- 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
  - B61, Mod 5
  - W56
  - 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
  - W78
  - B83
  - W88
  - W76
  - W80
  - W87

- 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.