that will substantially reduce the roles and risks of nuclear weapons as we move forward into the next century. Recognizing the fundamental significance of the ABM Treaty for these objectives, the Presidents have, in a separate joint statement, given instructions on demarcation between ABM systems and theater missile defense systems, which will allow for deployment of effective theater missile defenses and prevent circumvention of the ABM Treaty.

With the foregoing in mind, President Clinton and President Yeltsin have reached the following understandings.

Once START II enters into force, the United States and Russia will immediately begin negotiations on a START III agreement, which will include, among other things, the following basic components:

- Establishment, by December 31, 2007, of lower aggregate levels of 2,000 – 2,500 strategic nuclear warheads for each of the parties.

- Measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads and any other jointly agreed technical and organizational measures, to promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads.

- Resolving issues related to the goal of making the current START treaties unlimited in duration.

- Placement in a deactivated status of all strategic nuclear delivery vehicles which will be eliminated under START II by December 31, 2003, by removing their nuclear warheads or taking other jointly agreed steps. The United States is providing assistance through the Nunn-Lugar program to facilitate early deactivation.

The Presidents have reached an understanding that the deadline for the elimination of strategic nuclear delivery vehicles under the START II Treaty will be extended to December 31, 2007. The sides will agree on specific language to be submitted to the Duma and, following Duma approval of START II, to be submitted to the United States Senate.

In this context, the Presidents underscore the importance of prompt ratification of the START II Treaty by the State Duma of the Russian Federation.

The Presidents also agreed that in the context of START III negotiations their experts will explore, as separate issues, possible measures relating to nuclear long-range sea-launched cruise missiles and tactical nuclear systems, to include appropriate confidence-building and transparency measures.

Taking into account all the understandings outlined above, and recalling their statement of May 10, 1995, the Presidents agreed the sides will also consider the issues related to transparency in nuclear materials.

FOR THE UNITED STATES OF AMERICA:

/S/

FOR THE RUSSIAN FEDERATION:

/S/

Helsinki

March 21, 1997

APPENDIX C

DETAILED SUMMARY OF
PREVIOUS DISMANTLEMENT STUDIES

History of Dismantlement Studies

A. Bibliographic list

John B. Brown, Jr., "Nuclear Dismantlement Center (NDC) Alternatives Study (U)" Executive Summary, Volume I and II, Report Classification SRD, Prepared by Pacific Northwest Laboratory for Division of Policy and Technical Analysis, Office of Arms Control, US DOE, PNL-X-1837, 1838, 1839, November 1990, pp.19 (Executive Summary), pp.172 (Vol. I), pp. 316 (Vol. II).

Report to Congress, "Verification of Nuclear Warhead Dismantlement and Special Nuclear Material Controls (U)", Report Classification SRD, Department of Energy, DP-5.1-7375, July 1991, pp.90 (the 3151 Report).

"Verifying the dismantlement of nuclear warheads", Federation of American Scientists, Report Unclassified, June 1991, pp. 58.

C. Olinger, W.D. Stanbro, D.A. Close, J.T. Markin, M.F. Mullen and K.E. Apt, "Potential Transparency Elements Associated with Warhead Disassembly Operations at the Pantex Plant", Report Unclassified, Los Alamos National Laboratory, LA-CP-93-355, December 1992, pp.28.

S. Drell (Chairman) et.al., "Verification of Dismantlement of Nuclear Warheads and Controls on Nuclear Materials", Report Unclassified, JASON/MITRE, JSR-92-331, January 1993, pp.119 (the Jasons' report).

Rodney K. Wilson (editor), "Analysis of Potential Measures for Monitoring U.S. Nuclear Warhead Dismantlement (U)", Executive Summary, Volume II and Volume III, Report Classification SRD, Sandia National Laboratories Draft Report Numbers VST-049 and VST-050, October 1993, pp.6 (Executive Summary), pp.52 (Vol. II), pp.116 (Vol. III) (the Wilson report).

Rodney K. Wilson and George T. West, "Cooperative Measures for Monitoring U.S. Nuclear Warhead Dismantlement", Report Unclassified, Sandia National Laboratories, VST-051, July 1994, pp.90.

Summary of Previous Studies

1. "Nuclear Dismantlement Center (NDC) Alternatives Study (U)", Unclassified Summary of the Brown Report, PNL, November 1990.

In November, 1990, the Pacific Northwest Laboratory (PNL) led a multi-lab team (PNL, LLNL, SNL) that produced this report for the Division of Policy and Technical Analysis of DOE's Office of Arms Control. The report is classified and consists of two volumes and a separate executive summary. Volume 1 (168 pages) is the complete report and Volume 2 (322 pages) is a series of appendices that provides the background support for the analysis and conclusions in the report.

The purpose of the report was to identify and analyze potential issues important to the DOE should the President determine that future arms control agreements require the dismantlement of nuclear weapons. It was not designed to identify dismantlement verification options. Issues identified and analyzed in the report include: 1) verification and monitoring; 2) safeguards and security; 3) risks to human health and safety; 4) economics; 5) public acceptance, institutional, and regulatory risks; and 6) co-location vs. separate dismantlement facilities.

Issues are identified for the six topical areas as functions of dismantlement approaches and dismantlement steps. Dismantlement approaches evaluated in the study include: 1) field demilitarization at the DoD site; 2) no action (business as usual); 3) declaratory; 4) bonded storage; 5) Intermediate-Range Nuclear Force (INF)-type; 6) dismantlement; and 7) SNM disposition.

The scope of the study is limited to the identification and analysis of key issues confronting DOE should the President determine that nuclear warhead dismantlement be included in future international agreements. The study does not address the question of whether U.S. policy should endorse nuclear warhead dismantlement or issues relating to warhead and SNM stockpile initialization.

The report's major conclusions are as follows:

- Verification/Monitoring - Sensitive information will be at risk for all verification approaches examined. Therefore measures will have to be taken to keep the classified information from being placed at risk by the arms-control-mandated process. The level to which this information is potentially revealed is strongly dependent on the dismantlement approach. Declaratory dismantlement and chain-of-custody approaches have the lowest risk, while direct observation and radiographic examination have a much greater risk.

- Safeguards and Security - Incremental risks to DOE's safeguards and security program will result from any of the proposed approaches. Current DOE safeguards and security programs need to be re-evaluated if warhead dismantlement becomes an accountable activity.

- Human Health and Safety - Potential incremental risks fall into three groups. There are risks associated with: 1) accidental nuclear detonation, 2) spread of plutonium, and 3) release of other hazardous substances. The incremental risks are due mostly to increased warhead handling, increased dismantlement operations, and increased warhead transportation.

- Economics - Cost factors are strongly dependent on the dismantlement approach and the details of the arms control agreement. Key factors affecting this analysis include time from agreement to implementation and use of current vs. dedicated facilities. Management of hazardous wastes generated by a large-scale dismantlement program must also be thoroughly evaluated.

- Public Acceptance, Institutional, and Regulatory Analysis - Public acceptance will likely depend on the type of facilities and operations, and can be greatly affected by the process used to select sites. Some dismantlement approaches will require resolution of regulatory issues involving NRC, EPA, and others.

- Co-location of Facilities vs. a Dedicated Dismantlement Center - This is a key issue. The decision made on this issue affects most of the others. The two key factors favoring co-location are short response time and low cost. The two key factors favoring a dedicated facility are lower security risks and an increased public perception of, and commitment to, arms control and nonproliferation.

The report provides a set of integrated recommendations for the next five years (now expired). Key recommendations included:

- Collect information regarding DOE's ability to respond to a treaty that mandates warhead dismantlement.

- Develop a site selection strategy.
- Develop a site-asset inventory for at least several DOE-owned sites.
- Determine special requirements, if any, that may exist with the tagging of nuclear warhead parts.
- Develop criteria for certifying that an accountable unit is indeed a real nuclear warhead.
- Continue to support development of methodology to assess the risks of disclosure.

2. "Verification of Nuclear Warhead Dismantlement and Special Nuclear Material Control, Executive Summary", Report to Congress, July 1991 (the 3151 report)

This is an unclassified executive summary of the report, with the same title, that was prepared in order to meet the requirements of Section 3151 of the National Defense Authorization Act of 1991, which mandates a report to the Congress on the on-site monitoring techniques, inspection arrangements, and national technical means (NTM) of verification that the United States could use to verify the actions of other nations with respect to:

- Dismantlement of nuclear warheads in the event that a future agreement between the US and the Soviet Union should provide for such dismantlement to be carried out in a mutually verifiable manner,
- A mutual US-Soviet ban, leading to a multilateral, global ban, on the production of additional quantities of plutonium (Pu) and highly-enriched uranium (HEU) for nuclear weapons,
- The end-use or ultimate disposal of any Pu and HEU recovered from the dismantlement of nuclear warheads

This report addresses on-site monitoring techniques, inspection arrangements, and NTM of verification that could be used to attempt to monitor compliance if a decision to pursue such arms control measures were made. The status, role, potential use, and possible further development of these verification techniques and inspection arrangements are examined. The report also identifies other impacts including the risk of compromising sensitive, nuclear-weapon-related information.

This report does not address the policy issue of whether it would be in the US national security interest to seek agreements with either the Soviet Union or other nations that would require the dismantlement of nuclear weapons, the disposition of the returned nuclear materials, and /or controls on the production of plutonium or HEU that could be used to build additional nuclear weapons. That issue can only be decided on the basis of strategic, military, and political judgments, including a net assessment of the objectives and capabilities of other nations relative to US security, which lie beyond the scope of this report.

This report, in keeping with the Congressional charter, emphasizes the technical monitoring and NTM techniques, and does not address in detail vulnerability of verification technology to cheating, potential cheating scenarios, etc.

The report points out, that if a proposed agreement provides for dismantlement of specified numbers of weapons or for specified reductions of Special Nuclear Materials (SNM) inventories, the following verification issues would need to be addressed:

- Actual and appropriate nuclear weapons are dismantled,
- Nuclear materials recovered from dismantled weapons are not used for prohibited purposes,
- Existing facilities and processing facilities are not used to produce prohibited materials or warheads,
- Clandestine/prohibited production and processing facilities do not exist.

Aside from the summary and introductory discussions, the main body of this Report to Congress is divided into a section covering general verification measures, and then three sections covering the primary topics of interest: verification of dismantlement, SNM controls/cutoff, and material disposition.

The report states that the warhead dismantlement process can be represented as three separate processes from a verification point-of-view.

- Warhead Identification - confirmation that the unit to be dismantled, in fact, is or contains a nuclear warhead (and perhaps a specific type of nuclear warhead) rather than a surrogate.
- Chain-of-Custody - verification that the unit identified as containing a warhead remains intact during transport from the site where identification took place to a dismantlement site and during any temporary storage. There must be assurance that the warhead was not removed and replaced by a surrogate during the transport and any temporary storage process.
- Dismantlement - disassembly of the warhead-containing system to the degree required.

The key observations made by this report concerning verification of warhead dismantlement are as follows:

- There is a high risk in disclosing sensitive information and such disclosures could reveal potential vulnerabilities of our nuclear forces or reveal design information.
- Determining the initial number of warheads that a side possesses at the time an agreement would enter into force would be an extremely difficult problem due to the ease of concealment and the paucity of external observables. Uncertainties in initial inventories would become more important as the size of the warhead stockpiles decreases.
- It might be possible to develop techniques that offer improvements in warhead identification with reduced risks of disclosing sensitive information.
- Chain-of-custody arrangements offer the possibility of verifying dismantlement with a lower risk of divulging sensitive information. For these possibilities, evasion scenarios must be carefully and thoroughly evaluated.
- In order to segregate new warhead production functions from dismantlement functions, modified or dedicated facilities, as well as new processes or procedures for carrying out warhead dismantlement in on-site inspection regimes, might have to be provided.

- The verified destruction of the non-nuclear parts of the dismantled warheads would have little arms control significance, since these parts could be reconstituted in a clandestine manner with only modest efforts and costs.

The key observations from this section of the report on the verification of SNM production control/cutoff are listed below:

- It would be extremely difficult to verify, without a significant margin of error, the size of the SNM stockpile that a side possesses at the time an agreement would enter into force.
- An integrated civilian/military material production complex, such as in the Soviet Union and other countries, would complicate the verification of the initial inventories of material available for weapons.
- In any agreement to limit production of SNM, verification would require monitoring of appropriate elements of the civilian fuel cycle.
- Tritium production reactors would also need to be monitored to foreclose the possibility of prohibited Pu production as well as the monitoring of other production and use of SNM.
- It would be very difficult to detect and identify production from undeclared uranium enrichment plants.
- The potential of new technology would open up significant new opportunities for SNM production with minimal observables.
- Benefits that could arise from monitoring of SNM include the opportunity for US on-site presence at Soviet facilities and an opportunity of strengthening commitments to the Non-Proliferation Treaty (NPT).

The key observations from the section of the report on the verification of SNM disposition are listed below:

- Most disposition options would be reversible at some cost.
- Down-blending HEU to LEU would significantly reduce the weapon utility of the material.
- The weapon utility of Pu can be significantly reduced by denaturing with other materials or by incorporating the material in a glass matrix. Both processes would require additional investments in costs and time for recovery and reuse.
- Options that return the SNM to non-weapons programs could cause an enlargement of the monitoring task and introduce concerns regarding protection of sensitive information.
- Long-term storage of material would likely be possible to monitor using standard safeguards technologies. The form and location of the material is critical in this disposition scenario, since the materials could be reused for military purposes in a short time.

3. "Ending the production of fissile materials for weapons. Verifying the dismantlement of nuclear weapons - the technical basis for action", Federation of American Scientists, June 1991

This study represents a joint effort between the Federation of American Scientists, the Committee of Soviet Scientists for Global Security and the Center for Program Studies of the USSR Academy of Sciences. Their objective was to outline the technical basis for a Soviet - US agreement to halt the production of fissile material for weapons and to verifiably eliminate retired warheads. Their underling concerns focus on two issues:

- Warheads associated with START and INF treaty eliminated nuclear delivery systems, and the fissile material that they contain are not constrained by treaty or agreement; therefore, there is great uncertainty about their disposition which may undermine the possibility of future reduction agreements. These warheads could be stored for possible rapid re-deployment or be recycled to increase the number of warheads available for uncontrolled or difficult-to-verify systems.
- The small but finite possibility that stored intact warheads might become targets for unauthorized use or subject to accidents.

Key study assumptions include:

- Both the US and Russia share a common interest in a bilateral agreement for a verified cutoff of the production of plutonium and highly enriched uranium for weapons.
- That an agreement on verifiable nuclear warhead dismantlement and disposal of associated fissile material would be ineffective if new fissile material production for weapons were unconstrained.
- Uncertainties in Russian and US knowledge about the sizes of each other's stockpiles are considerable but need not prevent either a halt in the production of fissile materials for warheads or a first round of stockpile reductions.
- In order to go beyond the first cuts of 50 percent or so, Russia and the US will want to have an improved idea of the sizes of each other's nuclear stockpiles.

The study's primary focus was on:

- A verified halt in the production of new fissile material for warheads. In this section, the study highlighted that verification would require reassurance that military production facilities are converted to safeguarded non-weapon uses or are shutdown, tritium production and naval propulsion reactors are not used to produce plutonium for weapons and the enriched uranium in their fuel cycles is not diverted to weapon use, and none of the enriched uranium or plutonium in the fuel cycles of civilian nuclear reactors is diverted to weapon production. In addition, the study addressed possible verification regimes for shutdown production facilities, the difficulties of effectively safeguarding naval reactor fuel cycles without releasing classified information about the fuel and reactor designs, highlighted the differences in the US/Russian civilian nuclear facilities and the strengths and weaknesses of the IAEA safeguards as related to verification, and attempted to dilute the concerns over clandestine production and breakout potential.

- Verified dismantlement of nuclear warheads and the safeguarded storage or non-weapon use of the highly enriched uranium and plutonium. Three basic approaches to stockpile reduction were proposed:

  — The verified dismantlement of agreed numbers and types of warheads and the placement of the recovered fissile material under safeguards for non-weapon use or disposal.

  — Transfer of agreed quantities of HEU and plutonium out of the control of the weapon complexes to safeguarded facilities for agreed uses or disposal.

  — A combination of both approaches.

For effective verification the study proposed tags and seals, portal-perimeter monitoring and intrinsic "fingerprints" of warheads, and safeguarding fissile material. Important to note is that dismantlement "would be done in privacy by the owning country in its own facilities." The study points out that the most difficult problem encountered in this approach would be to devise mutually acceptable approaches to verify the authenticity and intactness of the warheads being submitted for dismantlement.

Study recommendations are as follows:

- implement the joint Russian/US technical studies and demonstration projects that have been proposed by the US Congress,

- the placement of warheads to be retired in sealed, tagged containers,

- the verification of the shutdown status of plutonium production reactors and the placement under IAEA-type safeguards of key civilian nuclear facilities,

- warheads that are to be subjected to verified dismantlement should be stored at the likely location of the dismantlement facility and in a manner such that the integrity of the tags and seals can be periodically checked,

- elimination of unnecessary secrecy relating to past and present nuclear-weapon production activities especially by the Russian government.

It must be noted here that this study reaches the opposite conclusions regarding verification of the respective nuclear stockpiles and the concern over clandestine production as the "3151 Report."

4. "Potential Transparency Elements Associated With Warhead Disassembly Operations at the Pantex Plant", LANL, December 1992.

The objective of this Los Alamos study was to provide DOE with information necessary for policy formulation on the future course of transparency within the US nuclear weapons complex by identifying potential "transparency" elements that reflect nuclear warhead dismantlement operations at the Pantex Plant and assess the impact the elements would have on plant operations and the potential for loss of information. The main assumptions of this report are:

- The impact of transparency elements on plant operations (including environment, safety, and health, security, and dismantlement schedules) should be minimized,

- That limits will remain on the extent of sensitive information that might be declassified or accessed for transparency purposes.

The study addressed four broad categories of transparency elements and then performed an analysis using confidence, intrusiveness, impact on plant operations and costs as the evaluation criteria. The first category, Declaratory Elements, includes initial declarations, notifications and update declarations, hosted demonstrations, and access to management data bases, reports, and documents. Limited Independent Observations, the next category, limits either the amount of information revealed by observation or the frequency of observation. Elements include perimeter and physical plant infrastructure observations, monitoring the dismantlement support services such as training exercises, examination of disassembly products, and high explosive deliveries. The third category, Limited Independent Measurements, includes elements like independent portal monitors, SST loading, pit calorimetry, infrared imagery, aerial surveys, and analysis of effluent from High Explosive burning. The last and most intrusive category, Comprehensive Independent Observations or Measurements, would include short-notice inspections, independent intrinsic radiation measurements and direct observation of the dismantlement process. The general conclusions of the study are as follows:

- Declaratory transparency elements can reveal a broad scope of dismantlement activities while limiting risk; however information is not likely to be taken at face value due to ease of falsification,

- Limited independent observations and measurements could be designed to prevent or limit loss of sensitive information. However, they only reveal a fraction of the dismantlement process and in some cases they do not provide enough fidelity to distinguish between dismantlement and other operations,

- Comprehensive independent observations or measurements could provide high transparency but at increased risk and costs,

- No single transparency element would provide high confidence that dismantlement is occurring without disclosing significant sensitive information or severely limiting the dismantlement schedule,

- Any specific transparency system architecture incorporating more than one transparency element must be carefully designed and evaluated to prevent unintended loss of information,

- Once a coherent system is designed, individual transparency elements could be phased in incrementally.

One of the shortcomings of this report, noted by the authors, is that it addresses only individual transparency elements that could be incorporated into a transparency system and does not address what a system architecture might look like. The authors believe that before a specific architecture can be developed policy decisions regarding the extent and type of information that will be shared with inspectors, the costs each party will incur, and the desired level of confidence are needed.

5. "Verification of Dismantlement of Nuclear Warheads and Controls on Nuclear Materials", JASON Study, January 1993.

This study addressed the question of verification of future agreements with respect to dismantlement and destruction of nuclear warheads, bans on the production of additional quantities of plutonium and highly enriched uranium for nuclear weapons and agreements on the end use or ultimate disposal of special nuclear materials. Key assumptions included:

- There exist new opportunities for reducing arsenals of nuclear warheads and inventories of SNM that are beyond the usual framework of formal treaties and their elaborate frameworks for monitoring activities and verifying compliance,

- A bilateral agreement between the US and Russia would call for one or more of the following: a limited agreement ensuring that nuclear warheads removed from delivery systems eliminated under treaties or under matched unilateral statements are not available for reuse; an agreement of a similar nature as above but requiring full destruction of a specific number of warheads and secure storage for associated SNM; an agreement to retain all, or some of the weapons grade SNM now in national stockpiles in secure storage as an interim measure pending further agreement on ultimate disposition; an agreement establishing a verified bilateral cutoff on production of new HEU and plutonium, and an agreement not to manufacture new nuclear warheads,

- The US and Russia will retain nuclear weapons at a level that is significant in comparison to the overt nuclear states and maintain viable nuclear weapons complexes.

In general the study attempted to highlight the potential means of verification and assess their strengths and weaknesses. In particular the study measured the different verification regimes against two critical objectives:

- Ability to detect significant strategic Russian violations

- Ability to detect leakage of only a few weapons or kilograms of SNM to other countries

The primary focus was on National Technical Means, enhanced Open Skies sensors , data exchanges, perimeter portal monitoring, on-site inspection, tags/seals, emplaced sensors, and radiation monitoring. The study also addressed the issues associated with warhead totals and inventories of HEU and plutonium. Here they offer a number of possible measures to help narrow the uncertainty in the stockpile and HEU/ plutonium production; however, they recognized that "one can never count on finding clandestine warheads".

When addressing the issues of disassembly and destruction, the study emphasized that speed of action is more important than waiting for the best of facilities to proceed, and that "the most important channel of information for verifying dismantlement is to have inside knowledge of the day-to-day operation of the Russian weapons-handling bureaucracy". They clearly would "prefer to have inspectors with legal access to the main weapon production sites rather than to an isolated dismantlement facility." The study divided the flow of weapons to be dismantled into three phases, exclusive of the dismantlement itself;

- The movement of weapons from wherever they are to the dismantlement building entrance,

- The passage through the building to the exit where weapon components appear in separately packaged or batched containers,

- The movement of component packages from the dismantlement building exit to final disposal, storage, or destruction.

Within this breakout, the study highlighted that "the most crucial step in the verification of dismantlement occurs at the beginning, when a weapon is first declared to be a weapon and officially entered into the system. The study also used this construct to evaluate each of the verification measures in a range from "adequate, good, better, to best". Other areas considered in the study included SNM cutoff and storage and disposal of SNM.

The general conclusions of the study are as follows:

- NTM alone are inadequate for verification of warhead dismantlement and SNM production. However, they are very valuable for monitoring the shutdown of declared facilities and as a part of a larger verification system,
- Open Skies with multi-spectral sensors can provide an overt signal of suspicious activities. Additional sensors that collect air samples for gas and particulate analysis will increase its value in identifying clandestine activities,
- We face a tension in setting verification standards and requirements for monitoring caused by our desire for information versus what we are willing to give up.

Study recommendations:

- Continue strong R&D support for spaced-based sensors and systems for monitoring activities and changes,
- Develop and support a strong R&D program for identifying and characterizing source signatures and multi-spectral optical, IR, LIDAR, SAR, and air-sampling sensors for Open Skies,
- Develop an effective monitoring system that integrates cooperative procedures with Open Skies and NTM without requiring unnecessary and unwanted intrusive and comprehensive procedures.

6. "An Analysis of Potential Measures for Monitoring U.S. Nuclear Warhead Dismantlement", Volume 1: Unclassified Executive Summary of the Wilson Report, SNL, December 1993.

This report is an unclassified summary of the classified report by the same title. Agreements to reduce the number of nuclear weapons by both the US and the Russian Federation could result in externally-imposed monitoring and inspection of the DOE nuclear weapons complex and operations as means of assuring that nuclear warheads are being dismantled.

As a result, this study was initiated with two primary objectives:

- Evaluation of the potential impact of procedures for monitoring nuclear warhead dismantlement on the DOE nuclear weapons complex.
- Identification of cooperative measures that could both demonstrate dismantlement and enable the DOE to meet its legal obligations to protect sensitive information under the Atomic Energy Act of 1954 and Nuclear Non-Proliferation Act of 1978.

The study focused on three facilities in the DOE nuclear weapons complex:

— Pantex Plant, Amarillo, Texas

— Y-12 Plant, Oak Ridge, Tennessee

— Device Assembly Facility (DAF), Nevada Test Site, Nevada

The Pantex Plant and Y-12 Plant are the principal DOE facilities for the production, test, maintenance, and dismantlement of nuclear weapons and components. The DAF was used as a model of a dedicated dismantlement facility because it is a modern facility where nuclear warheads could hypothetically be disassembled.

The study had several sections that included the following areas:

- Descriptions were obtained of facilities and the dismantlement process at each facility.
- A set of scenarios for monitoring dismantlement was developed that spanned the possible range of intrusiveness (and corresponding level of confidence that weapons were being dismantled).
- A set of criteria for evaluating the impact of the various monitoring procedures on dismantlement facilities was developed and values (high, medium, low, none) for each on these impact criteria were assigned for each of the scenarios.
- Cooperative measures could substitute for externally-imposed monitoring procedures and inspections.

The classified report that was produced as a result of this study developed several dismantlement monitoring scenarios at each of the three facilities. Thirteen scenarios were developed for Pantex, eight for Y-12, and seven for DAF. At each facility dismantlement scenarios fell into four categories:

- Scenarios that involved intrusive monitoring of the warhead disassembly process for all or some of the weapons being dismantled.
- Scenarios that involved procedures for monitoring inventories of weapons, components, or special nuclear material (SNM).
- Scenarios that involved portal perimeter monitoring procedures at area and plant boundaries to monitor the flow of SNM.
- Declarations (e.g., of information related to facilities, processes, schedules, and inventories) which, in some cases, could be supplemented by invitations to visit or inspect facilities.

In order to evaluate the impact on operations the study considered several criteria:

- The effort required to protect different types of sensitive information and the risk of inadvertently disclosing such information. The sensitive information was of several types: facility security procedures, weapon design information, equipment, stockpile vulnerabilities and effectiveness, non-dismantlement activities, and other stockpile information.
- Facility security concerns such as the requirements to modify security systems or procedures.
- Impacts on nuclear explosive safety.
- Impacts on other environmental, safety, and health requirements.
- The likelihood and relative magnitude of disruptions and delays to dismantlement schedules caused by monitoring procedures.

- The final criterion addressed the impact on facility resources and included the cost and impact of modifications to facilities and procedures that might be required, the magnitude of requirements for additional personnel to support or accommodate monitoring procedures, and requirements for additional fiscal resources.

Principal Results and Conclusions

Although DOE facilities were not designed to accommodate monitoring procedures, implementation of a variety of dismantlement monitoring and cooperative measures at DOE dismantlement facilities is feasible. The report concluded that the analysis of each category of monitoring procedures produced different and widely varying results. The results in the individual categories are given below.

Monitoring the Disposition of Components and Materials from Warhead Dismantlement

For the above category one can demonstrate that weapons are being dismantled and measures can be undertaken at low cost and without disrupting ongoing dismantlement activities. Monitoring the inventory of nuclear components and materials would provide strong indications that warheads were being dismantled. The confidence provided by monitoring inventories could be relatively high, but will depend on the equipment, procedures, and standards used to identify components and materials which, in turn, will depend on the requirements to protect sensitive information.

Direct Observation of Warhead Disassembly

Observation of the dismantlement process would provide direct evidence that nuclear weapons were being disassembled. Continuous pit inventory monitoring would be required to assure that warheads were not being re-assembled. Extensive changes in facilities and operations that are required to segregate dismantlement from other activities would cause an increase in costs and would also impact safety and security.

Protection of Sensitive Information

Intrusive measures for monitoring dismantlement could compromise various types of sensitive information. The impact of disclosing sensitive information would depend on the inspecting party.

Portal Perimeter Monitoring (PPM)

PPM could provide direct evidence of the flow of nuclear warheads and nuclear warhead components into and out of a facility. However, it would not provide direct evidence of dismantlement. Furthermore, PPM procedures would need to be applied differently at dismantlement facilities than in other verification regimes. Monitoring components as they move from place to place would be difficult for reasons such as, small sizes of components from dismantled nuclear warheads, large volumes of components, and the need to protect sensitive information during normal operations at the facility. The cost of PPM would be high because of the need for continuous on-site presence to make the necessary modifications to facilities to allow for accurate flow measurements while still protecting sensitive non-dismantlement information.

Use of a Dedicated Dismantlement Facility

The advantages of using a dedicated dismantlement facility like the DAF are limited and are primarily related to reduced risk of disclosing sensitive information and the reduced impact on non-dismantlement operations. The report estimates that using an existing facility like the DAF would still require an investment of up to hundreds of millions of dollars and several years to develop the environmental, safety, health assessments, nuclear explosive safety studies and reviews, security inspections and evaluations and operational readiness reviews.

The report details the requirements for implementing monitoring procedures that would need to be followed by DOE and the facility. The following actions will be required:

- Further technical analysis and planning will be necessary to address such issues as methods for detecting the presence of Pu or HEU that do not reveal sensitive information.
- A review of classification issues will be necessary to determine whether information disclosed by a monitoring procedure or cooperative measures is classified or proliferation-sensitive.
- Readiness plans would need to be developed at each facility.
- A commitment of resources to plan and implement monitoring and cooperative measures will be necessary.

From the analysis of potential monitoring procedures for Pantex and Y-12 in the report, four options were identified for further analysis.

- Declarations of nuclear weapons stockpiles, dismantlement facilities, processes and schedules, and inventories of weapons and SNM at dismantlement facilities.
- Combination of declarations of dismantled weapons and components with procedures to inspect non-SNM parts derived from those weapons and components.
- Combination of periodic declarations of dismantlement activities with procedures to monitor the inventory of SNM components (pits) and materials (HEU) derived from nuclear weapon disassembly.
- Combination of declarations of flow of weapons and components with PPM procedures at plants or area boundaries to monitor the flow of SNM in and out of nuclear dismantlement facilities.

7. "Cooperative Measures for Monitoring U.S. Nuclear Warhead Dismantlement", SNL, VST-051 Report Summary, July 1994:

Based on an earlier analysis of potential measures for monitoring nuclear warhead dismantlement at U.S. nuclear weapons dismantlement facilities, four types of cooperative measures were identified

- Declarations and site visits,
- Monitoring the disposition of components and materials from dismantled nuclear warheads,
- Monitoring inventories of pits from dismantled nuclear warheads,
- Portal perimeter monitoring at weapon and component storage areas.

This report presents the results of a more detailed analysis of these cooperative measures. The analysis identifies the requirements to implement dismantlement procedures at the Pantex Plant. The results provide a comparison of the cooperative measures based on their impact and the confidence they provide about the transparency and irreversibility of dismantlement in the United States.

Declarations and site visits

As a result of the analysis, the study found, regardless of whom the inspecting party may be, that:

- The DOE has made significant declarations of activities and allowed visits to dismantlement facilities upon which confidence-building and cooperative measures for demonstrating nuclear warhead dismantlement can be built. Further declarations and more extensive site visits are not necessary at U.S. facilities to establish other cooperative measures for building confidence that warheads are being dismantled. However, declarations related to specific cooperative measures may be necessary.

- With specific regard to the Russian Federation (or other nations with which a bilateral agreement might be considered), further declarations and site visits are necessary to determine whether other, reciprocal cooperative measures for monitoring nuclear warhead dismantlement are feasible. This conclusion is consistent with one of the key findings in the Office of Technology Assessment report on dismantlement (OTA-O-572, Sept.1993). It may be more desirable to share sensitive information with the Russians under a cooperative bilateral arrangement rather than by declassifying information.

Monitoring the disposition of components and materials from dismantled nuclear warheads

The disposition of parts and components from dismantled U.S. warheads could be monitored as a means of demonstrating dismantlement. The type of components and parts chosen primarily would depend on whether they contained sensitive information that would be disclosed during inspection and whether their destruction or other disposition could be monitored. Generally, the components providing the strongest evidence that warheads were dismantled are those that contain unique identifiers that can be compared to records. The components most easily inspected would be those that are non-nuclear, non-hazardous, and do not contain sensitive information. However, monitoring of these parts would provide less assurance regarding warhead dismantlement than would other, classified parts.

The greatest challenge in implementing procedures to inspect parts and monitor their disposition at Pantex would be in creating an environment in which to conduct the monitoring and inspection activities without compromising sensitive information and with a minimal impact on the dismantlement rate or other non-dismantlement activities.

The confidence (that weapons were being dismantled) provided by monitoring the disposition of parts is not easily assessed, but is expected to be lower than the confidence provided by monitoring the inventory of pits or by PPM. If parts critical to the warhead, such as nuclear components or critical electrical components, are monitored, the confidence will be greater than if the parts are commercially available. Finally, if the destruction of the parts can be confirmed, confidence will be greater.

Monitoring inventories of pits from dismantled nuclear warheads

It is feasible to provide access to pit inventory data and procedures at Pantex to provide a relatively high degree of confidence, albeit indirect evidence, that warheads are being dismantled, and a high degree of confidence (direct evidence) that SNM is under control and not being used to reassemble warheads. Furthermore, the cost of providing access, relative to PPM monitoring or other intrusive measures, will be relatively low and primarily related to the cost of providing security escorts.

Protection of sensitive information and other security requirements place limitations on the amount of information related to inventory procedures that can be provided to observers. Since the schedule for conducting inventories can be made well in advance, the suspension of activities involving weapons should not be a concern (unless short-notice inspections are permitted).

Under the Stage Right procedures for the interim storage of pits, the inventory process itself can be observed without revealing any classified information. All Stage Right inventory information will be collected using remotely controlled equipment; the data will be stored in a computer. There may not be high confidence to the observers that the items being inventoried are pits.

In this case, it might be desirable to allow confirmatory measurements to be made by the inspectors.

The cost of monitoring pit inventory data and procedures is much less than the cost for portal perimeter monitoring and other intrusive measures. The initial costs do not include any costs for the development and acquisition of radiation measuring equipment used to make independent measurements on pits by inspectors.

The concern over radiation exposure to workers and visitors as a result of these monitoring measures will be no greater than it would be during regular operations, unless it is necessary to retrieve a pit from a magazine and allow observers to make independent measurements.

Portal perimeter monitoring (PPM) at weapon and component storage areas

With the requirements to protect sensitive information, and recognizing the realities of the existing nuclear weapon complex where both dismantlement and non-dismantlement activities occur in a concurrent and co-located manner, three options were examined for PPM at Pantex in this report:

- No Segregation; No Disclosure of Sensitive Information,
- Certain Sensitive Information is Shared with Inspectors,
- Sensitive Information is Not Disclosed; Dismantlement and Non-Dismantlement Items and Activities are Segregated
  - Segregation of Zone 4 West
  - Use of Zone 4 East for Staging

PPM measures can be implemented in a number of ways at Pantex to provide varying degrees of confidence that warheads being dismantled as part of stockpile reductions are not reassembled. Protection of sensitive information and other security requirements place limitations on the means by which PPM could be implemented.

Option 1, in which PPM is applied within the current configuration of Pantex and without permitting the sharing of sensitive information, results in a situation in which little more is done than vehicle counts. Option 1 would involve significant recurring annual costs relative to the very low confidence that it provided.

The cost of Option 2 is significantly less than all variations of Option 3, but requires that sensitive non-dismantlement information be shared. Option 2 provides higher confidence than the other options that weapons are being dismantled and not reassembled because all shipments (inbound and outbound) can be inspected.

Of the options involving segregation, Option 3a (segregate the existing staging area) has the least initial cost. However, segregating Zone 4 could disrupt current Pantex operations.

Alternatively, to modify Zone 4 East (Option 3b) could require a number of safety and security assessments and reviews.

Options involving segregation also will require that a number of weapons and perhaps pits be moved from their current locations. To comply with security requirements, these moves could require a significant amount of time to complete and, particularly for Option 3a, could result in a loss of weapon staging flexibility (i.e., capacity). This would affect both DOE's transportation safeguards system and the DoD.

Finally, a difficult problem that remains for the PPM option is determining a way to differentiate between a weapon and a pit.

APPENDIX D

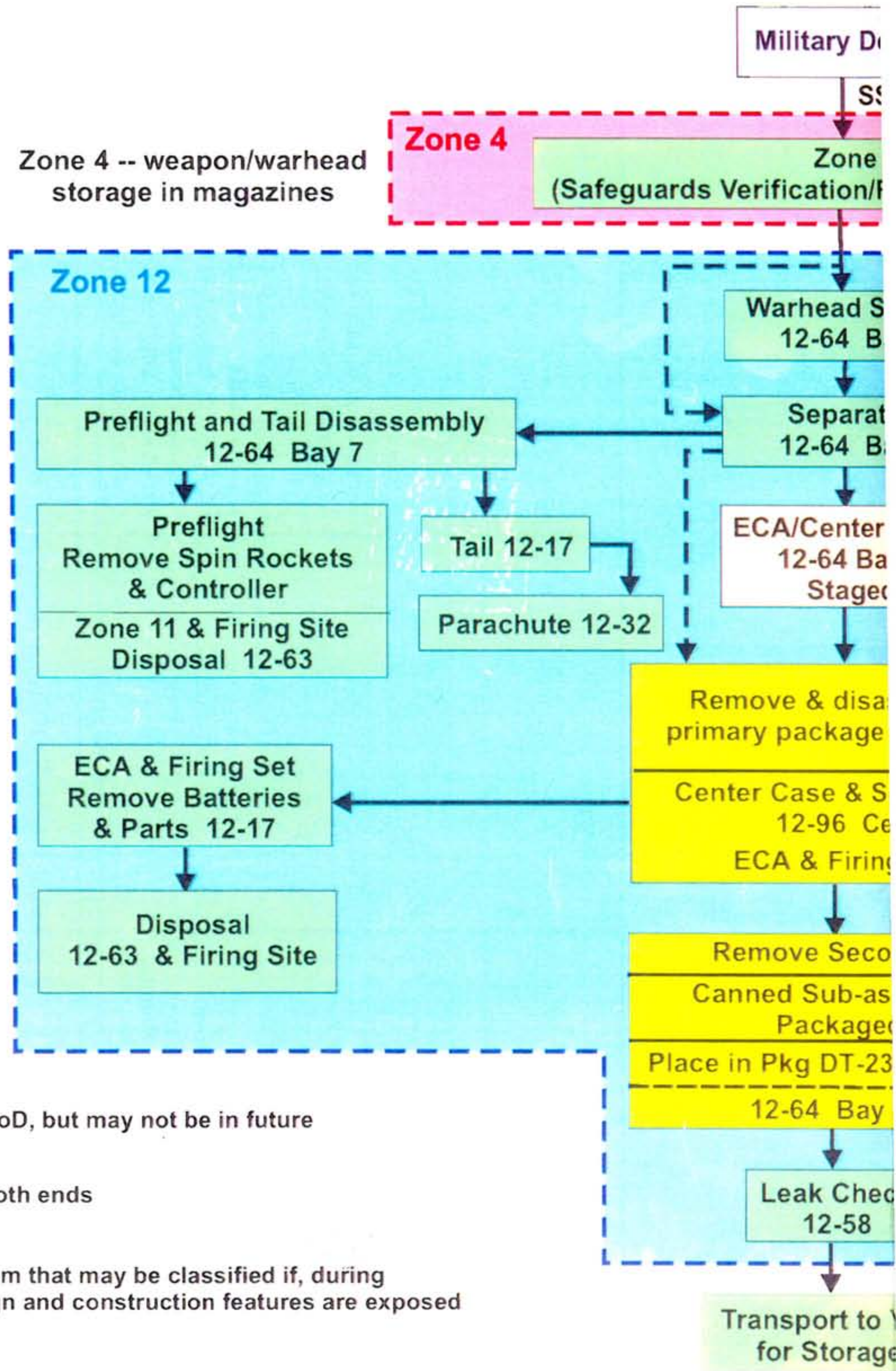
DETAILED DESCRIPTION OF THE DISMANTLEMENT PROCESS

B-61 Dismantlement

(Representative of Dismantlem

Zone 4 -- weapon/warhead storage in magazines

Zone 12 -- disassembly, staging, and disposal of nuclear weapons/warheads



Acronyms:

SST - Safe, Secure Trailer
TSD - Transportation Safeguards Division (DOE)
ECA - electronic component assembly
HE - high explosives

Notes:

[a]Bottles removed (ALT) by DoD, but may not be in future

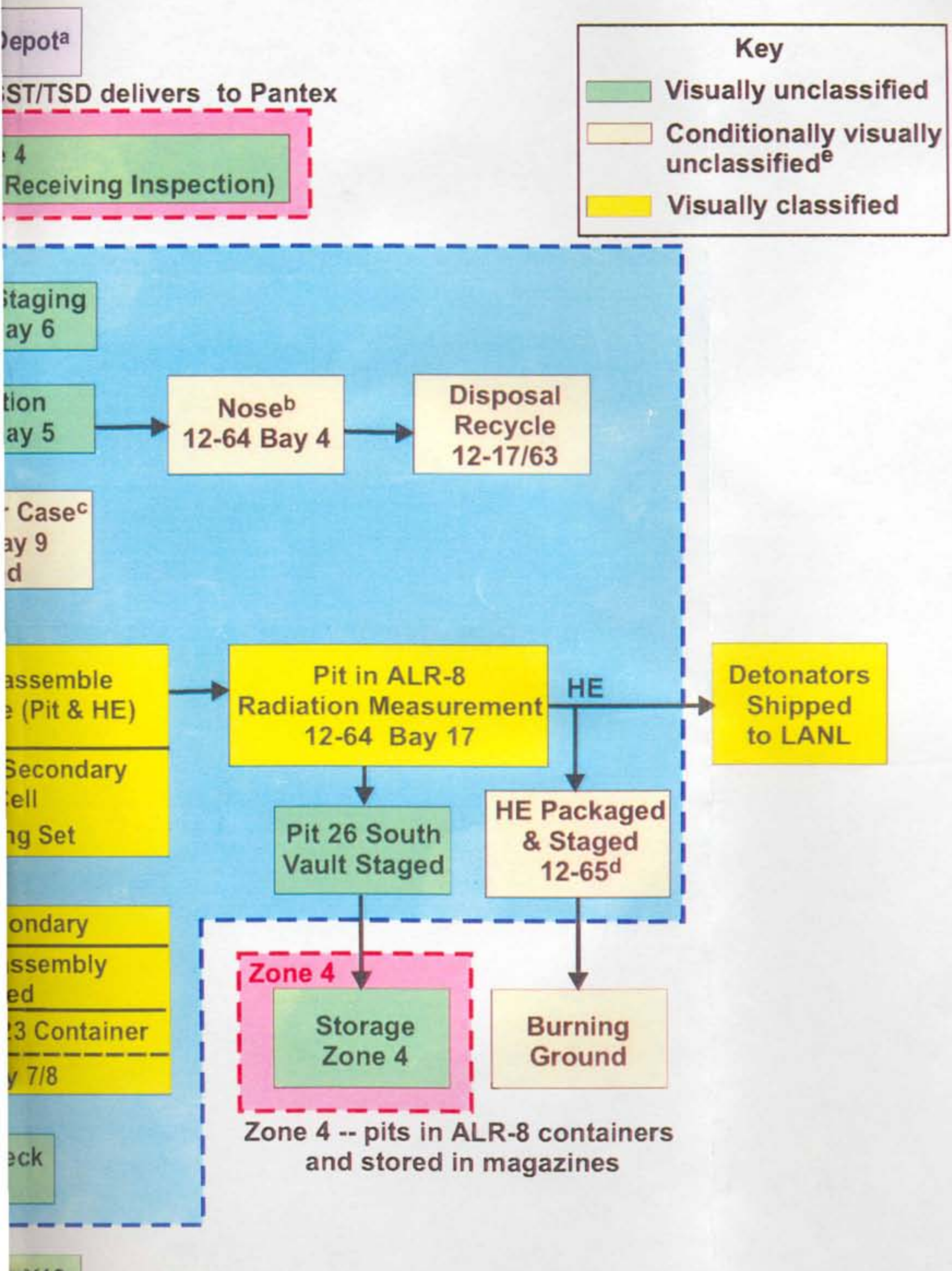
[b]Radar visually classified

[c]Classified if not closed at both ends

[d]Shape classified

[e]A weapon component or item that may be classified if, during disassembly, detailed design and construction features are exposed

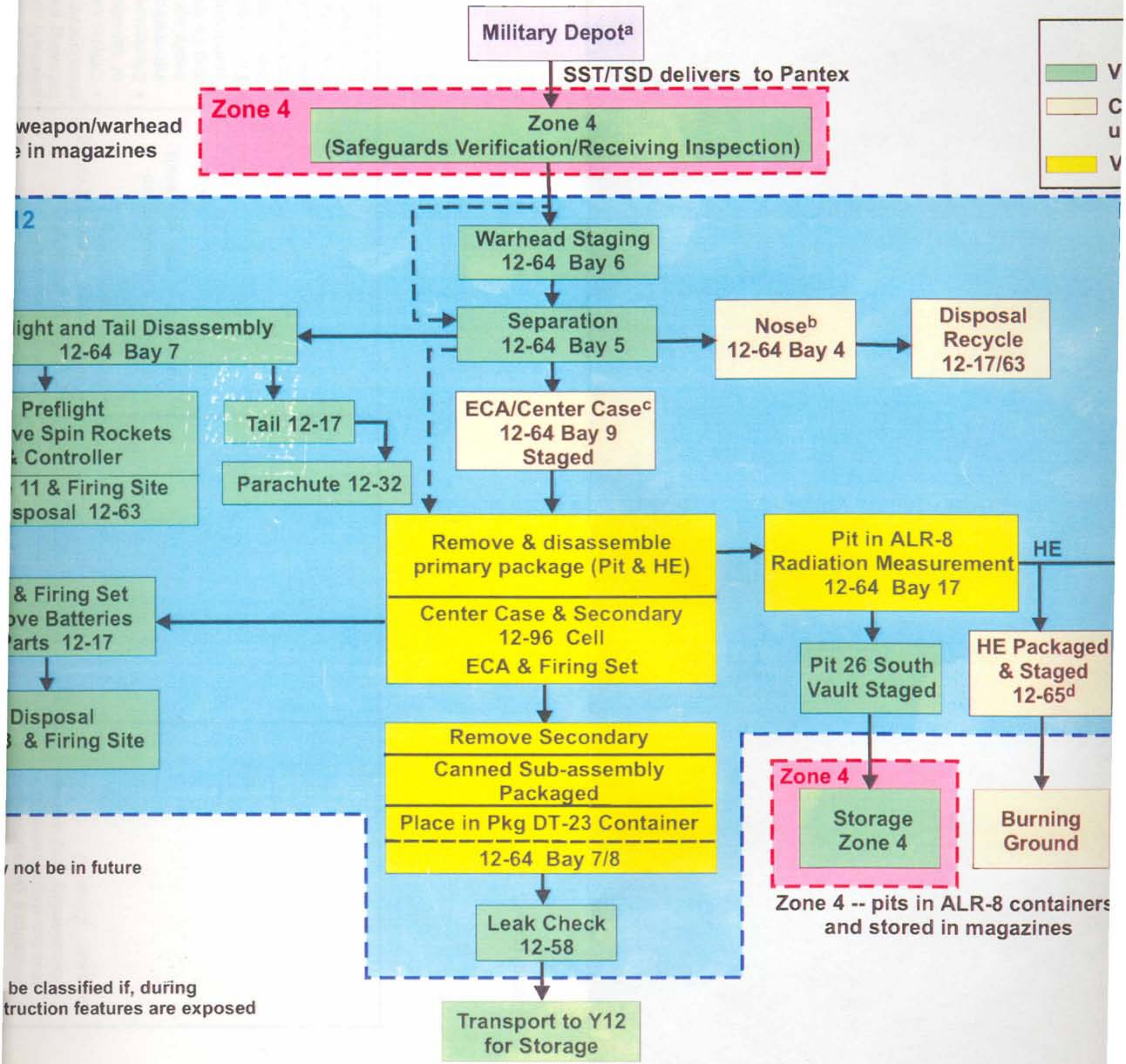
t Steps at Pantex
ent for all Gravity Bombs)



5300-96-00463P
3/5/97

B-61 Dismantlement Steps at Pantex

(Representative of Dismantlement for all Gravity Bombs)



Pantex Nuclear Weapon Dismantlement Process
Major Steps for Gravity Bombs

Pantex Process Steps	Classification	Verification Measures	Comments
1. Arrival of weapon/warhead at Pantex Location: Zone 4	Unclassified	• Visual inspection/observation • Radiation measurements • Inspection of tags and seals	• The arrival schedule for a weapon is classified • The interior of an SST is classified • Measures can be taken to protect sensitive information *Before any weapon dismantlement can begin, an extensive "start-up" activity, called the *SS-21 process*, is required. This process takes a minimum of 2 years to complete.
2. Refer to work process layout guidelines (weapon-specific process requirements) - Disassembly Bay set-up. Location: Zone 12	Unclassified	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements • Inspection of tags and seals	It is important to note that work activities listed under 1-10 are generally unclassified, but the following must also be considered: • Official use only and presence of sensitive information • Disclosure of gratuitous information that exceeds the treaty/agreement language and its impact on DP operations and facilities • Each weapons system has highly customized requirements and classification issues can vary • Information should be protected because of proliferation issues

Pantex Process Steps	Classification	Verification Measures	Comments
3. Refer to pre-shift set-up requirements (designation of specialized equipment and materials) Location: Zone 12	Unclassified		
4. Refer to preshift operational requirements (designation of specialized operational requirements) Location: Zone 12	Unclassified		
5. Transportation of weapon from Zone 4 to Zone 12 • Post-load inspection • Weapon received in Zone 12 at the loading dock (12-117, or 12-98) • Weapon placed in interim storage in Zone 12, or • Immediately transferred to disassembly bay Location: Zone 4 ⇒ Zone 12	Classified (the exact schedule of weapon movement at Pantex is classified SNSI and the number of weapons moved at Pantex is SNSI) Unclassified visual access is possible on a particular movement from Zone 4 to Zone 12	• Visual inspection of weapon moved from Zone 4 to Zone 12 per Pantex transportation operating procedure • Tracking by serial /part numbers of the nuclear weapon	Pantex transportation and storage procedures are followed for moving nuclear explosives and nuclear components. Internal plant trucks are used for on-site transportation.

Pantex Process Steps	Classification	Verification Measures	Comments
5A. Receive warhead/ weapon at the Disassembly Bay. • Initial radiation dose rate information collected • Removal of the DOE acceptance stamp • Remove the protective blanket • Review safeguards verification inspection form and data • Verify the unit Inspection Record Card (IRC) for agreement with the unit stenciling • Verify the unit is permanently marked "Nuclear" • Ensure that the IRC indicates that the unit contains a Weapons Unique Code for Retirement (WUCFR) Location: Zone 12	Visual classification issues will arise depending on weapon system Classified as high as SFRD (IRC is classified when filled in with data from DoD and DOE.)	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	Shrouding techniques will be required to protect information See statements listed for 1-5 IRC documentation includes DoD data entries for the weapon when it was in DoD custody
6. Set-up for unit removal from cart (H1125/A-twin pack cart)	Unclassified	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	

Pantex Process Steps	Classification	Verification Measures	Comments
7. Removal of unit from H1125/A cart • Position the center case transport cart • Position tail cart in line to accept unit • Loosen and release the swing bolts • Remove the H1125/A upper cradle • Install tail cart template • Lift the unit from the H1125/A cart using the hoist • Adjust the tail cart to approximately mate with the template against the tail section • Secure the sections on the carts Location: Zone 12	Unclassified	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	
8. Set-up for removal of the nose and tail pre-flight assembly Location: Zone 12	Unclassified	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	

Pantex Process Steps	Classification	Verification Measures	Comments
9. Remove the radar nose and place on nose cart • Remove screws from the preflight center bomb joint • Separate the preflight case from the center bomb case far enough to reach the interior electrical connectors • Disconnect and cover electrical connectors • Coil cables inside preflight case • Cover preflight case Location: Zone 12	Classified Visual classification issues will arise and, if open, the radar nose is visually SFRD, components are SFRD, and antenna assembly parts are CFRD Unclassified if the nose is viewed closed as a whole assembly	• Visual inspection • Radiation measurements • Remote monitoring technologies	Internal components are visually classified. Shrouding or some other type of protective covering will be required
10. Set-up for cover plate assembly removal - center case • Remove screws and loosen bulkhead connector nuts • Remove cover plate assembly • Stamp components as required by the DISDOC Location: Zone 12	Unclassified This operation is unclassified, but the interior of the weapon (inside the nose and center case) is classified as high as SRD. Shrouding or some type of visual covering will be required	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Radiation measurements • Remote monitoring technologies	DISDOC - disposal document
11. Electronic Component Assembly (ECA) (ECA = fire sets, neutron generators and batteries) • Remove the top cover from the ECA • Ensure that electrical connector covers are installed on ECA connectors • Remove the connectors as indicated in the NEOP • Stamp components as required by the DISDOC Location: Zone 12	Classified ECA may be visually classified at SRD if process exposes internal view of components and SNM shapes; if protected from visual access, process is unclassified	• Track components with serial/part numbers • Visual inspection/observation	Any visual observation will require shrouding to protect sensitive information. Pantex Nuclear Explosive Operating Procedures (NEOPs) will have to be reviewed for each weapon system to determine and modify shrouding and other protective measures that must be put into place. NEOP documentation may be classified

Pantex Process Steps	Classification	Verification Measures	Comments
12. Support and Cap Assembly Removal • Remove the cap assembly using a vacuum fixture fitting • Remove physics package from center casing Location: Zone 12	Classified Materials are SNM and classified SRD; visual access to shapes is SRD during this process step	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Radiation measurements • Remote monitoring technologies	
13. Removal of the support and valve assembly • Remove the tube from the valve Location: Zone 12	Classified Materials contain SNM and are classified SRD; visual access to shapes is SRD during this process step	• Track components with serial/part number	
14. Fire set removal operations • Remove the screws and gold retainer plates • Remove connector covers • Install the separation fixture over fire set • Remove fire set Location: Zone 12	Classified Fire set is classified CFRD, but visual access to shapes of internal components is SRD		
15. Set-up for removal of caps and detonator cables • Loosen the rear cap/inner cap assembly • Remove cap assembly • Remove the detonator/cable assemblies • Apply and tighten the horizontal wedge screws on the separation fixture Location: Zone 12	Classified Detonators and cable components are CRD, but visual access to shapes and detonator configurations is SRD during this process step		Visual classification issues for HE and detonators will arise

Pantex Process Steps	Classification	Verification Measures	Comments
16. Set-up for HE removal • Remove the HE • Write the top level unit serial number on the HE • Place HE in storage container Location: Zone 12	Classified The observation of this process is SRD due to visual access to classified shapes. Until the HE is in separated into pieces, it will be in a classified shape and this shape is SRD	• Application of tags and seals	
17. Set up for pit packaging • Prepare pit storage container as specified in the procedure • Install the pit in the FL carriage fixture • Place FL fixture in the pit storage container Location: Zone 12	Classified Material is SNM and is classified SRD, visual access to this shape is SRD for the entire process	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Radiation measurements • Remote monitoring technologies • Track components with serial/part number • Application of tags and seals	
17A. Package pit and return it to Zone 4 storage	Classified	• Radiation measurements • Inspection of tags and seals • Track components with seal/part number • Workplace certification	Pit is packaged in ALR-8 or AT-400A container and transferred to Zone 4. Packaged pits may be stored in Zone 12 temporarily until enough are accumulated for economical shipment to Zone 4
18. Set-up for Parachute Removal • Place tail assembly on the cart • Position the tail cart • Position center case cart to receive parachute • Stamp components as required by DISDOC	Unclassified		
19. Tail disassembly • Remove fins from the tail case • Place components in routing bins	Unclassified		

Pantex Process Steps	Classification	Verification Measures	Comments
20. Set-up for disassembly of the radar nose	Classified Visual classification issues will arise and, if open, the radar nose is visually SFRD, components are SFRD and antenna assembly parts are CFRD	Unclassified if the nose is viewed closed as a whole assembly	Radar is visually classified
21. Removal of Secondary • Remove bolts • Extract secondary • Place in DT-38 container • Move to staging area	Classified Materials are SNM, which is classified SRD; visual access to the shape is SRD during this process step	• Application of tags and seals	Storage of secondary at Y-12 Schedules of movement and numbers of components are classified
22. Disposal of Non-Nuclear Components Location: Zone 12	Classified and Unclassified Minor components from CSA are classified CFRD and CRD; this step may be visually unclassified	• Visual observation • Record of disassembly • Remote monitoring technology • Workplace certification	
23. Pit Storage - long term • Pit storage in Zone 4	Classification issues will be based on the information to be provided under the treaty/agreement	• Remote monitoring technology • Review of records and data • Radiation measurements • Tags and seals	

Pantex Nuclear Weapon Dismantlement Process
Major Steps for Reentry Vehicle/Reentry Body

Pantex Process Steps	Classification	Verification Measures	Comments
1. Arrival of weapon/warhead at Pantex Location: Zone 4	Unclassified	• Visual inspection/observation • Radiation measurements • Inspection of tags and seals	• The arrival schedule for a weapon is classified • The interior of an SST is classified • Measures can be taken to protect sensitive information *Before any weapon dismantlement can begin, an extensive "start-up" activity, called the *SS-21 process*, is required. This process take a minimum of 2 years to complete.
2. Refer to work process layout guidelines (weapon-specific process requirements) - Disassembly Bay set-up. Location: Zone 12	Unclassified	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements • Inspection of tags and seals	It is important to note that work activities listed under 1-10 are generally unclassified, but the following must also be considered: • Official use only and presence of sensitive information • Disclosure of gratuitous information that exceeds the treaty/agreement language and its impact on DP operations and facilities • Each weapons system has highly customized requirements and classification issues can vary • Information should be protected because of proliferation issues

Pantex Process Steps	Classification	Verification Measures	Comments
3. Refer to pre-shift set-up requirements (designation of specialized equipment and materials) Location: Zone 12	Unclassified		
4. Refer to preshift operational requirements (designation of specialized operational requirements) Location: Zone 12	Unclassified		
5. Transportation of RV/RB container from Zone 4 to Zone 12 • Post-load inspection • Container received in Zone 12 at loading dock (12-117, or 12-98) • Container placed in interim storage in Zone 12 • Perform x-ray • Transfer to Disassembly Bay (12-84) Location: Zone 4 ⇒ Zone 12	Classified (the exact schedule of weapon movement at Pantex is classified SNSI and the number of weapons moved at Pantex is SNSI) Unclassified visual access is possible on a particular movement from Zone 4 to Zone 12	• Visual inspection of weapon moved from Zone 4 to Zone 12 per Pantex transportation operating procedure • Tracking by serial /part numbers of the nuclear weapon • Application of tags and seals	Pantex transportation and storage procedures are followed for moving nuclear explosives and nuclear components. Internal plant trucks are used for on-site transportation.
6. Receive the RV/RB in the container at the Disassembly Bay. • Verify x-ray • Collect initial radiation dose rate information • Remove protective blanket Location: Zone 12	Unclassified Visual classification issues will arise depending on RV/RB system	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	

Pantex Process Steps	Classification	Verification Measures	Comments
7. Set-up for RV/RB removal from container • Remove lead seals and lockwire from container • Remove applicable nuts and bolts • Take alpha swipes • Review Safeguards Verification Inspection Form and data Location: Zone 12	Visual classification issues will arise depending on RV/RB when removed from container	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	See statements listed for 1-5
8. Removal of RV/RB from container to mechanical work stand • Position the transport cart near work stand • Loosen container bolts and slide latches • Transfer RV/RB to work stand and attach • Verify the unit Inspection Record Card (IRC) for agreement with unit stenciling • Verify the unit is permanently marked "nuclear" • Ensure that the IRC indicates the unit contains a Weapons Unique Code for Retirement (WUCFR) Location: Zone 12	Visual classification issues will arise depending on RV/RB when removed from container. Visual observation of RV/RB is classified up to SFRD IRC can be classified as high as SFRD when filled in with data from DoD and DOE	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	Shrouding techniques will be required to protect RV/RB shape, size, antenna window locations, etc. See statements listed for 1-5 IRC documentation includes DoD data entries for the weapon when it was in DoD custody

Pantex Process Steps	Classification	Verification Measures	Comments
9. Pre-disassembly inspection/ preparation • Remove angle cover and flow switch • Inspect rupture disk • Remove plug seal • Perform helium sniff • Remove purge valve and rupture disk • Take alpha swipe Location: Zone 12	Unclassified/classified Visual observation of RV/RB aeroshell/shroud in some systems is classified up to SFRD	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Remote monitoring technologies • Radiation measurements	
10. Remove pressure cover and RV/RB shroud • Visually inspect for damage • Stamp components as required by the DISDOC Location: Zone 12	Classified Visual access to shape of internal components is SRD	• Track components with serial number/parts number	Internal components are visually classified. Shrouding or some other type of protective covering will be required
11. Disconnect cable assemblies and wiring harness • Cut detonator cables • Take alpha swipe • Install protective cover • Disconnect P-1 through P-4 cables and secure Location: Zone 12	Classified Visual access to shape of internal components is SRD. However, configuration of cable assemblies and wiring harness is unclassified	• Track components with serial number/parts number • Visual inspection/observation	Any visual observation will require shrouding to protect sensitive information. Pantex Nuclear Explosive Operating Procedures (NEOPs) will have to be reviewed for each weapon system to determine and modify shrouding and other protective measures that must be put into place. NEOP documentation may be classified

Pantex Process Steps	Classification	Verification Measures	Comments
12. Remove electronic components (firing sets and neutron generators) • Cut firing set wire • Remove J-1 cover and support cable • Perform helium sniff • Take alpha swipe • Remove neutron generator components • Stamp components as required by the DISDOC Location: Zone 12	Classified Component may be visually classified up to SRD if process exposes internal view of components and SNM shapes; if protected from visual access, process is unclassified	• Track components with serial /part numbers • Visual inspection/observation	
13. Remove case shielding • Remove bracket and covers • Cut outer surface • Perform helium sniff • Separate impact detectors • Remove shields Location: Zone 12	Classified Materials are SNM and classified SRD; visual access to shapes is SRD during this process step	• Track components with serial /part numbers • Visual inspection/observation	
14. Prepare for primary removal • Install milling tool • Install air motor to milling tool • Install HEPA vacuum • Mill key way • Cut support D • Operate vacuum Location: Zone 12	Classified Materials contain SNM and are classified SRD; visual access to shapes is SRD during this process step		

Pantex Process Steps	Classification	Verification Measures	Comments
15. Remove primary and package • Install primary gripper • Unscrew primary • Remove primary from RV • Install on transport cart • Ship to cell Location: Zone 12	Classified Materials contain SNM and are classified SRD; visual access to shapes is SRD during this process step	• Application of tags and seals • Inspection of tags and seals • Tracking of components with seal/part numbers • Radiation measurements	
16. Install RV and secondary in shipping container • Remove permanent marking from RV • Position RV on H1138A cart • Install and secure cross bar • Install in container • Secure end cap and cover • Emplace TID seal • Stencil unit • Move to staging area/ship to Y-12 Location: Zone 12	Classified Materials contain SNM and are classified SRD; visual access to shapes is SRD during this process step	• Application of tags and seals • Inspection of tags and seals • Tracking of components with seal/part numbers • Radiation measurements	Storage of secondary at Y-12 Schedules of movement and numbers of components are classified
17. Set-up for HE removal • Remove transportation cover • Adjust work stand to appropriate height • Engage primary and secure • Remove transport cart Location: Zone 12	Classified Materials contain SNM and are classified SRD; visual access to shapes is SRD during this process step	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Radiation measurements • Remote monitoring technologies • Track components with serial/part number	Visual classification issues for HE will arise Shrouding techniques could be used to protect sensitive information

Pantex Process Steps	Classification	Verification Measures	Comments
18. Remove case and compression pads • Install press and apply force • Remove lock ring • Install forward case ring • Install case removal tool and lower assembly • Lift case and install into shipping container • Remove outer compression pads Location: Zone 12	Classified Observation of this process is SRD since it allows visual access to classified shapes	• Workplace certification • Review of equipment lists and set-up procedures • Review of checklists • Visual inspection/observation • Radiation measurements • Remote monitoring technologies • Track components with serial/part number	
19. HE removal • Cut grindle • Remove detonators • Remove aft and forward HE • Install protective covers • Install HE in containers Location: Zone 12	Classified Observation of this process is SRD since it allows visual access to classified shapes. Until the HE is separated into pieces, it will be in a classified shape and this shape is SRD Number and configuration of detonators is classified up to SFRD	• Application of tags and seals	Detonators by themselves are visually unclassified
20. Set-up for pit packaging • Remove protective covers • Prepare pit storage containers as specified in procedures • Install bird cage • Place pit in storage container Location: Zone 12	Classified Material contains SNM and is classified SRD; visual access to shapes is SRD for the entire process		
20A. Package pit and return to Zone 4 storage Location: Zone 12 ⇒ Zone 4	Classified	• Radiation measurement • Inspection of tags and seals • Tracking of components by seal/part number • Workplace certification	Pit is packaged in ALR-8 or AT-400A container and transferred to Zone 4 Packaged pits may be stored in Zone 12 temporarily until enough are accumulated for economical shipment to Zone 4

Pantex Process Steps	Classification	Verification Measures	Comments
21. Disposal of Non-Nuclear Components Location: Zone 12	Classified and unclassified The RV aeroshell and the radar antenna window location are classified CFRD or SFRD depending on system type; however, this step may be visually unclassified	• Visual observation • Record of disassembly • Remote monitoring technology • Workplace certification	
23. Pit Storage - long term • Pit storage in Zone 4	Classification issues will be based on the information to be provided under the treaty/agreement	• Remote monitoring technology • Review of records and data • Radiation measurements • Tags and seals	

APPENDIX E

INTERIM TECHNICAL REPORT ON RADIATION SIGNATURES FOR MONITORING NUCLEAR WARHEAD DISMANTLEMENT

Interim Technical Report on Radiation Signatures for Monitoring Nuclear-Warhead Dismantlement

Gerald P. Kiernan,[1] Thomas B. Gosnell,[1] M. William Johnson,[2] and Hugh L. Scott[3]

Introduction

At the January 1994 summit, Presidents Clinton and Yeltsin agreed on the importance of ensuring the transparency and irreversibility of the nuclear-weapons reduction process. Both presidents re-affirmed that commitment at the May 1995 summit, suggesting cooperative measures to confirm the dismantlement of nuclear weapons. Further affirmation came in the joint statement of the presidents issued at the recent Helsinki summit stating their intent to negotiate a START III treaty. This agreement would "include measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads." Measurements of warhead radiation signatures is an approach to confirm that warheads have been dismantled—without intrusive inspections within dismantlement facilities.

The concept behind warhead radiation signatures is making measurements that correlate warheads going into the dismantlement process with warhead components coming out. If successful, this could greatly increase the confidence in monitoring warhead dismantlement, while avoiding highly intrusive monitoring of activities inside the dismantlement area. Several approaches are being evaluated to determine if such a correlation is feasible. It is assumed that nuclear warheads and the resulting components will be stored and observed in sealed containers and successful measurement techniques would need to be effective in spite of their presence. (If the exterior view of a weapon is not classified, such as in a bomb case, the warhead may not be in a container during measurement.)

The major technical challenges to successfully applying radiation signatures are the degrees of uniqueness of the signatures and the alteration of signatures during the dismantlement process. Another challenge is to minimize impact on dismantlement operations. One consideration in this regard is to select methods that have short measurement times, minimizing inspection time. Yet another important issue is the amount of sensitive information that might be revealed by different measurement techniques and how such information can be protected. Finally, technologies need to be evaluated with regard to their environmental, health, and safety effects.

Ideally, components that come out of the dismantlement process—the pits, and the canned subassemblies (CSAs)—would be uniquely correlated with a particular warhead that went in. However, because of the similarities between different warheads of the same type (such as MX missile warheads, or Trident I or II warheads), it may be that radiation measurements can only differentiate *types* of warheads. Such measurements could still confirm that, say, so many warheads of a certain type went in and a corresponding number of components associated with that type of warhead came out. Radiation signatures may be altered during dismantlement by removing different attenuating materials between the fissile material and the measurement detector. Therefore, signatures from full-up warheads may have different signatures than the components removed from them.

This report focuses narrowly on a limited chain-of-custody through the dismantlement process (although we mention a limited chain-of-custody for pit conversion in passing). It is assumed that the objects about to go through the dismantlement process have been previously vetted as being nuclear weapons. The nature of this vetting, or initialization process, is beyond the scope of this report and remains a difficult and important issue.

---

[1]Lawrence Livermore National Laboratory
[2]Los Alamos National Laboratory
[3]Sandia National Laboratories, Albuquerque

Due to increased interest in this subject as a result of the Helsinki summit, we are releasing this interim report on radiation signatures. We will publish a final report in the fall.

About Radiation Signature Techniques

General Approaches

Radiation signatures can be associated with either *passive* or *active* techniques:

- Passive techniques observe the radiation given off naturally by plutonium or uranium in the warhead and components. The intrinsic radiations from the natural radioactive decay of uranium and plutonium are numerous and complex. In the context of radiation signatures, passive measurement techniques focus on observable radiations, those that escape from the surface of the weapons or components and penetrate their shipping or storage containers—neutrons and gamma rays. Measuring intrinsic radiation is likely to be only specific to the type of warhead because, by design, the mass and configuration of fissile material does not vary greatly among different warheads of the same type. If very detailed measurements are made, small differences might be seen. The question to be evaluated is whether intrinsic radiation from the warhead and components can be correlated, to show that the warhead was dismantled.
- Active techniques involve exposing the object under inspection to an external radiation source. The externally imposed radiation may create its own signature, as in the case of radiography. Alternately, signatures different from the intrinsic radiation of the fissile material can be induced by irradiating the material to create nuclear reactions within the inspected object, resulting in the emission of induced radiation. With neutron irradiation, the principal effect is to induce large numbers of fissions in the nuclear material. Nonnuclear parts of the warhead might also be activated. Because active techniques probe the interior of objects under inspection, they are generally considered more intrusive than passive techniques and are usually employed in situations where passive measurements are unsatisfactory.

About Neutron and Gamma-Ray Emissions and Their Detection

The discussions of individual radiation signature technologies pre-suppose some knowledge of the neutron and gamma-ray emissions associated with uranium and plutonium and their means of detection. In this section, we present a brief primer on both subjects.

Neutron Emissions Associated with Uranium and Plutonium

Neutrons are emitted from uranium and plutonium as a result of nuclear fission. Spontaneous nuclear fission is observed in heavy elements, beginning with thorium, and the importance of this decay mode increases rapidly with atomic number. Spontaneous fission neutrons are emitted too weakly to be useful as a radiation signature for uranium but are quite observable from plutonium. Fission neutrons, from spontaneous fission or from fissions induced by an external source of neutrons, can interact within the fissile material and cause further fissions. This multiplying effect is a function of the kind and amount of fissile material present and the geometry of the object.

A possible third source of neutrons may come from the alpha decay of uranium and plutonium. If materials with low atomic number are adjacent to or within the alpha-emitting material, the alpha particles undergo a nuclear reaction with the light nuclei, resulting in the release of neutrons. This mechanism is principally of significance for plutonium because the alpha-particle emission rate of plutonium greatly exceeds that of uranium.

Neutrons emitted from nuclear fission exhibit a distribution of energies above 1 MeV—called a spectrum—that differs by materials and by the nature of the fission reaction. As they pass through the weapon, they scatter and lose energy, giving rise to an even broader spectrum. Energy-resolved measurements can be carried out to examine these spectra, but total counts are often done as well.

Gamma-Ray Emissions Associated with Uranium and Plutonium

Highly enriched uranium and weapons-grade plutonium contain a number of isotopes of each these elements. All are radioactive, and decay through a complex series of radioactive daughters, releasing characteristic gamma rays with each succeeding decay. The uranium emits nearly 1,400 known characteristic gamma rays and plutonium emits more than 2,100. While the majority of these gamma rays are emitted with negligible intensity, the resultant gamma-ray spectra for both of these materials are still extremely complex and rich in information about the nature of the emitting object.

Other high-energy photons appear in the gamma-ray spectra of these materials due to beta decay of some of their daughters. High-energy beta radiation is accelerated in the presence of surrounding nuclei and produces a broad distribution of photons called bremsstrahlung (braking radiation). The most notable bremsstrahlung continuum is associated with ^{238}U, caused by the beta decay of its ^{234m}Pa granddaughter.

Small numbers of prompt gamma rays are also emitted in coincidence with spontaneous fission in plutonium, and delayed gamma rays are emitted with the decay of the fission products. The fission neutrons induce gamma-ray activity from both inelastic scattering and capture reactions within surrounding materials. While these emissions from spontaneous fission are too weak to be a practical signature, they *can* serve as a practical signature if a large number of fissions is induced by an external neutron source.

For radiation-signature determination, gamma-ray measurements are usually energy-resolved. The level of detail available from such measurements depends on the type of detector used. The highest energy resolution obtainable is with high-purity germanium detectors (HPGe). HPGe detectors must be cryogenically cooled, usually with liquid nitrogen, which may pose problems with their use.

The second most commonly used detectors for energy-resolved gamma-ray measurements are alkali-halide scintillators. These detectors operate at ambient temperatures. The most commonly used is sodium-iodide (NaI). The energy resolution of NaI detectors is roughly a factor of 15 worse than that for HPGe. Nevertheless, the spectra of uranium and plutonium taken with these detectors are rich in information and can provide quite useful radiation signatures.

With this technical introduction, we will proceed with a discussion of technology options.

Radiation Signature Technology Options

Technologies Evaluated

Options for both passive and active techniques have been evaluated and include—

- Passive techniques
  - Isotopic Ratios
  - Gamma Radiation Signature Method
  - Multiplicity Fingerprint

- Active techniques
  - Radiography
  - Fission-Product Tagging
  - Nuclear Weapons Identification System (NWIS)

Passive Techniques

Isotopic Ratios

It has been suggested that a possible signature for dismantlement transparency is isotopic ratios associated with fissile materials. This suggestion is motivated by the usual practice of determining isotopic ratios from a gamma-ray spectrum. This is done by exploiting gamma-ray lines closely spaced in energy—because the intensity ratios of closely spaced lines are minimally affected by varying amounts of attenuating material (e.g., the full-up warhead compared to the component removed from it during the disassembly process). Therefore, a possible indication of dismantlement would be a satisfactory match of selected isotopic ratios before and after dismantlement. Because of this close line spacing, the high-energy resolution of a high-purity germanium detector is required for the measurement.

For dismantlement transparency, measurement of isotopes of fissile materials would be focused on higher energy gamma rays from plutonium in the 300-keV region, and preferable higher. This is because the plutonium is deep within the nuclear warhead and low-energy x rays and gamma rays around 100 keV—normally used to do high-precision isotopics for international safeguards—are absorbed within the warhead and container and are not available for use.

If this concept can be demonstrated, it has some very attractive attributes: it is a passive technique, it uses commercial off-the-shelf instrumentation, and the basic technology for analysis of the data is well developed. The gamma-ray spectra of nuclear weapons and their components do contain sensitive information, however, and measures would have to be developed to protect these data while still providing the desired results.

Current work is focused on high-resolution, gamma-ray spectra acquired from a full-up weapon and its disassembled components to determine if useful isotopics information can be obtained.

Key issues are unresolved with this approach:

1. It has not yet been determined that isotopic gamma-ray lines exist which can be used to demonstrate transparency.
2. The degree of uniqueness that such a measurement would provide needs to be pursued.
3. If issues 1 and 2 can be satisfactorily resolved, a combination of technical and administrative means would need to be developed to protect the sensitive spectral information while still obtaining the desired results.

Gamma Radiation Signature Method

This technique, based on full-spectrum analysis of low-resolution gamma-ray spectra, exploits the fact that the spectrum of radiation emitted by a weapon depends not only on the amounts and types of radiation emitters but also on the thicknesses and types of materials (including nonradioactive materials) through which the radiation is transmitted. Attenuation and scattering effects produce characteristic changes to the gamma-ray spectrum. These effects occur throughout the spectrum, not just in the region of full-energy peaks due to the radiation sources. Because of this, the entire spectrum must be analyzed, not just the full-energy peaks.

The Gamma Radiation Signature Method can generally be used effectively to confirm that two objects have the same or different designs, but the technique cannot be used to confirm that two measurements were made on exactly the same device, or to distinguish between two different devices of the same design.

While this technique can be used with a variety of gamma-ray detector types, such as NaI, CsI, or HPGe, NaI is adequate for all tasks that have been encountered in applications similar to dismantlement transparency. Using NaI detectors has several advantages. They are the lowest cost detectors routinely used for energy-resolved, gamma-ray measurements, are commercially available from several vendors, are rugged, and require little in the way of power and maintenance.

In its simplest form, a collection and analysis system would consist of a detector, an electronics box (consisting of a high-voltage supply, a signal amplifier, an analog-to-digital converter), and a small computer with removable storage media. When used at a fixed installation where the objects of interest could be isolated from others, it would be desirable to have a neutron detector in addition. In the analysis, the neutron count rate would be treated as an extra channel in the gamma-ray data. Application programs on the computer could permit the collection, storage and comparison of spectra.

Experience in a Similar Application. A series of measurements were made at Pantex to design a system that tracks weapons and weapon parts. A fixed detector was set up in a "ramp" (hallway) in the plant, and various weapons and parts were brought by the detector in a normal transit mode of about 4 mph. This resulted in data being recorded for a few seconds. Multiple measurements of the same type of object were collected. This means that several signatures for a particular object were available for comparison. One of these signatures was chosen as the "ground truth" or exemplar signature for the object type. All the other signatures, for this as well as other objects, were then compared to the exemplar signatures. Even though the measurements were made in a "passby" mode and for only a few seconds of exposure to the detector, excellent agreement was found when comparing signatures of a particular object type to that type's exemplar signature. It was also observed that relatively poor agreement was found when comparing signatures of objects with exemplar signatures of a different type. It should be noted that, because of the short data collection time, the pass-by mode of measurements is far more challenging than the measurements in fixed positions envisioned for dismantlement transparency.

Proposed Application to Dismantlement Transparency. This technique poses initialization problems beyond vetting an individual inspected item as a nuclear weapon. For dismantlement transparency, vetted templates are required for whole classes of weapons *and for their dismantled components.* A template is a spectrum representing a particular type of object. Developers anticipate that such templates would be formed by assembling a number of objects declared by the inspected party to be of the same type. The inspecting party would select a small number (say, three to five) of the objects and record their spectra. Without either side seeing the data, the computer would compare the spectra to ensure that they are sufficiently alike and are not due to empty containers. When the computer determined that these requirements were met, it would store the average spectrum as a template for that object type. This procedure would be repeated for as many object types as may be included in the treaty or agreement. These templates would then be formed into a library, to be used for comparison to any new measurement in a verification application.

The templates and any new spectrum measurements would be stored on removable disks. These disks would be stored in a tamper-proof facility under dual-lock, so that neither side would have access to them (or the measuring equipment) without the other side also being present. There is precedent for a dual-lock arrangement for the Radiation Detection Equipment of the INF and START treaties.

Key issues are unresolved with this approach:

1. This technique poses initialization problems beyond vetting the initial inspected item as a nuclear weapon. The developers have proposed a solution for vetting the nuclear weapon that may suffice, but more thought is needed on how to vet the templates of the dismantled components.

2. The retention of the templates, which would contain sensitive information, for possibly the duration of the entire dismantlement process, poses an increased hazard for inadvertent release of this information. More thought may be needed regarding methods to protect this information.
3. All of the signatures may not be unique. The impact on any lack of uniqueness on transparency confidence needs to be evaluated.
4. The signatures proposed are time-variant, particularly regarding the growth and decay of ^{241}Am from the decay of the plutonium impurity isotope, ^{241}Pu. Adequacy of the methods used by the developers to compensate for these time variances, and their impact on the efficacy of the template signatures, should be demonstrated.

Multiplicity Fingerprint

For this method, gross multiplicity measurements would be made of time-correlated radiation from the fissile material. Gamma rays are being included as well as neutrons, so that the mass can not be inferred to pursue a measure that would not be classified. The "fingerprint" being studied consists of the ratio of triply-coincident signals to doubly-coincident ones. Experiments have been conducted with ^{252}Cf and AmLi sources. It still remains to determine to what extent the measurement is affected by differing amounts of attenuating material, as is the case in its application to the dismantlement process. It should be noted that this system exploits physics somewhat similarly to that in the Nuclear Weapons Identification System described later, although the data presentation and interpretation are different from it. Because development efforts to date have worked with plutonium alone, the method is currently passive, relying on the intrinsic spontaneous fission of the inspected object. In principle, the method can be extended to uranium objects but would require an external neutron source to stimulate fissions in the object.

This approach has been examined using detectors sensitive to both neutrons and gamma rays plus multiplicity-counting hardware and software from the safeguards program. In general, measurements for different samples were taken over a range of source intensities to provide information on pile-up and dead-time corrections. Also, because similar measurements have been taken at several different locations (TA-3, TA-18, TA-35, and the IAEA Schoolhouse at Los Alamos National Laboratory), these measurements address issues of the stability and repeatability of the system. At a higher level, they also provide the basis for evaluating parameter sensitivities and optimizing the multiplicity fingerprint itself. For example, many of the sources have been studied as functions of source shielding, detector moderation, number of detector elements, amplifier baseline restoration, and discriminator pulse-height threshold, in addition to other parameters unique to multiplicity counting. Current efforts are focused on developing an empirical model for the detector that encompasses the different parameters, which will make it possible to define a figure of merit and determine an optimum system configuration for particular applications.

Key issues are unresolved with this approach:

1. Uniqueness—to what extent is the multiplicity fingerprint truly characteristic of the item being measured?
2. Reproducibility—to what extent is the signature associated with a piece of special nuclear material (SNM) preserved, either in different counting geometries and with different materials surrounding the SNM, or in multiple measurements under ostensibly identical geometrical conditions?
3. Can classified or sensitive information be extracted from the signatures? (Questions pertaining to classified information would be examined in detail if the uniqueness and reproducibility issues are resolved satisfactorily.)

Active Techniques

Radiography

This is perhaps the most intuitive of all the techniques. Radiographs produce images of the internal configuration of the materials in a shipping or storage container, quite analogous to medical x-rays of the human body. Applying radiography to dismantlement transparency would involve obtaining a radiograph of the weapon before dismantlement that reveals the configuration of its components. This radiograph would be compared to radiographs of the components taken after dismantlement. Matching radiographs would confirm dismantlement of a weapon type. A major drawback to this method is its extreme intrusiveness. These radiographs would contain an extraordinary amount of sensitive information that would have to be protected in some manner.

Recent technological advances in radiographic capability in the field suggest the applicability of storage phosphor imaging to provide automated image collection for the warhead and components before and after dismantlement. Storage phosphors do not produce a visible image, but the image can be scanned into a computer. This removes some of the operational security issues associated with traditional film imaging, but any radiograph contains an extraordinary amount of sensitive information, and it would have to be secured. The largest hurdle to adapting the technology would be the development of a sufficiently robust image comparison algorithm to compare the images of the warhead and the components (to show the component is contained in the image of the warhead).

The constituents of such a system would consist of a photon source (either a radioisotope or an accelerator), an 11″ × 17″ storage phosphor cassette, a phosphor scanner with computer, and a portable generator, if AC power were not available in the facility. All of these components are commercially available, though each company has its own definition of "portable." A radiography station outside of a disassembly area would then expose a phosphor for a weapon entering the disassembly area. The phosphor would then be scanned in, and the image file stored on the computer. The major advantage of the phosphor is that there is no visible image on the phosphor and the scanning process itself destroys the image data. In addition, complete erasure of the phosphor can be accomplished simply by exposing it to sunlight for a few moments. Once the initial radiograph is taken, the weapon would proceed to the disassembly area to be taken apart. Once this is completed, a second radiograph would be taken of the component storage container as it leaves the disassembly area. Then the image comparison software resident on the scanner computer would decide if the component in the storage container matches the component in the weapon which went in for dismantlement.

Several issues need to be addressed if this technique is to be seriously considered:

1. Can the security concerns associated with radiography in general be satisfactorily addressed?
2. Can a sufficiently robust image comparison algorithm be developed that does not itself reveal classified or sensitive information? This appears to be the most important issue, and satisfactory answers are not obvious.
3. Are there adequate places at the various dismantlement facilities where radiography can be performed?
4. To what extent do any techniques need to be "portable"?

While there have been significant advances in field radiography capability in recent years, it still appears sufficient drawbacks means this will not be applicable to dismantlement scenarios without significant additional work. In addition, it may well prove to be impossible to address the fundamental security concerns associated with radiography to a point that both sides find acceptable.

Fission-Product Tagging

For this technique, the warhead to be dismantled is irradiated with neutrons prior to dismantlement. Following dismantlement, the abundance ratios of the various fission products (which change with time) in the components extracted from the warhead would be used to determine the time elapsed between the initial irradiation and the measurement to determine the radiation time. This would be compared to the known time of irradiation, and a match would be evidence of dismantlement of a specific weapon. Because the signature associated with the initial measurement (an arbitrary time of irradiation) is independent of the design or materials in the weapon, it is the only one of the techniques under consideration clearly specific to an individual weapon. Calculations and experiments are being conducted to understand the evolution and decay of the fission products as a function of time.

Experience in a Similar Application. This concept is being examined for application to the ARIES process for hydride-dehydride recovery of plutonium in disassembly of plutonium pits from previously dismantled nuclear warheads, and in those experiments an accelerator-based neutron source is used. Using fission product tagging in transparency for the ARIES process would take the following form:

- Under observation by the interested parties, fissions would be induced in the pits bound for ARIES using an appropriate radiation source. The time of the irradiation would be noted. For the prototype ARIES line being developed at Los Alamos, the Godiva fast-burst reactor at LACEF (the Los Alamos Critical Experiments Facility) is a satisfactory source of neutrons. If the final, large-scale ARIES system were to be located somewhere else, a different source would have to be used.
- Pits would be transported to the closed ARIES facility and delivered for conversion.
- At the exit of the ARIES facility, gamma-ray spectroscopy would be done, possibly using nondestructive analysis (NDA) hardware or possibly dedicated hardware, to determine the quantities of various fission products present in the now-unclassified material leaving the facility.
- The abundance ratios of the various fission products (which change as time progresses) would determine the time elapsed between irradiation and measurement, which would then be compared to the known time of irradiation to provide the transparency measure.

The ARIES application of fission-product tagging has been examined in detail and a prototype ARIES fission-product tagging system is being developed. Fission-product inventories at times up to 500 hours post-irradiation have been calculated using the computer code, CINDER, and combined with the spectrum-simulating code, SYNTH, to generate simulated gamma-ray spectra. The CINDER–SYNTH calculations show that induction of 10^{12} fissions suffices to produce adequate numbers of fission products for analysis with a standard HPGe spectrometer up to ~50 hours post-irradiation, with under 1 hour of counting time and in the presence of the intense radiation field of the plutonium itself. For longer delays between irradiation and measurement, more fissions would be required, the number rising rapidly as the delay time increases. However, fewer fissions would be required if the item being tracked was a uranium, rather than plutonium, piece, owing to the much lower intrinsic radiation of such a component.

The calculations have been confirmed experimentally at the LACEF. A pit scheduled for conversion in the ARIES prototype system was subjected to the neutron flux from a Godiva burst, resulting in the induction of $\sim 2 \times 10^{12}$ fissions. The pit was then processed with the ARIES system and a resulting unclassified piece of Pu counted 36 hours post-irradiation. The inventory of fission products revealed in this spectrum is consistent with the CINDER–SYNTH simulation of the experiment.

Several issues need additional investigation for fission-product tagging for dismantlement transparency:

1. How can the necessary number of fissions be induced at a site not equipped with a Godiva-like burst reactor or similar neutron source? This question has both technical (producing a large enough source) and procedural (health-physics concerns) components and is probably the main impediment to implementing fission-product tagging in other settings.
2. In applications other than ARIES, the radioactivity induced in the SNM may pose health-physics concerns. The Godiva experiment showed that the intrinsic radiation of the plutonium piece was raised only by a factor of ~2 by irradiation even at post-irradiation times as short as 2 hours (at which time many very short-lived fission products are still present), and by less than 10% at 10 hours post-irradiation. However, the intrinsic radiation of the piece was already substantial simply because of the intense radioactivity of the plutonium itself, so that careful handling precautions would have to be used in the ARIES process. Comparable precautions might not already exist for some other processes involving SNM.
3. To be useful as a signature in monitoring dismantlement, the fission product tag must persist from the time a warhead is irradiated before it enters the dismantlement facility until components come out and can be measured. In the ARIES application, the elapsed time can be as short as a few tens of hours; however at Pantex, the elapsed time can typically be many days to, occasionally, a few weeks. A question will be whether a high enough level of radiation that can be detected can be induced within a reasonable exposure time with a radiation source that can be placed at the entrance to the dismantlement facilities.
4. A related issue to signature persistence is the time resolution of the signature, a function of time from initial irradiation to final measurement. Is the resolution sufficient to discriminate between irradiation of individual warheads, or is that a concern at all?

Nuclear Weapons Identification System (NWIS)

NWIS is an active interrogation technique that measures the time and frequency history of events resulting from neutron-induced fissions in the fissile material. It is used extensively at Y-12 for tracking some specific warhead component types, and gives high confidence in identifying these components against a template originally measured. The technique has proven particularly useful for identifying uranium components in which the intrinsic gamma-radiation spectrum is significantly weaker than for plutonium.

In the NWIS method, a ^{252}Cf source built into an ionization chamber irradiates the object under inspection, inducing fissions in the fissile material. The exact time of emission of the incident neutrons from the ^{252}Cf source is detected in the ionization chamber. The induced fission neutrons and gamma rays from the fissile components are then detected using two or more detectors. The time-dependent detector responses are correlated with the spontaneous fission of the ^{252}Cf source, correlated with themselves and with each other. The time correlations are also represented in the frequency domain. NWIS also measures the multiplicity of counts in the detectors and the detector count rates. In all, NWIS generates 19 correlations in the time and frequency domains, some of which show very high sensitivity to small changes in the weapon's configurations. The correlation between the source and detectors depends only on induced fissions by the ^{252}Cf source and is independent of the object's intrinsic radiation or background radiation. This makes this signature very useful for measurements with full-up weapons. The correlation between detectors depends on both induced and intrinsic fissions but is not affected by other background radiation. The correlation of a detector with itself dependes on all detected radiation.

For dismantlement transparency, it is suggested that only one of the 19 signatures be examined: the neutron time history. This is a spectrum of neutron detection events as a function of time following ^{252}Cf fission. This signature has three elements: (1) a short time component that is the record of ^{252}Cf spontaneous fission neutrons that pass directly through the object without interacting within; (2) a longer-time component of neutrons not originally emitted in the direction of the detectors but which have scattered in the interior of the object and emerged in the direction of the detectors; and (3) another longer-time component resulting from neutrons released from fissions induced in the fissile material by the interrogating ^{252}Cf neutrons. Unlike its traditional application at Y-12, it would be unnecessary to retain standard templates for long periods of time. A signature would be measured of a weapon going into dismantlement and then compared a number of days later with signatures from the components. If a match is obtained, the signatures could be destroyed at that time.

Several issues are unresolved with this approach:

1. Additional experimental work is needed to validate its application to the problem of correlating general warheads and components.
2. The time history spectra are being evaluated to determine if their shape may be unclassified, even though the neutron signal measured in each detector would be sensitive. This will depend on whether or not it is possible to extract weapons-design information from the signals.
3. Measurements to date indicate that the source-detector correlations are unique to weapon type but continued study with more weapons types is needed.
4. Nuclear warheads are thick, dense objects and the transmission of radiation through a warhead is daunting. This poses the question of whether an adequate neutron signal can be transmitted through the warhead to allow the NWIS system to acquire an adequate number of counts in an acceptably short measurement time.

Recommendations

At this point in time, the most mature of the technologies investigated in this report is the Gamma Radiation Signatures Method. Template initialization is a potential drawback that can probably be accommodated in the U.S. but is problematic in the Russian Federation. The requirement to retain classified templates, possibly for the duration of weapons dismantlement, is another undesirable feature. Nevertheless, the method has the advantage of being a passive technique with a track record of some success in a related application. We recommend retention of the Gamma Radiation Signatures Method as a dismantlement transparency option with a continued effort to mitigate its drawbacks.

Another mature method is the Nuclear Weapon Identification System (NWIS). This has the disadvantage of being active but has the advantage of retaining a possible classified signature for only the few days required to dismantle the weapon. NWIS has, to date, focused on weapon secondaries and does not have a broad track record in this regard. We recommend that work on NWIS be accelerated with regard to testing its applicability to a wider range of weapons and exploring its possible application to the inspection of primaries.

The Fission Product Tagging system is a method still in development. The signature determined before dismantlement, the time and date of irradiation, has the considerable advantage of being unclassified and is the only signature that has the potential of being specific to a particular weapon. Its known drawbacks stem largely from its immaturity. In particular, it is necessary to develop an intense source of neutron radiation for application in locations other than Los Alamos. The positive attributes of this method are sufficient to recommend continued vigorous development.

The Multiplicity Fingerprint method is also a method still in development, although hardware has existed for some time. The system is currently passive, measuring the spontaneous fissions from plutonium. In principle, the technique could be extended to the active inspection of radiation objects using an external neutron source to stimulate fissions in the inspected object. We also recommend continued development of this system.

The Isotopic Ratios method has not been pursued as vigorously as other methods and doubts exist as to whether isotopic ratio measurements in the context of dismantlement transparency can be carried out reliably, if at all. If measurements are determined to be feasible, there is still the question of their uniqueness. Nevertheless, the method has the advantage of being passive, uses off-the-shelf instruments, and the data-analysis method is well understood and easily implemented. We recommend continued investigation of this method through the remainder of this fiscal year, with further review of its efficacy near year's end.

The Radiography method, while intuitively pleasing, requires the acquisition of extremely sensitive signatures and further requires the development, from scratch, of a robust automated image comparison algorithm that does not itself reveal classified or sensitive information. We believe that this technology is too immature to pursue further at this time.

While the measurement of radiation signatures could be a valuable tool in confirming warhead dismantlement, all the technologies investigated in this study have some undesirable properties. One of these common to the technologies is that all of the signatures have the potential for the unintended release of classified information. This is not because of the inadequacy of technology, but due to the inherent intrusiveness of monitoring something as sensitive as dismantling a nuclear weapon.

Summary

Measuring radiation signatures from nuclear warheads and their components in the process of dismantlement holds the promise of being an important method to enhance confidence that nuclear warheads are indeed being dismantled. If radiation signatures prove to be a practical approach to monitoring warheads going into dismantlement and the components coming out, it would allow each side to achieve increased confidence without the highly intrusive monitoring of the actual dismantlement process itself.

The most promising technologies for application to the warhead dismantlement problem are the Gamma Radiation Signatures Method for correlation of pits, and possibly CSAs, to warheads, the Fission Product Tagging method for correlation of pits (and possibly CSAs) to warheads, and NWIS for correlation of CSAs (and possibly pits) to the warheads. Current experimental work will determine if these technologies can serve as useful tools to monitor warhead dismantlement.

APPENDIX F

COST ANALYSIS

COST ANALYSIS

INTRODUCTION

Cost estimates for a complex activity still in the scoping and conceptual planning stage, such as monitoring of warhead dismantlement under an international arms control treaty which has yet to be negotiated, are by necessity approximate. All costs reflected in this analysis are projections of costs associated with warhead dismantlement monitoring options that have been generally defined. The cost estimates given in this Appendix are therefore not budget-quality numbers. However, the study group found them useful in discussing the financial impact of the four warhead dismantlement monitoring options discussed in the study report. As a warhead dismantlement monitoring regime becomes better defined and specific procedures are developed, the cost estimates will become more definitive.

For monitoring of warhead dismantlement in the United States, most of the dismantlement monitoring activities would occur at the Pantex and Y-12 plants, with a significant majority of the activities, and costs, occurring at Pantex. For the purposes of this study, therefore, only the costs estimated to be incurred at Pantex have been studied in detail. Facilities represented in the graphics in this report are included for cost estimating only. The actual magazines, bays, cells, etc. used in a warhead dismantlement monitoring regime may differ from these illustrated.

COST BREAKDOWN

- The cost estimates for each option reflect a projection of all costs associated with:
  - preparing for and hosting a first-time inspection, including the cost of site and procedure modifications (including construction costs).
  - preparing for and hosting each of the routine inspections which follow the first-time inspection.
  - the annual cost of routine inspections, which will be the cost per routine inspection times the number of routine inspections per year, plus miscellaneous costs not attributable to individual inspections.

An additional cost factor, the cost of lost productivity due to monitoring activities, was considered by the study group, but it was decided to include lost productivity in evaluating the "Impact on Operations" of the four monitoring options, rather than including it as a dollar cost.

Initial Inspection Cost

The first inspection under a given warhead dismantlement monitoring option would be more costly than the routine regularly recurring inspections which follow, due to one-time site and facility modification costs and preparation costs. Preparation activities include all tasks the facility must complete prior to the arrival of inspectors at the site.

Cost of Each Routine Inspection

The routine inspections which follow the initial inspection will also involve preparation costs, but these in general will not involve construction costs, major facility modification costs, etc. This cost category represents the routine cost of preparing for and hosting each individual inspection after the initial modifications have been completed.

Annual Cost

Annual inspection costs for the routine regularly recurring inspections under an ongoing arms control treaty include the preparation activities that the facility must complete prior to the arrival of inspectors at the site, hosting activities that the facility must accomplish while the inspectors are at the site, and recovery activities to return the site to normal operations after the inspectors depart the site.

COST ESTIMATE ASSUMPTIONS

The basic assumptions used in structuring the cost analysis follow.

Caveats

The following assumptions are intended for use in generating cost estimates for the four monitoring options. They represent current thinking within the Department of Energy concerning a possible warhead dismantlement monitoring regime at Pantex. An actual warhead dismantlement monitoring regime under a START III treaty would result from extensive interagency discussion within the U.S. Government and intergovernmental negotiations with the Russian Federation, and may differ considerably from the assumptions presented in this Appendix.

The study group assumed that the Department of Energy will work with the Pantex operating contractor to put in place a set of procedures and regulations fully consistent with cost-effective operations under a future arms control treaty requiring transparency or verification measures for monitoring of the warhead dismantlement process, while maintaining the high standards of security and environmental, safety, and health responsibility currently in effect at Pantex and continuing to fulfill the Department's responsibility to maintain a safe, secure, reliable nuclear weapons stockpile. Without such changes in the Pantex procedural and regulatory guidelines, the cost of implementing any of the warhead dismantlement monitoring options discussed in this report would be considerably higher than the cost estimates given in this Appendix.

It may be possible to perform inspections at the Unclassified-Confidential National Security Information level. It is assumed that the legal mechanism (a General Security of Information Agreement or Executive Order) for sharing classified National Security Information with the inspectors will be in place. If it is necessary to exchange Restricted Data/Formerly Restricted Data with the inspectors, it is assumed that an Agreement for Cooperation allowing the exchange of such information under the Atomic Energy Act of 1954, as amended, will be in place.

Inspections

- Only Treaty Limited Items (warheads scheduled for monitored dismantlement and/or pits, canned subassemblies, and other nuclear and nonnuclear components removed from such warheads) will be subject to inspection.
  - Dismantlement of Treaty Limited Items will continue without interruption before, during, and between inspections, except as required to prepare for and recover from inspections.
- The inspectors will have the right to conduct a discrete number of routine inspections per year.
  - In order to have a definite number for planning purposes, cost estimates were prepared based on up to 12 routine inspections per year.

- The inspections will be of two types, regular inspections and short-notice inspections, with different advance notice required for each type of inspection.
  - For the purpose of cost estimates, it was assumed that the up to 12 routine inspections per year will consist of up to 8 regular inspections, which require 30-day advance notification of arrival date at Pantex, and up to 4 short-notice inspections, which require 48-hour advance notification of arrival date at Pantex.
  - The cost estimates were based on regularly recurring monthly inspections.
  - Pantex will prepare the declared buildings/facilities/areas for inspection prior to the arrival of the inspectors.

- Each inspection will be of relatively short duration.
  - For the purpose of cost estimates, it was assumed that each inspection will last up to one week (five working days).

- For the purpose of making cost estimates, it was assumed that there will be no permanent presence of inspectors in Options 1, 3, and 4.
  - The annual cost for routine inspections for Options 1, 3, and 4 will include the cost per inspection times the number of discrete inspections per year, plus miscellaneous costs not attributable to individual inspections.

- The inspectors will have a "permanent presence" in Option 2, in order to perform Portal Perimeter Continuous Monitoring of a segregated, dedicated portion of Zone 12.
  - In Option 2 the inspectors will be permitted to perform a discrete number of Option 1 type inspections in Zone 4, in addition to permanent presence PPCM inspection in Zone 12.
    - The annual cost for Option 2 will include the annual cost for permanent presence in Zone 12, the cost per inspection for discrete inspections in Zone 4 times the number of discrete inspections per year, plus miscellaneous costs not attributable to individual inspections.

- There will be a limited number of inspectors per inspection team.
  - For the purpose of making cost estimates, it was assumed that there will be up to 10 inspectors per inspection team.

- The inspectors will have the right to divide into a limited number of inspection parties.
  - For the purpose of making cost estimates, it was assumed that the inspectors will have the right to divide into up to three inspection parties.

Declarations

- As part of the declarations which are a part of all the options, the United States will provide to the inspectors, on an annual basis, information on Treaty Limited Item dismantlement schedules and projected Treaty Limited Item warheads and component storage activity during the coming year.
  - As part of the annual declarations, the United States will declare which Pantex storage areas (and dismantlement areas if applicable for a given option) will be used for Treaty Limited Items during the coming year.

- The inspectors will receive periodic updated declarations of activities involving Treaty Limited Items. For the purpose of making cost estimates, monthly declaration updates were assumed.
- The inspectors may choose to visit any of the buildings/facilities/areas which are declared to involve Treaty Limited Items, subject to the restrictions of the various warhead dismantlement monitoring options.
- The inspectors will not be permitted to visit additional areas.

Adding and Removing Facilities From Eligibility for Inspection

- It may be possible to occasionally add facilities to or remove facilities from the list of facilities eligible for inspection in order to balance the treaty-related and non-treaty- related components of the Pantex workload.

  - It was assumed for the purpose of making cost estimates that during the regular declaration updates, facilities can be added to (promptly) or removed from (following a waiting period) the list of facilities eligible for inspection.
  - When a facility formerly declared to involve Treaty Limited Items is declared to no longer involve Treaty Limited Items, the inspectors will have one final "close-out inspection" opportunity to inspect that facility, to confirm that it does not contain Treaty Limited Items.

    -- For the purpose of making cost estimates, it was assumed that such a close-out inspection must be completed within 60 days of a declaration that a given facility will no longer be used for activities involving Treaty Limited Items.

  - Following the final opportunity for a close-out inspection, the inspectors will no longer have access to a facility removed from the list, until such time as it is declared, as part of a subsequent declaration update, that that facility again involves Treaty Limited Items.

Segregated, Dedicated Facilities for Warhead Dismantlement Monitoring Activities

- Activities related to U.S. responsibilities under an arms control treaty requiring transparency or verification measures for the monitoring of warhead dismantlement will be conducted in facilities segregated and dedicated to monitored dismantlement or monitored storage of Treaty Limited Items, both in Zone 4 (for all options) and in Zone 12 (for options 2, 3, and 4).

  - The construction costs and other costs involved in establishing a set of facilities segregated and dedicated to the monitored dismantlement or monitored storage of Treaty Limited Items, both in Zone 4 (for all options) and in Zone 12 (for options 2, 3, and 4), are included in the cost analysis for the initial inspection for each option, and the costs of maintaining a set of facilities segregated and dedicated to the monitored dismantlement or monitored storage of Treaty Limited Items are included in the cost of routine inspections for each option.

Safety and Security Procedures

- To ensure that safety and security are maintained, special safety and security procedures taking into account the presence of inspectors will be in effect during inspections in the segregated, dedicated portions of Zone 4 and Zone 12 when inspectors are present.

  - Normal operations, and normal safety and security procedures, will be in effect in the remaining portions of the Pantex plant.

  - Pantex regulations and operating procedures will be changed, with the assistance of the Department of Energy, to allow this to happen.

Non-Treaty Limited Item Activities

- Normal Pantex operations involving non-treaty-related activities such as the Stockpile Laboratory Test and Stockpile Lifetime Extension programs will continue without interruption in the portions of Zone 4 and Zone 12 not involving Treaty Limited Items, before, during, and after the routine regularly recurring inspections conducted under the treaty.
  - Pantex operating procedures and regulations will be changed, with the assistance of the Department of Energy, to allow this to happen while maintaining the current high standards of security and environmental, safety, and health responsibility currently in effect at Pantex.
  - Structural modifications will be made to buildings, facilities, and security perimeters to allow normal operations to continue in the portions of Zone 4 and Zone 12 not related to activities involving Treaty Limited Items.
  - The cost of establishing such structural modifications should be included in the cost estimates for the initial inspection under each option, and the cost of maintaining such structural modifications should be included in the annual cost estimates for each option.

Zone 4 Modifications

- The segregated, dedicated portion of Zone 4 will initially contain at least two empty storage magazines, one suitable for the storage of Treaty Limited Item warheads scheduled for dismantlement and one suitable for the storage of Treaty Limited Item pits removed from dismantled Treaty Limited Item warheads.
  - The cost of emptying the storage magazines included in the dedicated, segregated portion of Zone 4 should be included in the cost estimate for the initial visit under each option.
- If required in order to allow normal Zone 4 operations to continue in the portions of Zone 4 not involving Treaty Limited Items before, during, and after inspections, an opaque barrier (e.g., a wall or fence) may be constructed between the segregated, dedicated portion of Zone 4 and the remainder of Zone 4.
  - The cost of establishing such an opaque barrier is included in the cost estimates for the initial inspection under each option, and the cost of maintaining such an opaque barrier, is included in the annual cost estimate for each option.
  - As the mix of work at Pantex changes over time, additional magazines can be added to the segregated, dedicated portion of Zone 4 as required by operational needs from time to time, by, for example, extending the opaque barrier to include additional empty storage magazines required for the storage of Treaty Limited Items, subject to declaration and waiting period requirements as discussed above.
  - As the mix of work at Pantex changes over time, magazines can be removed from the segregated, dedicated portion of Zone 4 as required by operational needs from time to time by, for example, modifying the opaque barrier to no longer include magazines which are no longer required for the storage of Treaty Limited Items, subject to declaration and waiting period requirements as discussed above.
- If required in order to allow normal Zone 4 operations to continue before, during and after inspections, an opaque barrier (e.g., a wall or fence) may be constructed between the portion of Zone 4 available for normal Zone 4 operations not involving Treaty Limited Items and the roads used for transport of Treaty Limited Items between the dedicated, segregated portions of Zone 4 and Zone 12.
  - The cost of establishing such an opaque barrier is included in the cost estimate for the initial inspection under each option, and the cost of maintaining such an opaque barrier, if required, is included in the annual cost estimate for each option.

Zone 12 Modifications

- The same segregated, dedicated portion of Zone 12 will be used for monitored dismantlement of Treaty Limited Items in Options 2, 3, and 4.

  – A continuously monitored perimeter will be established around the segregated, dedicated portion of Zone 12 in Option 2.

- For the purposes of this study, the cost estimates assume that the dedicated, segregated portion of Zone 12 will initially contain at least one loading dock, one dismantlement cell, one disassembly bay, and one LINAC.

  – It may be more cost effective to include more bays and cells in the segregated, dedicated portion of Zone 12, to balance workload between treaty-related and non-treaty-related activities and to minimize construction costs.
  – For example, the following facilities including 11 bays and 4 cells may be well-suited for inclusion in the dedicated, segregated portion of Zone 12:

    - Ramp 12-R-98.
    - A loading dock at a roll-up door in ramp 12-R-98.
    - Cells 12-98-1, 12-98-2, 12-98-3, and 12-98-4.
    - The portion of Building 12-84 west of ramp 12-R-84, including 11 bays, one LINAC, and one break room.

- For Option 2 the dedicated, segregated portion of Zone 12 will be separated from the remainder of Zone 12 by the construction of temporary opaque barriers (e.g., temporary walls) in the ramps connecting the dedicated, segregated portion of Zone 12 to the remainder of Zone 12.

  – For Options 3 and 4 the dedicated, segregated portion of Zone 12 will be separated from the remainder of Zone 12 by the posting of security personnel and the appropriate use of escorts or by the construction of temporary opaque barriers (e.g., temporary walls) in the ramps connecting the dedicated, segregated portion of Zone 12 to the remainder of Zone 12.
  – Bays or cells can be added to or removed from the dedicated, segregated portion of Zone 12 from time to time, as operational needs require, by moving the temporary opaque barriers or security personnel separating the dedicated, segregated portion of Zone 12 from the remainder of Zone 12, subject to treaty requirements concerning declarations, waiting periods, and close-out inspections as discussed above.
  – The cost of establishing the opaque barriers or security personnel is included in the cost of the initial inspection under each option requiring them, and the cost of maintaining the opaque barriers or security personnel is included in the annual cost of each option requiring them.
  – For example, the dedicated, segregated portion of Zone 12 could be established in the facilities mentioned above by installing temporary opaque barriers (for example, temporary walls) or security personnel in the following locations:

    - A temporary opaque barrier or security person in ramp 12-R-98 between Building 12-99 and Building 12-98.
    - A temporary opaque barrier or security person in ramp 12-R-104 at the north exit from Building 12-84.
    - A temporary opaque barrier or security person in the north corridor in Building 12-84, between the entrance to the break room and ramp 12-R-84.
    - A temporary opaque barrier or security person in the south corridor in Building 12-84, between the LINAC and ramp 12-R-84, chosen carefully to both allow access to the LINAC from the dedicated, segregated portion of Zone 12 and to avoid interference with non-Treaty Limited Item traffic in ramp 12-R-84.

- For the purpose of making cost estimates, it is assumed that a portal to the dedicated, segregated portion of Zone 12 will be constructed, including a separate, dedicated loading dock, located, for example, at a roll-up door in ramp 12-R-98.
  - Such a portal would include a covered loading dock similar to, but smaller than, Building 12-117, office space for the inspectors, and a break room with ventilation sufficient to allow smoking.
    - It would probably be necessary to have separate break rooms for inspectors and Pantex personnel to avoid fraternization.
- In Option 2, an additional opaque barrier (e.g., a temporary wall with a door) or security person would be required to separate the portal from the remainder of the dedicated, segregated portion of Zone 12.
  - For Option 2, portal monitoring will be done at the portal to the segregated, dedicated portion of Zone 12, and perimeter monitoring will be done by remote monitoring of the inner walls of the segregated, dedicated portion of Zone 12, including the temporary opaque barriers separating it from the remainder of Zone 12.
- It should be noted that additional planning and execution of rearranging of magazine contents might be required in Zone 4, depending on dismantlement status and enduring stockpile activities at the time of signing of the START III treaty.

Traffic Between Zone 4 and Zone 12

- When they are present for an inspection, the inspectors would have the right to accompany, as a part of the convoy and with appropriate security escorts, the movement of Treaty Limited Item warheads and/or components between the segregated, dedicated portions of Zone 4 and Zone 12.
  - In Option 1 the inspectors would leave (for convoys enroute to Zone 12) or join (for convoys enroute to Zone 4) the convoy at the gate to Zone 12.
  - In Options 2, 3, and 4 the inspectors would have the right to accompany the Treaty Limited Items to and from the portal to the separate, dedicated portion of Zone 12.
- Traffic for normal Zone 12 operations not involving Treaty Limited Items will continue without interruption before, during, and after inspections, except when inspectors are present and in a position to be able to observe such traffic (e.g., when the inspectors are traveling to and from the portal to the segregated, dedicated portion of Zone 12).
  - Treaty Limited Item traffic and normal traffic not involving Treaty Limited Items will enter and leave Zone 12 through the same gate, but will proceed to and from different loading docks.

On-Site Inspection Agency

- The On-Site Inspection Agency (OSIA) will provide and budget for escorts and linguists.
  - One OSIA escort or linguist will accompany each group of inspectors throughout each inspection.
  - OSIA will provide and budget for travel and living arrangements for the inspectors.

Inspection Equipment and Role of Pantex Personnel

- Equipment required for the inspections will be provided by the inspectors or by the U.S. Government, and is not included in the cost estimates.
  - Pantex personnel will move/calibrate/set-up equipment under monitoring by the inspectors.
  - Pantex personnel will take measurements under monitoring by the inspectors.
  - For the purpose of the cost estimates, it is assumed that all personnel involved in inspection activities will work regular eight-hour days, and overtime will not be required.
  - Pantex personnel will work one, two, or three shifts per day as required for workload requirements and cost-effective operations involving Treaty Limited Items.
    - The inspectors will have the right to be present when operations involving Treaty Limited Items are being performed, subject to limitations on the number and duration of inspections and the constraints of each option.
    - In the permanent presence Option 2, the inspectors would have the right to be present 24 hours per day.

COST ESTIMATES FOR WARHEAD DISMANTLEMENT MONITORING OPTIONS

A detailed cost estimate was performed, based on the assumptions discussed above, for each dismantlement monitoring option, using the Inspection Cost Analysis Model (ICAM) developed for the DOE Office of Arms Control and Nonproliferation. These cost estimates are based on many uncertain parameter choices, since the details of an arms control treaty requiring monitoring of warhead dismantlement remain to be negotiated. The cost estimates presented here should therefore be regarded as preliminary, and are intended only to highlight differences among the four warhead dismantlement monitoring options.

The costs estimated for an initial inspection (including one-time site and facility preparation costs), a routine regularly recurring inspection, and for 12 routine regularly recurring inspections (one year) are shown in Table F1.

Table F1. Cost Estimates for Warhead Dismantlement Monitoring Options.

Option 1: Monitored Storage
Option 2: Portal Perimeter Continuous Monitoring of a portion of Zone 12
Option 3: Chain of Custody from monitored storage to and from the dismantlement bay or cell
Option 4: Direct Observation or Remote Monitoring of the dismantlement process in the bay or cell

	Cost of First Inspection[1]	*Cost of Routine Inspection*	*Annual Cost*[2]
Option 1	$2.5 M	$0.12 M	$1.5 M
Option 2[3]	$12 M	N/A[3]	$7.0 M
Option 3	$6.5 M	$0.2 M	$2.5 M
Option 4	$6.5 M	$0.2 M	$2.5 M

1 Substantial site and facility preparation would be required for an initial inspection which would not be required again for regularly recurring routine inspections.
2 Twelve routine inspections are assumed per year, of 5 days each.
3 Option 2 would require permanent presence of inspectors for PPCM of a dedicated portion of Zone 12. In addition, the annual cost estimate for Option 2 includes twelve Option 1 type inspections in Zone 4 per year.

ON-SITE INSPECTION AGENCY COSTS

Table F1 addresses DOE costs incurred by Pantex for warhead dismantlement monitoring. In addition to these expenditures, costs would be incurred by the On-Site Inspection Agency (OSIA) in performing escorting and linguistic duties, and for logistics support for the inspectors. These costs are incurred for all four monitoring options, and are relatively similar in all the options. Based on recent Russian visits to Lawrence Livermore National Laboratory (LLNL) and to Y-12, OSIA estimated that during the preparation phase for an initial visit, the agency will spend a total of approximately $18,000 for an initial site visit and a subsequent walkthrough site visit. During a regularly recurring inspection visit, OSIA expects to spend approximately $8,000 in support of the inspectors' visit to Pantex for transportation, lodging, meals, etc., and approximately $7,500 on escort activities at Pantex during the inspection. Depending on the level of involvement of Y-12 in warhead dismantlement monitoring activities, the annual cost to OSIA of supporting any of the four monitoring options at Pantex is therefore expected to be about $200,000. OSIA activities in support of monitoring of the disassembly of canned subassemblies at Y-12 would be expected to have a similar cost.

COST FACTORS

Several factors directly influence the cost estimate for each option. These factors are intrusiveness, production stoppage and lost production, and construction.

Intrusiveness. The most significant cost factor is intrusiveness. Typically, the more intrusive the inspection, the higher the inspection cost. Inspections are considered intrusive when they allow the inspectors to enter large or sensitive areas of the site. Preparation efforts then become larger in scope, more training is required of site personnel, more areas need to be safeguarded, more planning, scheduling and coordination is required, and more items need to be moved. An inspection that allows inspectors into a large number of areas within the site or involves sensitive processes is also likely to significantly impact production, unless the procedural and regulatory modifications detailed above were implemented.

At Pantex, options that are comprised of activities that allow inspectors to visit Zone 12 incur higher costs than those that would essentially contain the inspection within Zone 4 and terminate at the gate of Zone 12 (Option 1). If inspectors visit areas that are not common to visitors, such as Zone 12 South, personnel will require extra training and the area will require more preparation. Therefore, Options 2, 3, and 4 are more costly than Option 1 because they allow inspectors the most access to the site. This is particularly true for the initial visit under each option.

Production Stoppage and Lost Production. For safety and security reasons, some or all production operations would be suspended during the inspection, regardless of the monitoring option, unless significant procedural and regulatory changes were made. At Pantex, for options which directly involve Zone 12, there may be competition for facility resources that could significantly affect the dismantlement program schedule. Lost production costs have been included in estimating the impact on operations of each option, assuming substantial relief from current procedural and regulatory constraints.

Construction. For all options, Pantex or Y-12 would need to modify one or more facilities in preparation for inspections. Construction costs have been included in the cost estimates for the initial inspection under each option.

REMOTE MONITORING

The following assumptions were made concerning remote monitoring conceptual designs for the purpose of making cost estimates.

Option 1

- Start with two empty magazines, one for warheads and one for pits
- Two video cameras monitoring each magazine
    - Each camera in the field of view of the other
    - Normal operating power will be provided by basic electrical service
    - Cameras will be installed in tamper indicating housings with emergency UPS
    - Video signals will be authenticated
    - Both cameras triggered by "activity" at the magazine entrance and system will record the activity until the magazine is secured.
    - Both cameras triggered by seismic sensor detecting tunneling or other "forced entry" activities.
- System will be functional at all times
- Cameras will be mounted on existing poles if possible, otherwise poles will be installed as necessary in such a manner as to avoid the disclosure of Pantex security activities.
- Data collection and transmission system essentially the same as the Argonne West/Kurchatov remote monitoring system.
- Data transmitted to MINATOM in Russia by telephone, satellite, or a combination of both.
- All transmitted signals also recorded locally.

Option 2

- Zone 4 remote monitoring as in Option 1
- PPCM area of Zone 12 will be segregated as described in the assumptions above
- Eight (8) CCTV cameras to be used to monitor interior of the outside walls of the ramps which constitute the perimeter of the dedicated, segregated area
    - Normal operating power will be provided by basic electrical service
    - Cameras will be installed in tamper indicating housings with emergency UPS
    - Video signals will be authenticated
- Cameras will be capable of operating at all times
- CCTV signals will be hard wired to the inspectors' portal monitoring station
- CCTV signals will be temporarily recorded on a 24-hour cycle. No permanent record of the signals will be kept
- Alarms on the emergency exits and outside exits for equipment rooms will be received at the inspectors' portal monitoring station

Option 3

- Zone 4 remote monitoring as in Option 1
- No additional remote monitoring requirement

Option 4

- Zone 4 remote monitoring as in Option 1
- The proposed segregated area in Zone 12 will contain 1 LINAC cell, 4 dismantlement cells, and 11 dismantlement bays.
- Every cell and bay where dismantlement activities take place will be equipped with CCTV to facilitate remote monitoring of those activities
- Four (4) CCTV cameras will be used to monitor the interior of each cell as well as the equipment interlock, passages, and staging areas associated with the cell
  - Two out of the four cameras will monitor the interior of the cell where the actual dismantlement takes place. Only one will be operating; the other will be in a stand-by mode.
  - *Thus only one camera actually will be used to monitor the dismantlement operation.*
- Three (3) CCTV cameras to be used to monitor the interior of each bay as well as the equipment interlock, passages, and staging areas associated with the bay
  - Two out of each of the three cameras will monitor the interior of the bay where the actual dismantlement takes place. Only one will be operating; the other will be in a stand-by mode.
  - *Thus only one camera will actually be used to monitor the dismantlement operation.*
- For each cell and bay:
  - Field of view will be determined by dismantlement activity in the cell or bay
  - Normal operating power will be provided by basic electrical service
  - Cameras will be installed in tamper indicating housings with emergency UPS
  - Video signals will be authenticated
  - Cameras will be under the control of Pantex technicians at all times
- CCTV signals will be hard wired to the ramp outside of the individual bays and cells.
- CCTV signals will be temporarily recorded on a two-hour cycled. No permanent record of the signals will be kept

APPENDIX G

IMPLEMENTATION PLAN FOR THE DISMANTLEMENT STUDY GROUP

IMPLEMENTATION PLAN FOR THE DISMANTLEMENT STUDY GROUP

Action Items:

1. The leading warhead radiation signature technologies should be tested on U.S. nuclear weapons currently undergoing dismantlement to determine whether they can be used in a START III dismantlement monitoring regime. Specifically, the Nuclear Weapons Identification System (NWIS), gamma-ray spectral measurements, gamma-neutron threshold measurements, multiplicity fingerprint measurements, and the Controlled Intrusiveness Verification Technology (CIVET) should be tested immediately on the B61 Mod 5 (a representative bomb) and W69 (a representative warhead) which are currently undergoing dismantlement at Pantex.

   Date Due: October 1, 1997
   Lead Agencies: *NN-40/20*
   DOE/AL

   Comments: *DP and NN have drafted a memo requesting that such demonstrations take place as soon as possible. Such demonstrations must be performed so as not to interfere with ongoing operations at Pantex.*

2. A Working Group should be established to conduct an in-depth analysis of the use of a dedicated dismantlement facility, such as the Device Assembly Facility (DAF) at the Nevada Test Site. The analysis should include a review of the cost, schedule, and impact issues associated with performing START III dismantlement activities at the DAF. The cost analysis should include budget quality estimates that can be compared with the costs of using existing facilities at Pantex to support START III dismantlement activities. The DAF Working Group will include representatives from DP, NN, AL, NV, Pantex, LLNL, LANL, SNL, and will make recommendations to the DOE Warhead Dismantlement Transparency Task Force.

   Date Due: November 1, 1997
   Lead Agencies: NN/DP-13

   Comments: *DAF Working Group study should include detailed cost, schedule, and impact analysis. The security benefits of using DAF should also be documented.*

3. A more in-depth cost and impact analysis should be performed of the four warhead dismantlement monitoring options. A cost and impact analysis working group should also be established to facilitate the cost analysis with representatives from the Office of Defense Programs, the Albuquerque Operations Office (AL), and the Pantex Plant. The study group should be chaired by DOE/AL and will provide the results of their cost and impact analysis to the DOE Warhead Dismantlement Transparency Task Force.

   Date Due: November 1, 1997
   Lead Agency: DOE/AL

   Comments: *Study should be initiated immediately to provide a more thorough analysis of costs associated with implementing a monitoring regime at Pantex.*

4. A comprehensive glossary of definitions and terms relevant to warhead dismantlement should be developed. This should also include a comprehensive list of the applicable acronyms relevant to the dismantlement process.

   Date Due: November 1, 1997
   Lead Agencies: *DP, NN*

   Comments: *In order to ensure that the U.S. has a comphrensive list of agreed definitions, DOE should prepare the glossary as soon as possible.*

5. A ***quantitative*** analysis should be performed, to the maximum extent, to determine the level of confidence and inadvertent loss of classified information for each of the options considered in the report. NN, DP, LLNL, SNL, LANL, Pantex, and Y-12 will participate in this quantitative analysis.

   Date Due: December 1, 1997
   Lead Agency: NN

   Comments: *Study should be initiated immediately to provide a more thorough quantitative analysis of these two criteria.*

6. An Irreversibility Working Group should be established to conduct an analysis of various irreversibility options similar to that conducted for the various transparency and verification options. The Irreversibility Working Group will evaluate options consistent with the Helsinki Summit requirement that transparency measures should promote the "...irreversibility of deep reductions including the prevention of a rapid increase in the number of warheads." The Irreversibility Working Group should make recommendations on whether irreversibility requires that material from dismantled nuclear warheads be stored in forms other than components. The Irreversibility Working Group will include representatives from NN, MD, DP, LLNL, LANL, SNL, Pantex, and Y-12 and will make recommendations to the DOE Warhead Dismantlement Transparency Task Force.

   Date Due: December 1, 1997
   Lead Agencies: MD, NN, DP

   Comments: *The Irreversibility Working Group should consider the ongoing Trilateral Initiative as part of its analysis. The Irreversibility Working Group will issue a report by December 1, 1997.*

7. An in-depth analysis of the impact of a warhead dismantlement monitoring regime on the DOE Oak Ridge Y-12 Plant should be conducted. In the eventuality that a reciprocal warhead dismantlement monitoring regime may require that CSAs be monitored, DOE should be prepared to address the security, costs, and impact issues associated with monitoring the disassembly of CSAs at Y-12.

   Date Due: December 1, 1997
   Lead Agencies: ORO, Y-12

   Comments: *Y-12 issues were generally discussed in the Dismantlement Report. However, an in-depth analysis should be conducted to fully address Y-12 issues.*

8. An in-depth analysis should conducted to evaluate the security and vulnerability issues associated with performing any radiation measurements on nuclear warheads and/or components for both classified and unclassified measurements. Particular attention should be focused on evaluating security and vulnerability issues associated with performing classified measurements on those warhead types that could conceivably be dismantled under START III and still remain as part of the active enduring stockpile (e.g., the W76). The Security and Vulnerability Working Group will include representatives from DP, NN, AL, Pantex, LANL, LLNL, PNNL, and SNL and make recommendations to the DOE Warhead Dismantlement Transparency Task Force.

   Date Due: January 1, 1998
   Lead Agencies: NN
   DOE/AL

   Comments: *Study should be initiated immediately to provide a more thorough analysis of security and vulnerability issues associated with START III dismantlements.*

9. A Working Group should be established to conduct an independent assessment of the issues associated with tracking non-nuclear components. This analysis should include: a cost-benefit analysis of the monitoring of non-nuclear components, a determination of the classification issues associated with allowing Russians to track the disposition of non-nuclear components, red-teaming requirements needed to implement monitoring of non-nuclear components, and issues associated with the potential reuse of some non-nuclear components. This Working Group will include representatives from NN, DP, AL, Pantex, Y-12, LANL, LLNL, and SNL.

Date Due: January 1, 1998
Lead Agencies: DP, NN

***Comments:** Because many non-nuclear components are classified and may be reused, an analysis of non-nuclear component monitoring should be undertaken.*

10. An analysis should be performed of the feasibility of incorporating measures to protect classified information as part of the Seamless Safety for the 21st Century (SS-21) process. As currently designed, the SS-21 process has no provisions for protecting the classified information as part of the dismantlement process. This Working Group will include representatives from NN, DP, AL, Pantex, LANL, LLNL, and SNL.

Date Due: January 1, 1998
Lead Agencies: DP, AL, Pantex

***Comments:** Although it may be possible, in principle, to incorporate such measures as part of the SS-21 process, a thorough review of the needed measures, and their impact on the safety of the dismantlement process, will determine the feasibility of incorporating those measures into the SS-21 process.*

11. Following completion of a more in-depth cost and impact analysis of the four warhead dismantlement monitoring options and the DAF, DOE should reach consensus on its preferred and recommended option. If the preferred option is to use Pantex, DOE should also make specific recommendations on which weapons and pit storage magazines in Zone 4 and which bays and cells in Zone 12 should be segregated and dedicated for use in a START III treaty. This recommended DOE option should be developed and agreed to by the DOE Warhead Dismantlement Transparency Task Force, the Dismantlement Study Group, and the DP Executive Management Team.

Date Due: February 1, 1998
Lead Agencies: DP/NN/AL

***Comments:** DOE should make a recommendation on its preferred option consistent with its other priorities of stockpile maintenance and dismantlement.*

12. A peer review group should be established to evaluate the operational issues of the techniques being conducted on representative systems currently undergoing dismantlement at Pantex. The peer review group will include representatives from DP, NN, PNNL, LANL, LLNL, SNL, Pantex, and Y-12 as well as experts in security issues. The peer review group will comparatively evaluate the data from each of the warhead radiation signature technologies and make specific recommendations on next steps to the DOE Dismantlement Transparency Task Force.

Date Due: February 1, 1998
Lead Agency: PNNL

***Comments:** NN-20 and NN-40, who are co-funding the demonstrations, will draft a memo establishing the Peer Review Group. Peer Review Group conclusions are due February 1, 1998.*

13. DOE should develop an integrated schedule that incorporates the requirement to conduct activities associated with maintaining a safe, secure, and reliable stockpile (e.g., SLTs and LEPs) but also incorporates new dismantlement requirements under START III in a manner that will minimize the impact to Pantex. The schedule will be developed by DP in conjunction with AL and the Executive Management Team.

Date Due: TBD
***Lead Agency:* DP**

Comments: *Development of an integrated schedule will depend on a revised NWSM that specifies which weapons would be dismantled under START III.*

14. The Pantex Mission Statement will need to be modified in order to facilitate implementation of a START III treaty. In particular, current regulations and procedures that require all normal operations cease when foreign visitors are present will need to be changed to facilitate implementation of transparency measures under a START III regime. DP and AL, in conjunction with Pantex, will have the lead for this action.

Date Due: TBD
***Lead Agencies:* DP**
DOE/AL

Comments: *This action should commence after a more in-depth review of existing regulations and procedures is conducted.*

15. Conduct an in-depth analysis of potential warhead dismantlement monitoring activities that could be implemented at Department of Defense facilities. Such a study should identify potential monitoring procedures that could be implemented at various stages of Department of Defense custody of the weapon, including:

- When the warhead is on the delivery vehicle and during the time of removal of the warhead from the delivery platform.
- The appropriate starting point for chain-of-custody procedures for gravity bombs and cruise missiles, which are typically stored or staged in a location separate from the delivery system.
- When the warhead is at a storage depot or other storage location where retired warheads are stored prior to being picked up a Safe Secure Trailers (SSTs) for transportation to the DOE dismantlement facility.

Date Due: TBD
***Lead Agency:* DoD**

Comments: *The DoD monitoring options study should be conducted immediately to fully address potential transparency and verification options at DoD facilities.*

16. A study should be undertaken to identify and evaluate options for warhead dismantlement monitoring that could be implemented in the Russian nuclear weapons complex. Such a study should use as a basis the generic monitoring activities identified in the DOE study so that a comparative analysis of options could be performed.

Date Due: TBD
***Lead Agency:* DOE/NN-30**

Comments: *Study should be led by DOE/NN-30 and involve other agencies, as required.*