Report to Congress on the Defeat of Hard and Deeply Buried Targets

Submitted by the
Secretary of Defense
In Conjunction with the
Secretary of Energy

In Response to Section 1044 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, PL 106-398

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EXECUTIVE SUMMARY

This Report responds to Section 1044 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, PL 106-398, that requires the Secretary of Defense, in conjunction with the Secretary of Energy, to report on the defeat of hardened and deeply buried targets and chemical and biological agents. Section 1044 calls for:

- A review of requirements;
- an assessment of plans to meet those requirements;
- identification of potential future targets, research and development efforts, and options to defeat these future targets; and
- an estimate of cost to accomplish the various options.

Our potential adversary's weapons of mass destruction (WMD), long-range missiles, modern air defenses, most sophisticated command and control systems, national leadership in wartime, and a variety of tactical arms are increasingly concealed and protected by networks of hard and deeply buried facilities. If the United States does not have the means to defeat these facilities and the threatening assets they protect, adversaries may perceive that they have a sanctuary from which to coerce or attack the United States, its allies, or its coalition partners with threats much more powerful than in past conflicts.

The strategy and acquisition initiatives for the families of systems (including both intelligence and operations programs) summarized in this report will improve our national capability to accomplish each of the following necessary steps:

- Find and locate Hard and Deeply Buried Targets (HDBTs), their network connections, and civilian surroundings;
- characterize these HDBTs, including function, interrelationships, configuration, degree of threat, equipment, operational status, operational and collateral attack risks, and vulnerabilities;
- plan and practice multiple and diverse options for action, well ahead of any crisis, to make capabilities crisis-decision-ready;
- attack in a timely and integrated manner to neutralize HDBT functions and/or WMD agents; and
- assess attack outcomes and potential consequences to promptly support further military and political decisions.

Recent Activities

Each potential adversary's set of HDBTs and their associated functions and supporting network capabilities are unique. Each set requires careful attention, well ahead of the time when combat or political action may be required. In the past decade, the Department of Defense (DoD), the Intelligence Community, and the Department of Energy (DOE) have collectively determined our military needs first and then selectively applied technologies and funded investments in existing Intelligence, Surveillance, and

Reconnaissance and weapon programs as our technology and knowledge of the threats have evolved.

The Director of Central Intelligence (DCI) in 1996 directed the organization of HDBT collection requirements and analysis, as well as research and development into advanced collection and surveillance techniques. All of the intelligence agencies now conduct research and development or operational work that contributes to this mission area. The DCI is now assessing these diverse efforts for additional organization and funding attention.

The Military Services and Defense Agencies, based mainly on the Defense Acquisition Board-sanctioned Hard and Deeply Buried Target Defeat Capability Analysis of Alternatives and Operational Command Mission Need Statements, have used extensive experimentation, demonstrations, and technology programs to improve weapons and surveillance systems, seeking to achieve a balanced set of strike and Intelligence, Surveillance, and Reconnaissance capabilities. Service "kinetic" conventional weapon system modifications, now ongoing, will provide improved lethality, increased standoff, all-weather precision, and very short flight-time against a variety of HDBT types. These programs include:

- Procuring and integrating the 5,000-lb class Enhanced GBU-28 laser-guided bomb on the B-2 Bomber; and procuring the GBU-24D/BLU116 precision 2,000-lb Advanced Unitary Penetrator bomb for smaller strike aircraft;
- Developing and procuring the Conventional Air-launched Cruise Missile Block II Penetrator, the Joint Standoff Weapon with the BROACH shaped-charge warhead, and special Joint Air-to-Surface Standoff Missile applications;
- Initiating the Tactical Missile System Precision Penetrator surface-to-surface missile Advanced Concept Technology Demonstration with operational "leave-behinds" that can address extremely time-sensitive objectives; and
- Conducting Intelligence, Surveillance, and Reconnaissance and strike concept experimentation and operational testing at a number of specialized sites around the US – forming a "national test bed."

These programs, which are enhancements of well-established operational systems, will together provide a package of conventional weapon capabilities by Fiscal Year (FY) 2005 that address some – but not all – HDBT needs. We are therefore going beyond upgrading conventional kinetic weapons and Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C^4ISR) capabilities:

- DoD and DOE have completed initial studies on how existing nuclear weapons can be modified to defeat those HDBTs that cannot be held at risk with conventional high-explosive weapons or current nuclear weapons. Any development and procurement of advanced nuclear capabilities would be considered in the broad context of nuclear stockpile policy, plans, and priorities, as well as future DoD strategic programs.

- DoD has conducted studies and experimentation on the application of Special Operations and Information Operations, with the necessary intelligence support, to the HDBT problem. These new approaches will place an even greater burden on intelligence and will require a focused effort.

- Specialized "WMD Agent Defeat Weapon" development projects have been initiated, aimed at destroying or otherwise neutralizing an enemy's ability to use his chemical or biological weapons. Also, DoD and DOE are jointly developing methods to predict potential collateral effects from attacks against an adversary's chemical or biological weapons, as well as improved delivery tactics to minimize collateral effects. However, additional work is needed to understand the effects of rupturing stored chemical or biological weapons and to develop effective means of neutralizing the agents or preventing agent dispersal, particularly for biological agents.

- Based on a wide variety of past science and technology achievements, current strategies and budget plans for FY02 and beyond provide for HDBT-focused science and technology activities by DoD, DOE, and Intelligence Community components. These will address the full measure of needed mission capabilities for Intelligence, Surveillance, and Reconnaissance, strike planning, and system deployment.

Supporting all of these direct actions against HDBTs and chemical/biological agents, special C⁴ISR programs, now in development, will be leveraged to enhance intelligence capabilities to find, characterize, and assess damage against HDBT networks and chemical/biological agents. Moreover, these families of capabilities will be made interoperable with strike capabilities.

Looking To The Future

The US response to future HDBT and WMD Agent Defeat challenges will benefit from strengthened collaboration among the Intelligence, Operations, Requirements, Acquisition, and Science and Technology communities. The Combatant Commands and Joint Staff, with national technical support, have integrated mission needs and support capability requirements for HDBT Defeat into a Capstone Requirements Document (CRD) recently approved by the Joint Requirements Oversight Council. The CRD provides: 1) an overall approach to integration of national intelligence, acquisition, and combatant capabilities and pre-crisis operational planning, and 2) specific and practical objectives that guide development of families of intelligence and military capabilities that will evolve as we know more about the threat.

The Under Secretary of Defense (Acquisition, Technology and Logistics) and the Vice Chairman, Joint Chiefs of Staff, have directed integrating oversight of all HDBT intelligence enhancements, attack capabilities acquisition (kinetic weapons, information operations techniques, and special operations tools), mission planning activities, and science & technology efforts. The challenge is to build and maintain unified DoD, DOE, and Intelligence Community activities focused against HDBTs, their networks, and WMD defeat.

Based on the CRD and continuous intelligence inputs, the Strategic Review in 2001 has led to plans and budgets for FY02 that advance an overall strategy to accomplish, by 2005, substantial improvements over current capabilities. Key elements are the selective

funding and modification of established programs and integration of wide-ranging capabilities, either now operational or in development. Technically achievable improvements in intelligence awareness and analysis, operational planning and execution practice, and acquisition initiatives will advance our capabilities to address evolving threats and enemy vulnerabilities in a methodical and affordable way. However, we also must prepare for those unique and emerging strategic threats that are critical and well protected, both physically and through focused camouflage, concealment, and deception programs. This will require additional investment in intelligence, special weapons, and counter-WMD capabilities, including nuclear weapons. Comprehensive reviews of feasibility and cost for suitable nuclear and conventional weapons and their associated operations concepts are still underway to support DoD and DOE budget decisions in the coming two years.

In conjunction with DOE and the Intelligence Community, DoD has now moved beyond conceptual assessments and debates about the threat protected by HDBTs. There are no easy answers to either the HDBT or WMD Agent Defeat challenges, and certainly no "silver bullets." Solutions will take time, expansion of intelligence assets and capabilities, well-reasoned resources, technological progress, and steadfastness of direction. Even with the current strategy and acquisition initiatives, the United States will still not be able to hold all known or suspected HDBTs at risk for destruction, especially the deep underground facilities. Several major shortcomings, mentioned in the unclassified report and described in the classified annex, still exist that require further initiatives and investments. Sustained management attention and multi-year Congressional budget support are necessary to ensure that intelligence and technology efforts provide funded capabilities to meet the HDBT and WMD Agent Defeat challenges, and to ensure that fielded capabilities become part of military practice and confidently support our security policy.

1 Report Content

This report responds to the requirements of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (Public Law 106-398, Title X, Subtitle E, Section 1044.):

> Report on the Defeat of Hardened and Deeply Buried Targets
>
> (a) STUDY- The Secretary of Defense shall, in conjunction with the Secretary of Energy, conduct a study relating to the defeat of hardened and deeply buried targets. Under the study, the Secretaries shall:
>
> (1) review - (A) the requirements of the United States to defeat hardened and deeply buried targets and stockpiles of chemical and biological agents and related capabilities; and (B) current and future plans to meet those requirements;
>
> (2) determine if those plans adequately address all such requirements;
>
> (3) identify potential future hardened and deeply buried targets and other related targets;
>
> (4) determine what resources and research and development efforts are needed to defeat the targets identified under paragraph (3) as well as other requirements to defeat stockpiles of chemical and biological agents and related capabilities;
>
> (5) assess both current and future options to defeat hardened and deeply buried targets as well as concepts to defeat stockpiles of chemical and biological agents and related capabilities; and
>
> (6) determine the capability and cost of each option assessed under paragraph (5).
>
> (b) CONDUCT OF ASSESSMENTS- In conducting the study under subsection (a), the Secretaries may, in order to perform the assessments required by paragraph (5) of that subsection, conduct any limited research and development that may be necessary to perform those assessments.
>
> (c) REPORT-
>
> (1) Not later than July 1, 2001, the Secretary of Defense shall submit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives a report on the results of the study conducted under subsection (a). The report shall be prepared in conjunction with the Secretary of Energy.
>
> (2) The report under paragraph (1) shall be submitted in unclassified form, together with a classified annex if necessary.

This report summarizes past work, identifies the requirements to defeat hard and deeply buried targets (HDBTs), and itemizes ongoing programs and plans of the Department of Defense (DoD) and the Department of Energy (DOE) to meet these requirements. The report also addresses specific questions raised by the Congress under Section 1044. A classified annex is provided for material that cannot be discussed in unclassified form.

2 A Brief Introduction to Hard and Deeply Buried Targets

2.1 What is a Hard and Deeply Buried Target?

The term "hard and deeply buried target" (HDBT) refers to an adversary's threatening and well protected assets in structures ranging from hardened surface bunker complexes to deep tunnels. These facilities are typically large, complex structures incorporating the attributes of concealment, self-sustainment, multifaceted communications, strong physical security, modern air defenses, and siting in protective (often mountainous or urban) surroundings. In many countries, HDBTs are elements of a well-connected network of operational capabilities with duplication – a very important factor for both intelligence and strike planning. These facilities are protected for good reason – they are an essential element of any likely battle or crisis action. Such facilities routinely serve as: leadership shelters; command, control, and communications (C^3) centers; weapons production, assembly, storage and deployment facilities, especially for weapons of mass destruction (WMD); missile operations tunnels and garrisons; and point or integrated area defense system facilities.

2.2 Threats Made Possible by Hard and Deeply Buried Targets

Many nations have located critical operations in these facilities. The Cold War and its associated nuclear weapons capabilities prompted development of a wide range of hardened underground facilities in the former Soviet Union, North Korea, China, and the former Warsaw Pact countries. Many hardened facilities were also constructed in NATO nations to protect critical infrastructure from Soviet attack. However, the end of the Cold War did not result in an end to this method of concealment and protection. The Persian Gulf War and the series of conflicts in the Balkans revealed that facility protection, by hardening, concealment, and defenses, remains an effective response to the technology advantages in intelligence and weaponry enjoyed by the United States and its allies.

This same trend is prominent in the Third World, especially among "rogue nations" whose possession of WMD has led to serious efforts to protect these lethal resources. The Intelligence Community (IC) suspects with reasonable certainty that there are over 10,000 potential HDBTs worldwide and their numbers will increase over the next 10 years. Moreover, modern communications provide for high-tech network connectivity and even mobile capabilities that can be garrisoned in HDBTs. Denial and deception efforts further complicate the location, identification, and characterization of HDBTs. This places a high premium on human intelligence (HUMINT) and wide-area surveillance as sources of information to find, characterize, and assess HDBTs.

Many protected facilities are of shallow "cut and cover" design with a concrete structural overburden of less than ten feet thickness. ("Thickness" is measured in terms of equivalent reinforced concrete thickness; actual thickness of combined structure, rock, and soil may be considerably more.) This type of facility typically has a tactical function, like support to artillery or missile launchers. Many of them can be held at risk by current or developmental weapons, if our weapons numbers are adequate, accurate target location coordinates are known, and defenses overcome. The missile operations tunnels and armament bunkers in some theaters are particularly troublesome because of their sheer numbers, protective berms, and the strategic positioning of their entrances/exits away from direct routes of attack.

Hundreds of much harder facilities (having a concrete overburden equivalent of 70 to 300 feet) protect strategic functions (e.g., leadership, command and control, WMD) and were built using either conventional drill-and-blast tunneling techniques or more modern mining equipment. These are typically equipped with redundant ventilation, power, and communications systems. US capabilities to place these types of facilities at risk are not only challenged by the depths of burial and redundancies in critical functional systems, but also by sophisticated camouflage, concealment and deception (CCD) techniques, and some collocation of HDBTs in civilian areas. Such facilities conceal and protect an adversary's most valued and strategic capabilities.

Additional information on the challenges posed in finding HDBTs (i.e. detecting, locating, and identifying), characterizing potential vulnerabilities and attack risks, planning defeat options, decisively attacking, and assessing effectiveness of these actions is documented in Classified Annex A – Section 1 – Strategic Threat.

2.3 The Challenge of WMD

Physical destruction of hard and deeply buried structures is not enough if the WMD – for example, a biological agent stored inside the facility – remains viable or is released into the environment. This could cause casualties to innocent civilians and allied forces, and result in environmental contamination – either of which could hinder allied force operations and/or movements.

The US has so far emphasized technologies to attack and defeat WMD agents stored in the open or in soft structures. The ability to satisfactorily resolve these important technical challenges will set the stage for adapting new WMD Agent Defeat technologies to the overall problems posed by adversarial WMD protected by HDBTs. Current technology can potentially provide survivable warhead options that will penetrate an HDBT facility and defeat the WMD agent inside.

3 Accomplishments to Date

A number of integrated studies, as well as separate Service and Agency initiatives and program modifications, have advanced the overall capability for the defeat of HDBTs.

3.1 Summary of Previous DoD/DOE HDBT Defeat Activities

Following Operation DESERT STORM, the Office of the Secretary of Defense (OSD) brought together intelligence, combatant command, and acquisition specialists to define the technical, operational, and policy challenges concerning HDBTs. As a result, the Departments of Defense and Energy, with support from the Intelligence Community, have been formulating requirements and leveraging or integrating current systems with new technologies:

- In 1994, US Strategic Command (USSTRATCOM) and the Combat Air Forces (represented by Air Combat Command) each issued a Mission Needs Statement (MNS) for HDBT Defeat Capability that were subsequently consolidated. This consolidated MNS defined the spectrum of HDBTs without reference to the geographical area of Unified Commander-in-Chief (CINC) responsibility, and without prescribing weapon system concept solutions.

- The Joint MNS initiated a formal requirements and acquisition process for an HDBT Defeat Capability Phase 0 Concept Exploration acquisition study for kinetic non-nuclear concepts. An HDBT Defeat Integrated Product Team (IPT) was established in 1995 to conduct the study. The effort was conducted in two parts: Part 1, Mission and Concept Screening, and Part 2, Concept Definition.

- As Part 2 of the Phase 0 Concept Exploration, an Analysis of Alternatives (AoA) was conducted during 1997-1999 to address intelligence and strike issues related to defeating HDBTs. Service-planned weapons were effective against many of the targets, assuming adequate intelligence was available. Given a sufficient quantity of weapons and delivery platforms (e.g., forward-based as a result of warning), a large number of the target locations were accessible at reasonable risk despite defenses, and these systems would not require excessive support. Thus, the principal recommendation as a result of the AoA was for the Services not to develop new weapons concepts, but rather to buy more of the currently available or projected weaponry with modest-cost modifications – i.e. no major system new-starts. However, the AoA found that: 1) not all HDBTs could be defeated by current or conceptual weapons and, 2) a standoff weapon was required for the case of heavily defended targets in areas with few forward-based US forces. This, together with the need for more effective payloads, provides the rationale for additional Science and Technology (S&T) emphasis in standoff systems, all-weather precision guidance, and more energetic explosives. Deeply buried targets, generally accessible by tunnels, were only vulnerable to functional defeat by closing the access points (called adits). S&T efforts are needed to improve the defeat of such targets. The AoA did not address agent defeat or nuclear solutions. Most importantly, the Intelligence, Surveillance, and Reconnaissance (ISR) requirements to support functional and structural defeat planning, assessments, and objectives were judged to be substantially more demanding on the intelligence collection and analysis system. Further

discussion on conventional weapons is included in Section 5 of this unclassified report and in the Classified Annex A – Section 2 – Conventional Weapons.

- A classified study in 1997 addressed nuclear solutions for holding the most challenging HDBTs at risk. Based on the fact that the HDBT Defeat AoA had focused on conventional solutions and highlighted an inability to destroy all HDBTs with current or projected weapons, Project SAND DUNE was convened as a special study to fully address the joint Air Force and USSTRATCOM Mission Needs Statement published in 1994. Further discussion on nuclear weapons is found in Classified Annex A – Section 3 – Nuclear Weapons.

- A Defense Science Board (DSB) Task Force on Underground Facilities (1996-1998) documented certain limitations of current weapon and ISR technologies. The Task Force reviewed the threat to US interests posed by the growth of underground facilities in unfriendly nations, and investigated technologies and techniques to meet the challenges of finding, characterizing, and neutralizing these facilities.

- In 1999, DoD and DOE reported to Congress on a pilot effort for S&T programs to develop improved capabilities for defeating HDBTs. This pilot project is a collaboration of DoD, DOE, and the Intelligence Community and builds on existing interagency projects.

- Over the past few years, a variety of experiments and demonstrations have been conducted to defeat HDBTs including: the Defense Threat Reduction Agency (DTRA)-funded *Counterproliferation Advanced Concept Technology Demonstrations* (ACTDs); a series of live and static tests against scale and full-size structures that duplicate construction of HDBTs found elsewhere in the world; a "national test bed" in western states for ISR and strike experimentation and demonstrations; and USAF penetration tests for weapons such as the GBU-28 to demonstrate the ability of these weapons to penetrate hard rock. Additionally, demonstrations of precision guidance, high-speed penetration into weathered granite and testing of high-velocity fuze components have been conducted by the Air Force Research Laboratory through their *Missile Technology Demonstration* to support future standoff weapon needs. Classified Annex A – Section 4 – Intelligence, Surveillance and Reconnaissance, provides an overview of the demonstration and experimentation activities of the Intelligence Community, DOE, DTRA, and the Defense Advanced Research Projects Agency (DARPA).

- US Special Operations Command (USSOCOM) participated in the conventional weapons AoA as well as in the experiments and demonstrations described above. However, there were no explicit performance and cost analyses of Special Operations Forces (SOF) capabilities in the AoA. Discussion will be found in Classified Annex A – Section 5 – Special Operations. Over the past three years, Information Operations (IO) studies have been directed at support of the HDBT Defeat mission to supplement the kinetic weapon capabilities. Discussion will be found in Classified Annex A – Section 6 – Information Operations.

Figure 1 is a chronological display of recent activities to improve HDBT Defeat capabilities.

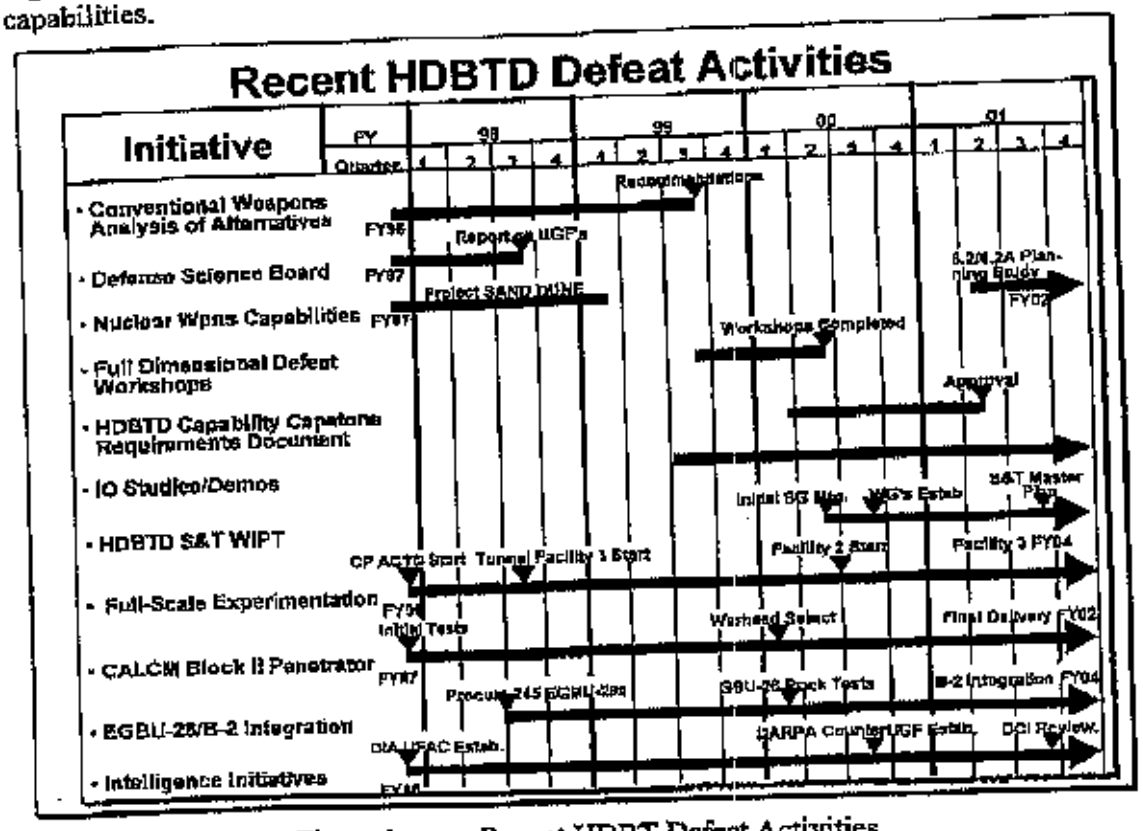

Figure 1 Recent HDBT Defeat Activities

3.2 WMD Agent Defeat Capability Against Chemical and Biological Weapons

Concern is growing about use of HDBTs to protect WMD production and deployment, especially chemical and biological weapons (CBW). The HDBT and CBW agent problems clearly overlap. Underground facilities can hide research, production, weaponization, and storage functions related to CBW agents. While current and projected US weapons are estimated to have destructive impact on relatively shallow structures, there remains the problem of what to do with CBW agents that are present inside the site during an attack. Mechanisms to destroy, neutralize, immobilize, disable or deny access to the potential adversary's WMD assets are needed, whether the assets are in underground structures, surface buildings, or in the open. In 1994, the Combat Air Forces issued a Mission Need Statement for development of a WMD Agent Defeat weapon. The subsequent Air Force Milestone 0 Acquisition Decision triggered an AoA, which is still underway. For greater detail on the WMD Agent Defeat AoA and the technologies that may be useful in satisfying this mission need, see Classified Annex A – Section 7 – Agent Defeat Weapons.

4 Validated Requirements

4.1 Requirements for HDBT Defeat Capability

In October 1999, the Vice-Chairman, Joint Chiefs of Staff, requested that a Capstone Requirements Document (CRD) for HDBT Defeat be developed. All of the players and experience described in the previous section supported USSTRATCOM and USSOCOM in the CRD composition. By approving a CRD in January 2001, the Joint Requirements Oversight Council (JROC) validated the following key performance parameters (KPP):

- **KPP-1, C^4I Interoperability:** The HDBT Defeat family of systems (FoS) must be interoperable among the Joint Force Commander (JFC), components, and supporting agencies to provide a collaborative planning and execution capability.
- **KPP-2, Find:** The HDBT Defeat FoS must facilitate locating and/or identifying HDBTs through collection, integration, and analysis against HDBT attributes to meet national strategy and CINC and/or JFC guidance and objectives with a level of confidence sufficient to merit further prioritization and characterization.
- **KPP-3, Characterize:** The HDBT Defeat FoS must have the ability to determine the function, operational status, and vulnerabilities of identified HDBTs, and provide the CINC and/or JFC a level of characterization sufficient to plan and attack those HDBTs nominated for targeting.
- **KPP-4, Plan:** Combatant planners require deliberate, collaborative HDBT Defeat planning and decision support applications that allow for intelligence estimates/uncertainties and the precision required by the weapons and methods of attack.
- **KPP-5, Full Dimensional Defeat:** HDBT Defeat FoS must have the ability to disrupt, seize, recover, render safe, neutralize, or deny critical functions for all types of HDBTs. [The CRD also states that Full Dimensional Defeat includes physical destruction of HDBTs.]
- **KPP-6, Combat Assessment:** (1) JFCs require combat assessment capability with sufficient fidelity to determine if timely follow-on attacks are required. (2) For WMD targets, this capability must provide prediction, detection, identification, and characterization of hazards following a strike and the ability to transfer that data without significant delays following a strike.

The objectives and thresholds for these KPPs, and further discussion concerning the CRD, are contained in Classified Annex A – Section 8 – Capstone Requirements Document.

4.2 Requirements for WMD Agent Defeat Capability

In addition to technology applications needed for defeat of hard or deeply buried facilities, capabilities also are required for effective engagement of biological or chemical warfare agent threats, while minimizing collateral agent effects. A number of specific requirements were validated by the Air Force Requirements Oversight Council:

- WMD target identification and characterization are required, both for production and storage facilities and for weaponized munitions. Some production facilities are inherently dual-capable; the facility can be used for legitimate civilian operations one day and to produce prohibited agents the next. Signatures may be difficult to obtain and analyze.

- Planning systems must deal with the special considerations involved in attacks against CBW targets, allowing enough time for appraisal of the unique and potentially lethal considerations.

- Special payloads are required to defeat a broad range of CBW agents, and to cope with target physical variations (e.g., agent type, agent containers, container layout, and facility structural design), with reasonable dependence on intelligence to distinguish either agent types present or internal facility configurations. Agents are likely to be within munitions or containers, which complicates attacks because mechanisms that might neutralize exposed agent may not be able to directly access the WMD materials.

- Ordnance employing fragmentation and blast effects will not accomplish this objective, and may further worsen the situation by releasing agents into the atmosphere and surrounding environment. In some situations, there may be a need for multiple types of payloads to accomplish several objectives. For example, in the case of CBW located within a hardened facility, the goals might be *in situ* neutralization of the agents plus access-denial that prevents adversaries from recovering and using agents or production equipment not destroyed. This class of problems is the most vexing challenge to defeat of HDBTs.

- Agent collateral effects must be predicted and minimized. Target-induced collateral damage is a specific concern. For example, an attack on a surface or shallow-buried facility containing stocks of CBW agents, using conventional bombs or cruise missile warheads, might result in the facility being breached and agent hazards dispersed. Weapon-induced collateral effects also need to be predicted and minimized. Emphasis here has included approaches for defeat mechanisms that involve explosions that allow *in situ* neutralization or reduced blast effects (with less potential for dispersal of both target- and weapon-induced hazards) and measures that would mitigate agent hazards during or following attack.

Additional discussion on WMD Agent Defeat Weapon Capability is provided in Classified Annex A – Section 7 – Agent Defeat Weapons.

5 Programs Responsive to the Capstone Requirements Document

5.1 Background

HDBT Defeat activities during the 1990s were spread among the Services and Agencies in DoD and DOE as separately funded and relatively low-level projects providing threat assessments, requirement formulation, concept explorations, and initiatives for "tweaking" previously funded and executed major system programs. However, in the last few years, there has been increased emphasis on an integrated approach to HDBT defeat and the status of a number of recent initiatives is described in the paragraphs that follow.

5.1.1 C^4I Interoperability

The HDBT Defeat Family of Systems will be organized to provide the warfighter with rapid and simple access to standardized, ready-to-use target information to facilitate timely planning and execution of necessary operations. The HDBT Defeat Command, Control, Communications, Computers, and Intelligence (C^4I) Support Plan was developed to begin documentation of C^4I infrastructure support requirements for specific HDBT Defeat systems. The plan's concepts will lead to a robust communications network to transmit requirements, unprocessed and processed intelligence, imagery-derived intelligence, and geospatial information to warfighters and DoD decision-makers.

5.1.2 Finding, Characterizing, and Assessing Damage

The key to effective HDBT Defeat is integrated intelligence information and analysis that meets warfighter requirements. This involves integrating the full spectrum of intelligence disciplines (human, signals, measurement and signatures, imagery, etc.). The goal is a seamless, integrated architecture for planning and direction, collection, processing, production, and dissemination to quickly get a high-fidelity intelligence product to policy makers and warfighters. Achieving this goal is a significant challenge, representing some of the DoD's highest priorities and greatest challenges. Current programmatic shortfalls are itemized in the classified annex.

Finding an HDBT requires fused analysis of all sources of intelligence, including material from recent improvements in multi-spectrum sensors. The Intelligence Community has focused its all-source collection and analysis resources on this job. The Director of Central Intelligence (DCI) is directing the development of HDBT intelligence data-fusion capabilities that can index and cross-reference information as data become available, regardless of sources and methods involved.

Characterization of an identified HDBT, particularly in a denied area, has involved the Services, Agencies, Commands, and components of DOE. This team is collaborating to use available analyses and full-scale experimentation to develop an ISR strategy that is balanced and affordable. Experiments against instrumented facilities and integration of intelligence capabilities, ranging from overhead imagery to close-proximity sensors, have indicated potential fruitful avenues for further experimentation. However, sensor-access to rigorously denied areas and their included facilities still poses a significant ISR challenge.

The Intelligence Community addresses the HDBT Defeat problem in a multi-faceted approach. Efforts at finding and characterization have been spearheaded by the Defense

Intelligence Agency's (DIA) Underground Facilities Analysis Center (UFAC), which was established in 1997 by DCI direction to manage the Intelligence Community's collection and analysis efforts against underground facilities. The UFAC, in close coordination with the National Imagery and Mapping Agency's (NIMA) Underground Issues Branch and USSTRATCOM's HDBT Branch, performs intelligence analysis to support finding, characterizing, and defeating adversary strategic facilities. OSD has addressed the spectrum of technologies associated with the HDBT problem with a series of IPTs that bring together broad representation to focus research and development (R&D) resources more effectively on HDBT Defeat. For additional background information, including the shortfalls and limitations associated with intelligence, refer to Classified Annex A – Section 4 – Intelligence, Surveillance & Reconnaissance.

Combat assessment, which includes Bomb/Battle Damage Assessment, comprises both intelligence tools and observations by sensors associated with the strike platform. The all-source tools mentioned previously that partially address the "find" and "characterize" task requirements are typically able to assist with the determination of the effectiveness of an attack mission using kinetic weapons. These means can be supplemented by real-time aircrew observations or by sensors on the attacking platform. It may also be possible to determine "success" by identifying changes in the interaction between the objective HDBT and its external support systems or connections. The effectiveness of IO against the HDBT will directly benefit by observing this interaction. For SOF missions, the reporting of results should be prompt, direct, and of high confidence.

A pre-planned strike course of action, that can provide multiple options well ahead of a crisis, has enormous benefits. The need to attack an HDBT network may come with little warning, especially if WMD are involved to precipitate a crisis. The intelligence research and databases to support potential operations should be maintained at all times and for all potential adversaries. The CINC warfighters should therefore be able to plan missions on short notice. This will require a concerted effort to overcome existing limitations in our ability to find and characterize HDBTs. Short-notice response necessitates having planned most of the basics, allowing the minimum final operational details to be added during the short period that may be available in a crisis. Thorough "end-to-end" planning of missions against vulnerabilities identified through intelligence analysis includes practice by the warfighter (by simulation and at test ranges) ahead of any need to actually employ the capability. Confidence of our national leadership in the military's capability to execute a mission against any adversary's HDBT network, especially one providing sanctuary for WMD, will benefit from demonstrated capabilities with high confidence in results. Such confidence only comes with the combatant commander having a working familiarity with the delivery system and weapon's performance. Planning as envisioned by the overall HDBT Defeat strategy is a structured cycle between combatants, intelligence, and acquisition. See Classified Annex A – Section 9 – Mission Planning Tools for more details on current mission planning capabilities.

5.1.3 Defeat of HDBTs

The US Army, Navy, and Air Force are now modifying and demonstrating conventional weapon systems in response to the HDBT threat. Different Service capabilities cover a diverse range of methods, exploit different vulnerabilities for HDBT Defeat, and are coordinated to eliminate duplication. In addition, SOF and IO capabilities are being

brought to bear in a collaborative fashion. While there are no current programs for a new or modified nuclear weapon for HDBT Defeat, DoD and DOE are investigating potential options and costs. As mentioned earlier, studies have also pointed to shortfalls, enumerated in the classified annex.

US Air Force Programs

Near-term programs focus on development and production of existing penetrating weapon designs. Included in this effort are: the Enhanced GBU-28 program, integrating the 5,000-lb EGBU-28 laser-guided bomb onto the B-2 (enhanced with incorporation of inertial and Global Positioning System (GPS) guidance); expanded testing of the GBU-28 in hard rock formations at the White Sands Missile Range; equipping 50 Conventional Air-launched Cruise Missiles (CALCMs) with a penetrating warhead, based on the Advanced Unitary Penetrator bomb; application of the Joint Air-to-Surface Standoff Missile (JASSM) against many targets in the HDBT set; and demonstration of common aero vehicle technologies to evaluate capabilities against many targets in the HDBT set.

Supporting these systems is the FMU-159/B Hard Target Smart Fuze that will provide void and layer counting, and depth of burial capabilities for air-to-ground penetrator weapons. These capabilities will allow warfighters to compensate for target structure unknowns, while reducing collateral effects of blast and chemical and/or biological agent release.

The Air Force, with DTRA, DARPA, and DIA, is producing an integrated suite of modeling tools linking sensors, target model definition and modification, and lethality computation tools. This "proof-of-concept" follow-up to the HDBT Defeat AoA seeks to analytically link intelligence collection for mission planning and damage assessment with attack strategy and weapons capability in an "end-to-end" approach. Successful integration of methodology lessons learned from the AoA will result in a decision support tool for tradeoffs to be made among sensors and intelligence collection, operations planning, and weapon design.

US Navy Programs

The US Navy's efforts include: development of the GBU-24 (BLU-116 penetrator), an improvement of the existing BLU-109; development of a variant of the Joint Standoff Weapon (JSOW) with a penetrating warhead, incorporating the British Bomb Royal Ordnance Augmenting Charge (BROACH) technology; consideration of a penetrating version of the Tactical Tomahawk Land Attack Missile as a follow-on to the ACTD investment by DTRA; research on technologies for a supersonic cruise missile; and participation with the Army in the Tactical Missile System Precision Penetrator (TACMS-P) missile program, providing a precision reentry body.

US Army Programs:

The primary US Army program is the collaboration with the Navy in the TACMS Penetrator ACTD, approved by the JROC and Congress in FY01. TACMS-P will demonstrate the integration of the Army Tactical Missile System booster with a reentry vehicle and penetrator technology to provide a high-availability, all-weather, survivable and short response time means to destroy selected HDBTs. The Army is the lead service for the ACTD, with US Pacific Command (USPACOM) serving as the Operational

Sponsor. Scheduled completion is in FY04. The ACTD will provide six field-ready residual missiles for the sponsoring CINC and will provide a path to develop modular payloads for other potential weapon systems.

Figure 2 summarizes the major acquisition programs for kinetic weapons. The performance of these weapons is provided in Classified Annex A – Section 2 – Conventional Weapons.

Weapon	Service	Procurement	IOC
GBU-28/EGBU-28/BLU-113	AF	531	FY91/04
CALCM Block II Penetrator	AF	50	FY02
JASSM	AF/Navy	2400(AF)	FY03
TACMS Penetrator	Army/Navy	6	FY04
JSOW/BROACH	Navy/AF	3000	FY04
GBU-24D/B/BLU-116	AF/Navy	450	FY03

Figure 2 Non-Nuclear Kinetic Weapons for HDBT Defeat

Non-Kinetic Weapon Approaches

In addition to these kinetic weapon activities, concept exploration, experimentation, and demonstration activities with Special Operations and Information Operations have been directed specifically at the HDBT challenge, as specified in the Defense Planning Guidance.

USSOCOM continues its efforts to improve US capability for seizing and/or neutralizing WMD, as well as conducting special reconnaissance. The SOF community has developed, demonstrated, and trained on a large scale to enhance present capabilities and to formulate acquisition efforts for new tools in the coming five years. Details are provided in Classified Annex A – Section 5 – Special Operations.

Following 1999 studies on Information Operations possibilities for HDBT Defeat, initiatives are underway by the Joint Warfare Analysis Center (JWAC). Details are in Classified Annex – Section 6 – Information Operations.

Nuclear Weapons

There is no current program to design a new or modified HDBT Defeat nuclear weapon. However, DoD and DOE continue to consider and assess nuclear concepts that could address the validated mission needs and CRD. They have formed a joint Nuclear Planning Group to define the appropriate scope and option selection criteria for a possible design feasibility and cost study. Further information is provided in Classified Annex A – Section 3 – Nuclear Weapons.

5.2 WMD Agent Defeat

The Air Force Agent Defeat Weapon (ADW) Program focuses on the capability to destroy, neutralize, immobilize, or deny an adversary's access to biological and chemical agents, while minimizing collateral damage. The desired WMD Agent Defeat payload is one that completely and near-instantaneously provides *in situ* neutralization of agents, eliminating the risk of both short-term and long-term collateral hazards outside the facility.

The ADW program is currently in concept exploration and an AoA is to identify and evaluate concepts to satisfy the mission need identified by the 1994 Combat Air Forces Mission Needs Statement. Analytical tools developed to support ADW include agent release models, internal dispersion and venting models, and a neutralization model to evaluate current and conceptual weapons effectiveness against chemical and/or biological targets as follows:

- A model for predicting initial agent release conditions from a weapon fragmentation environment (i.e., *Agent Release Model*, or *ARM*);
- a model to predict the thermodynamic environment and the internal dispersion/transport/venting of agent within a structure, following weapon activation (i.e., *Venting of Internal Pressure from Energetic Reaction* model, or *VIPER*);
- a model to predict hot agent cloud stabilization within the atmosphere, following venting (i.e., *Hot Effluent Rise* model, or *HER*); and
- a model to predict chemical/biological (CB) agent neutralization for various neutralizing mechanisms such as heat, radiation, ultra-violet, etc. (i.e., *Empirical Lethality Model (ELM)*.

These models, as well as others, are used to predict such things as weapon penetration, target damage, collateral damage, etc., and have been integrated and linked together under a user-friendly, graphic user interface driven shell code called *Simulated Environment and Response Program Execution Nesting Tool (SERPENT)*.

Nuclear weapons have a unique ability to destroy both agent containers and CBW agents. Lethality is optimized if the fireball is proximate to the target. This requires high accuracy; for buried targets, it also may require a penetrating weapon system. Given improved accuracy and the ability to penetrate the material layers overlying a facility, it is possible to employ a much lower-yield weapon to achieve the needed neutralization. The ability to use a lower yield would reduce weapon-produced collateral effects. The current nuclear weapons stockpile, while possessing some limited ground penetration capability and lower yield options (not yet certified), was not developed with this mission in mind. Several DOE laboratories, (Sandia, Livermore, Los Alamos, and Oak Ridge) have participated in the Air Force's Agent Defeat Weapon programs. See Classified Annex A – Section 7 – Agent Defeat Weapons for additional details.

6 S&T: Meeting Future Threats

6.1 Introduction

The overall objective of HDBT and WMD Agent Defeat S&T programs is to redress shortfalls in current operational capabilities against future threats. Elements include current (kinetic) technology conventional weapons, Information Operations, Special Operations, nuclear weapons, new types of non-nuclear munitions, and ISR capabilities.

6.2 HDBT Defeat Efforts

The recently approved Capstone Requirements Document has been used to define the baseline for operational requirements. A Working IPT with broad participation has appraised current HDBT Defeat capabilities, drawing on the sensitivity analysis done as part of the AoA, and has identified areas in which new technology development would alleviate significant shortfalls. Prioritization for S&T resource investment will be established based on performance metrics set forth in the CRD as well as independent assessments of military utility, as supported by Service mission area planning, wargaming and other scenario-based exercises. Integrated S&T packages, spanning the entire spectrum of HDBT Defeat needs, are a part of funding starting in FY02. This section provides highlights from current S&T planning and programs. Classified assessments, including an assessment of shortcomings and challenges, are provided in various sections of the classified Annex A to this report.

6.2.1 Technology Development Activities

Technology development to improve capabilities for the defeat of HDBTs is a priority DoD S&T program, undertaken in collaboration with DOE.

Joint Warfighting Science & Technology Plan (Ongoing). In December 1999, the JROC approved a new Joint Warfighting Capability Objective, thereby designating HDBT Defeat as one of twelve S&T priorities for warfighter support. Ongoing S&T programs supporting this objective are detailed in Chapter XV, Hard and Deeply Buried Target Defeat, from the current *Joint Warfighting Science & Technology Plan.*

S&T Master Plan (New). OSD is developing an S&T Master Plan in response to the CRD. This activity has been led by the Deputy Under Secretary of Defense (S&T), with broad participation from other OSD offices, the Joint Staff, the Services, Defense Agencies, DOE and its National Laboratories, the Intelligence Community, and the combatant commands. DOE participation is part of the DoD-DOE pilot project in this area. The DoD program is taking advantage of unique technical capabilities available within the national labs.

6.2.2 Capability Shortfalls

Past efforts have resulted in a better appreciation of the different capability shortfalls associated with two sets of HDBT target types.

The first target set involves hardened surface or shallow-buried facilities. One issue is how to deal with the subset of these facilities that may contain a chemical or biological agent, without incurring undesirable target-induced collateral hazards (See Section 6.3). Another issue is how to promptly identify, characterize, and engage all time-critical targets.

The second target set (more difficult and smaller in number) involves more deeply buried facilities. Defeat of most of these facilities with conventional means—in the traditional sense of physical destruction—is impossible. The challenge for non-nuclear options is to achieve functional disruption through technologies spanning conventional ordnance, special payloads, Special Operations, and Information Operations.

For destruction of more deeply buried facilities, DoD and DOE are studying the sensitivities and synergies of nuclear weapon yield, penetration, accuracy, and tactics.

6.2.3 S&T Programs

Work relevant to HDBT Defeat involves new applications for technologies previously developed for multiple DoD missions. In addition, a number of approved Defense Technology Objectives (DTOs) are directed specifically at HDBT Defeat or WMD Agent Defeat objectives. Applicable DTO project titles are in *italics* below.

Some improvements in broad enabling technologies are common to a number of these efforts, for example:

- Guidance and navigation: Unmanned systems used for both information collection and attack;
- smart fuses that allow weapons to detonate after they have penetrated facilities and allow stylized attacks that exploit the effects produced by multiple detonations; and
- new types of munitions with advanced payloads, optimized to exploit unique vulnerabilities of HDBTs.

Finding, Characterizing, and Assessing HDBTs

Several initiatives are underway to provide enhanced information concerning HDBTs:

The *Counter Underground Facilities Program* is a DARPA effort to develop and demonstrate sensors for characterizing underground facilities, with initial emphasis on passive acoustic, seismic, electromagnetic, and effluent sensors, as well as advanced signal processing techniques.

Hard Target Functional Defeat Ordnance is a US Air Force effort to identify and defeat critical elements of a target, and correlate damage to each critical element into an overall assessment of the impact made on the primary target. It includes on-board bomb damage information packages.

Battle Damage Assessment in the Joint Targeting Toolbox ACTD is a US Air Force-managed effort that uses advanced artificial intelligence and evidential reasoning technologies to provide post-attack assessments.

Pre-attack planning and post-attack assessment

The DTRA *Integrated Comprehensive Weaponeering Capability project* is developing a comprehensive capability for pre-attack planning and post-attack assessment for the full spectrum of high-value fixed targets, with particular emphasis on WMD-related hard and deeply buried facilities.

Some of the inputs for the previous product are being developed in the DTRA *Lethality/Vulnerability Models for High-Value Fixed Targets* effort, which includes models for new types of munitions, e.g., high-temperature incendiaries; development and validation of models for damage inflicted on CBW facilities.

Reaching the target

Delivery systems must have adequate range and must be able to counter active defenses, through using either low observable weapons and delivery platforms or by employing high speed weapons.

Tactical Missile System – Penetrator ACTD program will demonstrate the integration of technologies for a ballistic missile-delivered penetrator weapon to rapidly damage or destroy HDBTs.

A Navy program, *Hypersonic Weapons Technology Demonstration*, is developing technologies needed for hypersonic strike weapons, with average velocities of Mach 5 to Mach 6 and with ranges of 400 to 700 nautical miles. The design objective is a highly accurate (circular error probable of less than 3 meters) system capable of penetrating 18 to 36 feet of concrete.

Improved guidance and sensors

Multiple efforts are underway to provide improved guidance and to counter natural or deliberate obscuration that might impede accuracy. For example, the *Counter Camouflage Concealment and Deception Advanced Technology Demonstration* is developing synthetic aperture radar for detection of targets that are hidden or obscured by foliage. The Concept of Operations under investigation would host this new sensor capability on a Global Hawk Unmanned Aerial Vehicle (UAV).

Conventional kinetic weapons

New initiatives specifically directed at HDBT Defeat and WMD Agent Defeat objectives are:

- *Target Characterization and Defeat Technology* develops methodologies for characterizing and modeling physical and functional aspects of tunnel complexes. It includes assessments of the operational impact of attacks; physics-based models for relevant weapons effects and weapon–target interactions; advanced tunnel defeat technologies; and a computerized planning tool for operational users.

- *Tunnel Defeat Technology Demonstrations* uses high-fidelity tunnel testbeds to improve end-to-end tunnel defeat capabilities for missile operations, C^3I, and WMD production and/or storage facilities.

Relevant work is also underway in the DTRA *Counterproliferation 2 ACTD* demonstration of penetrator versions of the Conventional Air-Launched Cruise Missile and Tactical Tomahawk.

A US Air Force program, *Novel Energetic Materials*, is evaluating alternatives to conventional munitions that would provide a two to five times improvement in energy density. Similar work also is being conducted under the auspices of the "DoD–DOE Joint

Conventional Munitions Memorandum of Understanding" to investigate highly energetic materials.

6.2.4 Candidate Initiatives for HDBT Defeat

The HDBT Defeat S&T Plan (currently in coordination) will recommend priorities for technology investments. In reviewing the results of HDBT Defeat past tests and analyses, there are substantial challenges in finding, characterizing, and assessing future HDBTs, as well as planning for and defeating the most deeply buried targets. Improvements to minimize collateral effects, reduce response time, and provide the capability to operate across the entire spectrum of conflict are additional requirements that are not unique to HDBT Defeat and benefit from research conducted by other programs.

6.3 WMD Agent Defeat Weapon Efforts

The research on WMD Agent Defeat technology is intrinsically related to HDBT Defeat research. The following efforts elaborate certain aspects of the ADW effort.

6.3.1 Technology Development Efforts

Chapter XII of the Joint Warfighting Science & Technology Plan, *Chemical/Biological Warfare Defense and Protection, and Counter Weapons of Mass Destruction*, addresses counterproliferation capabilities and counterforce operations, including WMD Agent Defeat. Section 7 within the classified Annex A of this document provides a more detailed summary of technology development, and includes development of a data-based model of agent neutralization used to support appraisal of potential weapon options and estimation of potential collateral hazards.

Under the *Agent Defeat Ordnance* program, the Air Force Research Laboratory is developing: (1) low-collateral-effects fragmentation warheads that minimize overpressure and create a neutralizing atmosphere for exposed or aerosolized agent, (2) advanced fuzing techniques that assist in precise control of weapon function timing and payload dispersal, (3) new penetrator designs that facilitate payload dispersal, (4) methods to quantify/predict target-warhead interaction and collateral effects, and (5) systems to transmit Battle Damage Information from within a target to an airplane or satellite regarding the performance of the munition against the target. These technologies will be considered for a follow-on weapon development program in the FY05-FY08 timeframe.

Counterproliferation 2 ACTD develops, demonstrates, and transitions to the warfighter improved capabilities for planning, executing, and assessing strikes on WMD-related fixed facilities, including penetration of hardened facilities with standoff weapons.

6.3.2 Capability Shortfalls

A key shortcoming in the Agent Defeat Weapon is the lack of a penetrating warhead with a payload that can defeat or neutralize CBW agent, especially in situations in which bulk storage vessels are breached and agents dispersed. There are additional shortfalls involving capabilities for finding, characterizing, and assessing CBW threats, as well as planning for and accomplishing the defeat of such targets.

6.3.3 S&T Programs

WMD Agent Defeat with Minimal Collateral Hazards

High temperature incendiaries containing biocidal chemicals provide promise for this mission if detailed intelligence can be gathered on targets of interest (e.g., room sizes, vent paths, agent type, etc.) Such munitions must be delivered directly in the facility where agents are present. The US Navy is considering an ACTD that would develop a high-temperature incendiary payload for use in a new kinetic energy penetrator. (The US Air Force and DTRA might participate in this effort, if it is initiated.)

The *DTRA Tunnel Characterization and Defeat Technology* effort includes appraisal of solid fuel-air explosives, when used against a simulated tunnel facility target. While there has been a limited amount of experimental research, high temperature incendiary munitions R&D has not progressed to weaponization or full-scale development. A limited amount of additional experimental work is programmed.

DTRA's *Prediction and Mitigation of Collateral Hazards*, will establish the capability to accurately predict and mitigate hazards when WMD materials are released into the atmosphere.

A variety of other options for functional defeat could possibly render CBW agent threats unusable without physically destroying all of the agents.

Timely Target Identification and Characterization, Prompt Planning and Execution of Attacks, and Combat and Collateral Hazard Assessment

Efforts are directed at developing improved capabilities for characterization of CBW targets, and at providing significantly improved capabilities for planning attacks and estimating collateral hazards. Examples include: the DTRA Counterproliferation 2 ACTD; the Target Characterization and Defeat Technology; Tunnel Defeat Technologies; Prediction and Mitigation of Collateral Hazards; Unmanned Aerial Vehicles developed in the *Counterproliferation ACTD* that can carry sensors to provide theater commanders with a chemical combat assessment system.

Nuclear Weapon for ADW

DoD has not defined a requirement for a nuclear weapon for WMD Agent Defeat missions. See Section 7 within the classified Annex A for further discussion.