Report of the
Defense Science Board Task Force
on
Future Strategic Strike Forces

February 2004

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DEFENSE SCIENCE BOARD

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MEMORANDUM FOR THE ACTING UNDER SECRETARY OF DEFENCE (ACQUISITION, TECHNOLOGY, AND LOGISTICS)

SUBJECT: Final Report of the Defense Science Board Summer Study 2003 Task Force on Future Strategic Strike Forces

I am pleased to forward the final report of the DSB Summer Study 2003 Task Force on Future Strategic Strike Forces. The effort, chaired by ADM Dennis Blair (Ret), Gen Michael Carns (Ret), and Mr. Vincent Vitto, carefully studied the nation's future strategic strike needs, identified a comprehensive analytical framework, and provided a set of fully justified and actionable recommendations.

These recommendations are designed to give future Presidents an integrated, flexible, and highly reliable set of strike options with today's tactical-level flexibility but on a global scale. In many cases, these recommendations will require the Department of Defense to create systems and processes that do not now exist, but I agree with the Task Force that the nature of the potential threat demands that we consider solutions that go beyond "improvements on the margin."

I endorse the Task Force's recommendations and propose that you review the Task Force Co-Chairs' memorandum and report.

William Schneider, Jr.
DSB Chairman

DEFENSE SCIENCE BOARD

OFFICE OF THE SECRETARY OF DEFENSE
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MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Summer Study 2003 Task Force on Future Strategic Strike Forces

The Defense Science Board Task Force on Future Strategic Strike Forces looked 30 years into the future with the objective of providing future Presidents an integrated, flexible, and highly reliable set of strike options with today's tactical-level flexibility but on a global scale. To this end, the Task Force identified currently planned systems that will still be relevant and recommended new systems for development.

The attached report details the Task Force's full analytical framework and includes definitions, an overview of current strategic policy, and the spectrum of potential 2030 contingencies. It also includes our complete set of recommendations, many of which will require the Department of Defense (DoD) to create systems and processes that do not now exist.

Here we would like to highlight a few of the key recommendations:

Command and control: Command and control is the integrating element of future strategic strike. Among other things, we recommend that STRATCOM define and lead the development of the operational command, control, communications, intelligence, surveillance, and reconnaissance (C3ISR) architecture essential for a netted, collaborative strategic strike network.

ISR and battle damage assessment (BDA): We believe that we are currently pushing the limits of what we can achieve from space and airborne platforms, particularly against adaptive enemies that are learning to disperse, move, and hide. We therefore recommend that SOCOM, in conjunction with the Defense Advanced Research Projects Agency (DARPA), develop technologies and systems for networked close-in sensors. The technologies developed should be fielded and demonstrated in a C3ISR test bed.

Delivery systems: The future strategic strike mission requires delivery systems that can (1) hit time-critical targets promptly from long ranges in poor weather; (2) destroy hard and deeply buried targets; and (3) perform these functions more reliably, accurately, and stealthily than battlefield systems. We therefore recommend a limited number of delivery systems able to meet these requirements. These proposed systems include 50 Peacekeeper ICBMs converted to a conventional role and a new Navy intermediate-range ballistic missile (IRBM).

Payloads: Payloads should be considered in a more wide-ranging way: not only can they be more effective and better tailored, they can also help other links of the kill chain. For non-nuclear payloads, we recommend that the Services procure a contingency arsenal of current successful special-purpose, non-nuclear weapons and that the Defense Threat Reduction Agency (DTRA) assume responsibility for technological development of non-nuclear strategic warhead and payload-delivered associated sensors. For nuclear payloads, we propose that the government significantly scale back planned life extensions in the Stockpile Stewardship Program (SSP) and shift the SSP toward a new vision: a stockpile based on previously tested nuclear devices/designs to provide weapons more relevant to the future threat environment.

Taken as a whole, we believe the complete set of recommendations detailed in the attached report will meet the Task Force's mandate and give future Presidents realistic, high-confidence strategic strike options to reassure friends, change the behavior of enemies, and protect American interests.

We have enjoyed the experience of working with the Task Force's highly knowledgeable members and advisors. We thank them for their insight, hard work, and commitment.

ADM Dennis Blair, USN (Ret), Co-Chair	Gen Michael Carns, USAF (Ret), Co-Chair	Mr. Vincent Vitto, Co-Chair

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1. Executive Summary

Here we outline our objectives and review the context of our analysis. We also summarize our key recommendations.

1.1 OVERVIEW

1.1.1 *Objective*

The Defense Science Board Summer Study Task Force on Future Strategic Strike Forces looks to the 30-year future with the objective of providing the President with a broad range of strike options to

- Protect the United States and our forces abroad,
- Assure friends and allies of our future commitment, and
- Deal with future adversaries on terms favorable to the United States.

The Task Force identified currently planned systems that will still be relevant and recommended new systems for development.

1.1.2 *Approach*

Figure 1-1 illustrates the Task Force's approach. We began by characterizing the strategic environment, moved next to assessing the role of strategic strike, and then identified shortfalls in current plans. We then analyzed these shortfalls and recommended appropriate solutions. These solutions—and the accompanying analysis—appear in chapters 2 through 6 of this report.

Throughout the study process, we also assessed future systems and technologies. The results of this assessment helped shape and guide the proposed solutions mentioned above. The conclusions of the future systems and technologies assessment appear in chapter 7 of this report (a supplemental appendix—to be published separately—will provide additional detail). Chapter 8 and appendix C summarize the impact of this assessment.

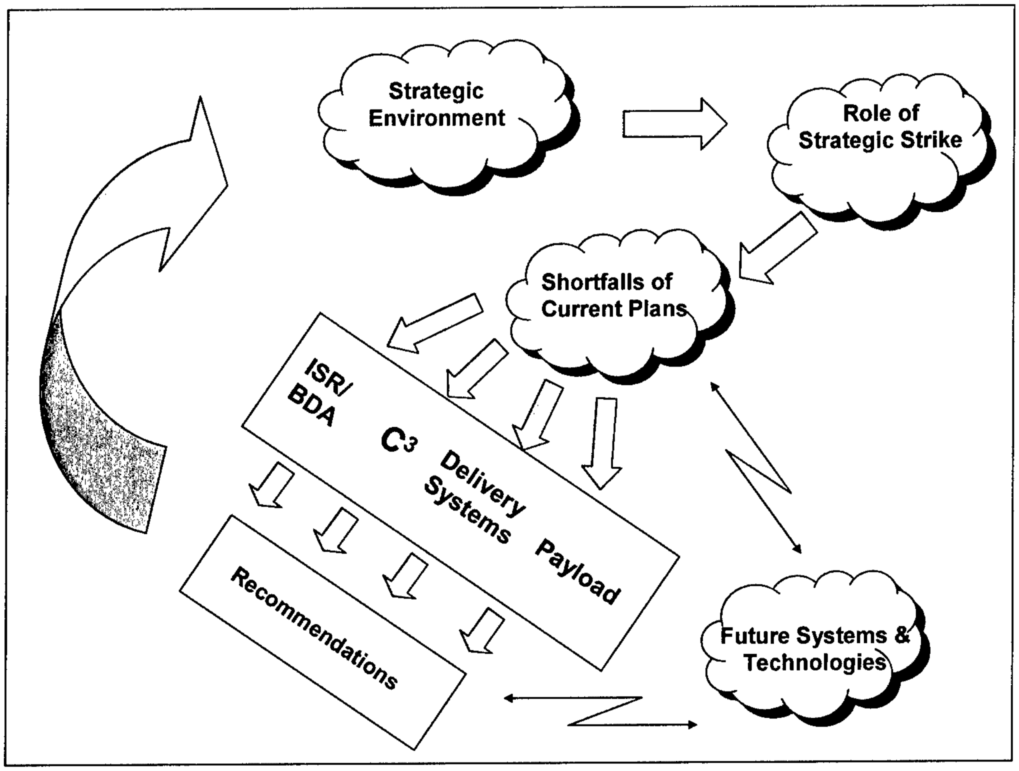

Figure 1-1: The Task Force's approach.

1.1.3 *Definition*

For the purposes of the Task Force, a strategic strike is "a military operation to decisively alter an adversary's basic course of action within a relatively compact period of time." A strategic strike can be either (1) an isolated event such as the Eldorado Canyon attack on Libya, or (2) part of a military campaign such as the Vietnam War's Linebacker II strikes or the attack on Saddam Hussein himself at the outset of Operation Iraqi Freedom.

1.1.4 *Policies*

The series of policy studies on strategic issues conducted by the current administration provides a basis for an orderly transformation of strategic capabilities and supporting forces. From the National Security Strategy, the Quadrennial Defense Review, the Nuclear Posture Review, and the Defense Planning Guidance the Task Force drew three key principles:

1. *Tailor capabilities for broad goals: assure, dissuade, deter, defend, defeat.* Assurance and dissuasion derive more from numbers, infrastructure, and enunciated policies than from technical details of systems; the Task Force concentrated on what is needed for deterrence, defense, and defeat.
2. *Shift from dependence on nuclear weapons to a synergistic combination of non-nuclear and nuclear strike forces, defenses, and a revitalized technical and industrial infrastructure.* The United States can build strong defenses

against all weapons of mass destruction (WMD) if that becomes practical, but effective and comprehensive protection is likely to be a matter of decades. It is more practical, more important, and most urgent to create strong defenses against rogue states and terrorist organizations.

3. *Shift from threat-specific scenarios to a capabilities-based approach to planning*. Because we cannot project the threat as accurately as we could in the past, we must have a flexible approach to planning that enables us to field the right mix of forces rapidly when the specific threat is clear. We must continually adapt to anticipate and stay ahead of adversaries' initiatives and reactions to our moves.

1.2 THE FUTURE ENVIRONMENT: THE SPECTRUM OF CONTINGENCIES IN 2030

The range of potential future adversaries runs from non-state organizations hostile to the United States (with or without deliverable weapons of mass destruction) through major countries of uncertain stability and intent armed with nuclear weapons. For the purposes of thinking about future strategic strike, the Task Force grouped adversaries into two distinct categories:

1. *Urgent emerging threats: rogues and terrorists.* This category includes non-state entities and less powerful nations (with and without weapons of mass destruction) hostile to the United States. Against this category of adversary, the U.S. strategic objective will be to field the strongest and most comprehensive defenses and strategic strike capabilities that can destroy or disable enemies' WMD before these enemies can attack us by whatever means. When in conflict with these enemies, the United States will seek to
    - Nullify and eliminate the adversary's WMD,
    - Remove the adversary's regime but save its country,
    - Terminate the WMD war quickly, and
    - Ensure that the war teaches the "right lessons."
2. *Future major power adversaries with WMD.* Against a major power that can pose a nuclear threat to the United States despite our defenses, our objectives will be different: to transform relations through dissuasion and assurance. The United States may still find itself in conflict with such an adversary, but the objectives will have to be more limited:
    - To dissuade, to deter, and to prevail, while minimizing the prospects of unwanted escalation and damage to allies; and
    - To terminate the conflict as quickly as possible on terms consistent with U.S. values and objectives.

1.3 TARGETS FOR STRATEGIC STRIKE

Targets for strategic strike are objects of greatest value to an adversary. Target sets include the following:

1. *Weapons of mass destruction* (deployed forces, storage and production facilities);
2. *Leadership* (command bunkers, residences, political control assets, economic assets);
3. *Other military assets* (command, control, and communications (C3); intelligence, surveillance, and reconnaissance (ISR); air and naval bases; other military infrastructure);
4. *Special* (hard and deeply buried targets (HDBT), fleeting targets, agent defeat); and
5. Specific assets or functions known to be of significant value to the leadership.

These target categories are similar for different types of adversaries, but what we have to be able to accomplish differs from adversary to adversary. For example, when striking rogue or terrorist leadership, the mission is to kill the leaders themselves. Dealing with a major adversary with an established continuity of government plan, the mission is to disable the adversary leadership's ability to carry out its responsibilities.

1.4 EFFECTIVENESS OF CURRENTLY PLANNED CAPABILITY

The Task Force used a qualitative/quantitative methodology to assess how well the strategic strike capability currently planned by the Department of Defense (DoD) will achieve the goal of providing future presidents a broad range of options in 30 years. Chapter 8 describes in detail the methodology, which involves considering the target sets (first from the adversaries' point of view, then from the U.S. point of view) and comparing the results. The overall result is shown in figure 1-2.

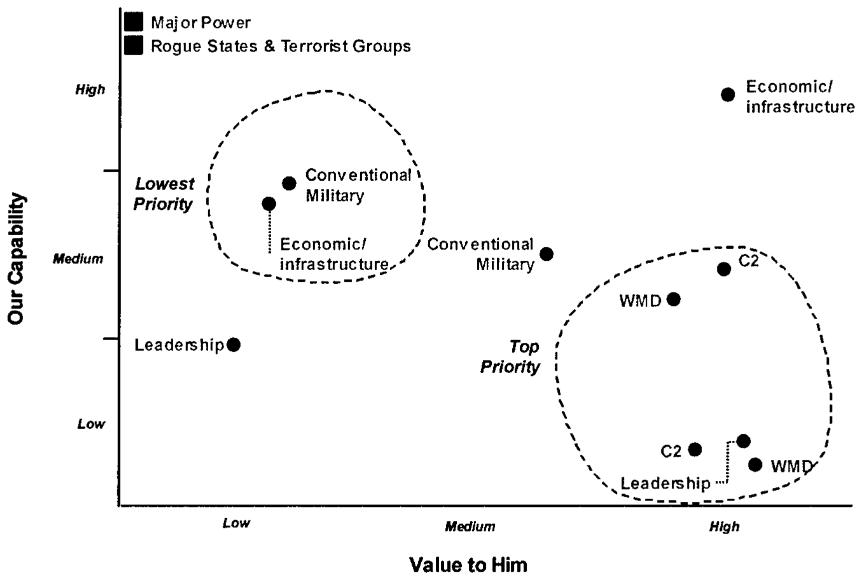

Figure 1-2: U.S. strategic strike capability: baseline.

Although against some categories of targets we will have high capability, the targets are often not of high value to potential adversaries. There are categories of great value to adversaries which we will not be able to touch with currently planned capabilities—the enemy will be moving and hiding them, and we will be able to hold few of them at risk or attack them.

The Task Force's recommendations are designed to achieve better strategic strike options for the United States. The recommendations are not for improvements on the margin. If there is to be capability to support our new strategy, DoD will have to undertake some major efforts to create systems and processes that do not now exist.

The best summary statement of the objectives for strategic strike is this: *To provide future Presidents an integrated, flexible, and highly reliable set of strike options with today's tactical-level flexibility but on a global scale.*

1.5 RECOMMENDATIONS: COMMAND AND CONTROL NETWORKS

The Task Force recommendations are built around the kill chain; the links of the kill chain each need to be strengthened, and they need to be integrated. It is command and control that makes the chain stronger than the sum of its links.

The deficiencies in our current and planned command and control network for strategic strike operations are well known: there is no common network for all participants, they do not share a common picture, quality of service of the networks is poor, and weapons are not controlled and monitored through impact.

Accordingly, the Task Force recommends the following:

1. *U.S. Strategic Command (STRATCOM) should define and lead the development of the operational C3ISR architecture essential for a netted, collaborative strategic strike network.* A netted command and control architecture will allow planners, decision makers, and supporting partners to meet the stringent timelines and confidence standards of future global strategic strike missions.

   The netted command and control architecture we propose rides on a robust Transformational Communications Architecture (TCA) and expanded Global Information Grid (GIG). It is a collaborative web with disciplined procedures that allow a flat chain of command; it has decision/collaboration aids and sophisticated security. It brings to bear all the nation's capabilities to plan, support, and conduct future strategic strike operations, integrated with defensive operations. It is based on a common interactive picture of the joint area of operations where the strikes will take place. The Task Force estimate is that it would cost $250 million to develop and install this network, $50 million per year to maintain it, and that it could be on line in 2005. The Navy, because of success with TACAMO and global tactical initiatives, should serve as the development lead for STRATCOM.[1]

2. *DoD should continue support for the TCA, the GIG-Bandwidth Expansion (GIG-BE), and Network Centric Enterprise Services (NCES) with enhancements to support this strategic network.* The Task Force finds that the vision of TCA, GIG-BE, and NCES is supportive of the future strategic strike objective. However, we are concerned that the services and agencies have not planned, programmed, and budgeted resources to support the transformation. For example, the Task Force estimates it would cost an additional $100 million for the STRATCOM "first mile" to ensure that these new systems have the additional robustness, capacity, and security to carry the strategic strike network. It is important to emphasize that this strategic strike network is a major departure from the legacy concept for command and control of strategic strike, which relied on specialized, independent communications systems designed to operate on their own across strategic nuclear exchanges.

3. *STRATCOM should use the recommended operational network for development of strategic strike capabilities.* STRATCOM can use the operational network for requirements development and refinement, operational architecture development and refinement, concepts development and refinement, leadership training, experimentation and exercises, wargames, and advocacy. The power of this process is that it uses the same system for operations and for development—we develop as we fight.

   The Task Force estimates that it would cost $250 million per year over the Future Years Defense Plan (FYDP) to develop and maintain full capability, which could be completed by 2005; implementation by STRATCOM can start now using current systems and then be improved as the operational network is developed. This concept, too, is a major de-

[1] TACAMO refers to the Navy's airborne nuclear command and control aircraft.

parture from current practice, in which requirements are developed and levied on the Services, resulting in programs that deliver capability in years. This development architecture will lead to rapid, spiral development of capabilities that can be immediately incorporated into operations. A C3ISR test bed (a virtual and distributed test range) essential to support the spiral development of the C3ISR architecture required for future strategic strike should be defined and led by STRATCOM with close coordination and implementation through Joint Forces Command (JFCOM), the regional combatant commanders, and cognizant "ISR agencies." The Task Force believes the test bed will need approximately $1.5 billion over the FYDP.

1.6 RECOMMENDATIONS: INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE AND BATTLE DAMAGE ASSESSMENT

Current deficiencies in these areas are well known:

- Intelligence organizations cannot find all of the strategic target sets and are not able to identify and track targets that are known to exist;
- Surveillance and reconnaissance systems lack persistence, penetration, and identification capability;
- Operational effects assessment (BDA) is often too little, too late; and
- The tasking, processing, exploitation, and dissemination (TPED) process cannot keep up with the data and inhibits fusion and integrated tasking.

These deficiencies were reinforced during the Iraq War—we did not find the entire Iraq "deck of cards" during the conflict, and we have not found the WMD we know is there, even with teams on the ground.

There is a great deal of ongoing effort to modernize and integrate the space and airborne layers of the ISR system. Our Task Force finds that we are reaching the limits of being able to identify and track the most difficult strategic targets from space and airborne systems. The enemy is learning and will get better at dispersing, moving, and hiding what is most valuable to him—exactly what we must hold at risk and destroy. The Task Force makes the following specific recommendations:

1. *SOCOM, in conjunction with DARPA, should develop*

   - *Technologies and systems for networked close-in sensors* (air and ground) and tagging, tracking, and locating invasive sensors;
   - *Networks* to self-form, infil and exfil data; and
   - *Sensors* of various types to manage power and gather information (to include tags and acoustic, seismic, visible, infrared (IR), radio frequency (RF), hyperspectral imagery (HSI), and magnetic sensors).

   The technologies developed should be fielded and demonstrated in the C3ISR test bed so that the effectiveness and interoperability of each tier of the C3ISR architecture can be assessed. The Task Force estimates that this program will cost approximately $3 billion over the FYDP.

2. *Invigorate ongoing efforts to improve and integrate TPED systems through data mining and appropriate algorithm development.* In addition, we recommend improving human intelligence through aggressive operations, utilization of linguists, and the development of cultural centers to understand values held by potential adversaries. These efforts are currently a very small and often ignored portion of the national intelligence apparatus and should have a budget increase commensurate with the significant importance they have in our future.
3. *Develop and apply improved red teaming to understand better how an adaptive adversary might undermine our emerging C3ISR system.* The C3ISR budget items today represent a significant portion of the Federal budget. However, by intention they are not assimilated into a C3ISR program. Our recommendations will lead to identifying the elements of C3ISR essential for future strategic strike, and through test bed development, assuring that the critical elements in each tier receive appropriate attention and funding. However, the Task Force remains concerned that no dedicated "red team" effort exists which concerns itself with camouflage, concealment, and deception; redout/blackout/electromagnetic pulse (EMP) vulnerabilities; and tactics which might be used by an adversary against our emerging C3ISR system. Such an effort would seem to be worth an annual expenditure of three percent or so of the total C3ISR budget.

1.7 RECOMMENDATIONS: DELIVERY SYSTEMS

Unlike ISR, in the delivery systems area we have choices. However, currently planned delivery systems for tactical battlefield missions cannot simply be dual-tasked for strategic strikes. They are not able to hit time-critical targets from long ranges in poor weather; cannot destroy hard and deeply buried targets; and need to be more reliable, accurate, and stealthy than battlefield systems. Not all delivery systems have to be capable of prompt strike. The Task Force anticipates that even a feasible close-in and intrusive ISR network by 2030 will not be able to locate, identify, and track more than 300 to 400 time-critical strategic strike targets requiring 15-minute strike responsiveness. We therefore recommend a limited number of delivery systems of this performance.

Specific recommendations are as follows:

1. *DoD should maintain and extend intercontinental ballistic missile (ICBM), submarine-launched ballistic missile/submarine-launched cruise missile (SLBM/SLCM), bomber and air-launched cruise missile/advanced cruise missile (ALCM/ACM) nuclear delivery systems in accordance with current plans.* The Task Force concludes that these systems are adequate for handling major power adversaries through 2040.
2. *The Air Force should preserve 50 Peacekeeper ICBMs currently being deactivated, and redeploy them to Vandenberg and Cape Canaveral for use with conventional warheads.* These weapons would give the United Sates a 30-minute response capability for strategic strike worldwide. The

cost of this recommendation is about $350 million for development and $600 million for deployment, and the system could be ready by 2010.

3. *The Navy should develop a new non-nuclear ballistic missile for its nuclear-powered cruise missile submarines (SSGNs), to be deployed later on surface ships, with a 1,500 nautical mile range, 2,000 pound payload, and 5 meter accuracy.* These weapons would provide a 15-minute response for strategic strike from a submarine off an adversary's coast to a 1,200-mile range inland. The system would cost $1.5 billion for development and $1 billion for production, with an initial operational capability (IOC) of 2012.
4. *The Air Force should initiate an analysis of alternatives for prompt strike capability, followed by concept definition of promising alternatives.* The Task Force looked at many imaginative candidates for prompt response: large, stealthy, unmanned, long-endurance refuelable airplanes; supersonic and hypersonic missiles or unmanned airplanes; and ballistic missiles with various payloads, including Common Aero Vehicles. No single alternative emerges as a clear winner. DoD needs to analyze the tradeoffs among such factors as technical maturity, basing modes, concepts of operations, vehicle system design, ISR architecture, and many others—followed by concept definition of one or more selected alternatives.

1.8 RECOMMENDATIONS: PAYLOADS

The Task Force recommends that payloads be considered in a more wide-ranging way: they can help other links of the kill chain as well as be more effective and better tailored.

For non-nuclear payloads, the Task Force recommends the following:

1. *STRATCOM should recommend the size and mix of non-nuclear payloads needed for strategic strike.*
2. *The Services should procure a contingency arsenal of current successful special-purpose, non-nuclear weapons.* DoD quickly developed some very effective specialized warheads such as MOAB for Afghanistan and Iraq. A supply of these weapons should be procured for future contingencies. This supply will cost about $600 million.
3. *The Defense Threat Reduction Agency (DTRA) should assume responsibility for technological development of non-nuclear strategic warhead and payload-delivered associated sensors.* DTRA has the expertise and the desire to lead DoD's conventional strategic payload development, but it does not have the resources. A level funding of $50 million per year is required for this effort.

The Task Force also addressed nuclear warheads. It is American policy to keep the nuclear threshold high and to pursue non-nuclear attack options wherever possible. In the future, however, nuclear weapons will probably proliferate and there are already open discussions in professional journals in other countries of nuclear attacks on U.S. deployed forces and communications. To deter and, if necessary, respond to these threats, future Presidents should have strategic strike choices between massive conventional strikes and today's relative large, high-fallout weapons delivered primarily by ballistic missiles.

The guidance in the Nuclear Posture Review is consistent with keeping the nuclear threshold high and with pursuing a Stockpile Stewardship Program (SSP) to provide safe, secure, and reliable nuclear weapons without resuming nuclear testing if at all possible. However, the nuclear weapons program as currently conceived—a program focused primarily on refurbishing the legacy stockpile—will not meet the country's future needs.

The Task Force, therefore, recommends the following:

1. *Significantly scale back planned life extensions in the SSP.*
2. *Shift the SSP toward a new vision: a stockpile based on previously tested nuclear devices/designs to provide weapons more relevant to the future threat environment.*

Nuclear weapons are needed that produce much lower collateral damage (great precision, deep penetration, greatly reduced radioactivity); have robust performance margins; are devised for ease of manufacture and maintenance; and produce special effects (e.g., enhanced EMP, enhanced neutron flux, reduced fission yield). *The Task Force recommends that research be initiated on weapons that meet this new vision.* Whether or not any new types of weapons require testing will depend on the results of the technical development work, as well as operational and policy considerations.

The Task Force also recommends that the Secretary of Defense provide guidance along these lines to the Commander, Strategic Command, who in turn would provide an annual statement of the required numbers and characteristics of nuclear weapons and the risks associated with his recommendations. Based on this statement, the Secretary of Defense would direct the Chairman of the Nuclear Weapons Council to coordinate the technical efforts to provide the nuclear devices with the National Nuclear Security Administration (NNSA). *In addition, the Task Force recommends that the Under Secretary of Defense for Policy be added to the Nuclear Weapons Council.*

Finally, the Task Force recommends that the Nuclear Weapons Effect Program be greatly improved. This can be accomplished by STRATCOM, DTRA, and NNSA in partnership.

1.9 CONCLUSION: POTENTIAL U.S. STRATEGIC STRIKE CAPABILITY

To determine the result of its recommendations, if adopted, the Task Force repeated the analysis of U.S. capability against future adversaries. The revised results are shown below:

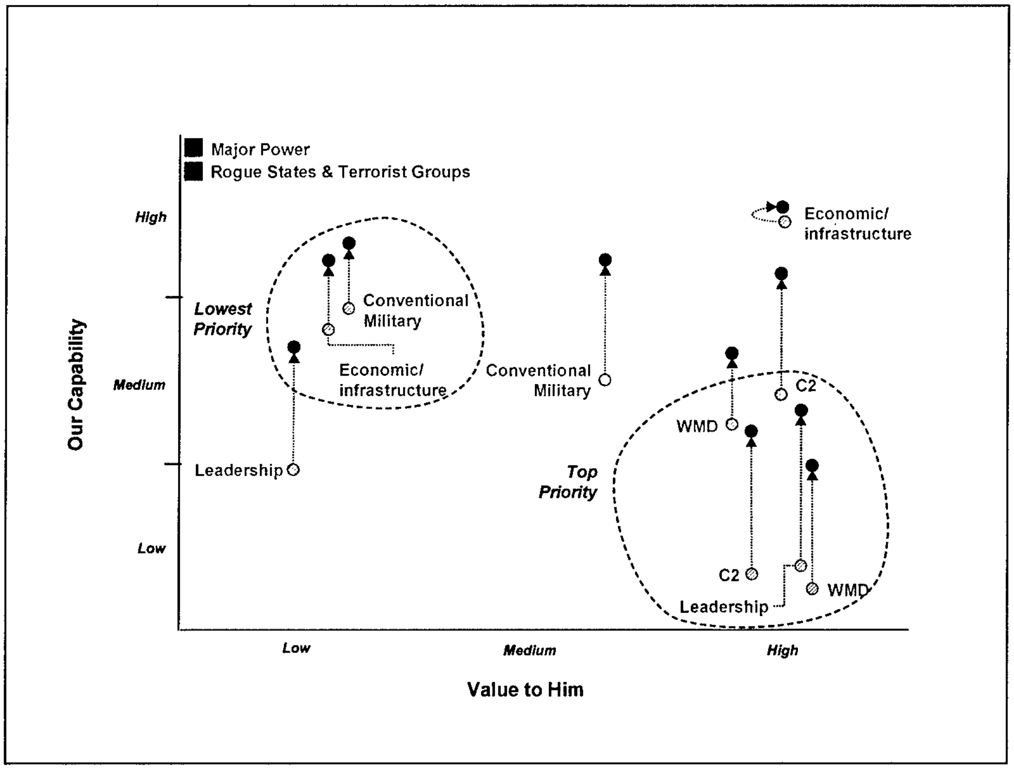

Figure 1-3: U.S. strategic strike capability with recommendations.

Our ability to detect, identify, and track what potential adversaries value the most improves significantly. The President will have realistic, high-confidence strategic strike options to reassure friends, change the behavior of enemies, and protect American interests.

2. Concepts of Operation

We begin by defining strategic strike. We then review three key principles that define the approach to transforming the nation's strategic posture. Next, we discuss the future strategic environment, notional contingencies, and targeting requirements. We conclude with an assessment of current and future shortfalls.

2.1 DEFINING STRATEGIC STRIKE

For the purpose of this study, a strategic strike is defined as a military operation undertaken by the United States that is designed to alter decisively an adversary's course of action in a relatively compact period of time. This basic definition has several subelements.

- U.S. military operations could alter the adversary's course of action by
  - Directly impacting capabilities,
  - Indirectly influencing decision making, or
  - Achieving some combination thereof.

  In the first case (directly impacting capabilities), military power could *inter alia*
  - Shatter an adversary's capabilities to continue a conflict,
  - Degrade critical command, control, communications, and intelligence (C3I) nets, or
  - Decapitate the senior-most political and military leadership.

  In the second case (influencing decision making), military operations would be designed to influence the choices made by the adversary leadership, from possibly compelling that leadership to agree to desired U.S. actions (e.g., to end support for a terrorist organization) suppressing its readiness to escalate (e.g., in a conflict involving power projection by a nuclear-armed great power) up to shattering a leadership's will to continue a major conflict (e.g., in a clash with a regional rogue that had used biological weapons). A large part of carrying out these tasks requires understanding what the adversary values, how it sees the world, and the nature of its domestic political structures.

- Viewed in isolation, a strategic strike could occur in a relatively compact period of time, measured in hours or days, not weeks or months.[2] A strategic strike could also be part of a broader political-military campaign. For example, U.S. strategic strike capabilities may be repeatedly called on to support a prolonged U.S. war on terrorism by undertaking tactically discrete but strategically interconnected strikes against time-urgent and other terrorist-related targets.

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[2] A good example of a strategic campaign measured in hours is the 1986 El Dorado Canyon strike on Libya. A good example of a strategic campaign lasting days is the series of 1972 Linebacker II air strikes against Hanoi.

- Throughout the Cold War, *strategic* was virtually synonymous with *nuclear*. This is no longer so. While we could previously execute some military operations only with nuclear weapons, we can now execute many of these with highly precise conventional weaponry. The benefits of this shift are significant:
    - Advanced conventional weapons can decisively affect the options and calculations of future U.S. adversaries, and
    - U.S. interests are best served by preserving into the future the half-century plus non-use of nuclear weapons.

  It is especially important to continue to maximize the set of non-nuclear strategic strike options available to the president in peacetime, crisis, or conflict.
- A very wide range of forces operating from either within the United States or overseas can be used in executing strategic strike. These forces include traditional longer-range missile and air assets, missile assets at sea, in-theater air and naval assets, and in-theater special operations forces (SOF). Newer information operations capabilities could also be used as part of a strategic strike mission. All of these military assets need to be integrated together.

2.2 THE FUTURE AGENDA

Several recent documents have elaborated some important new concepts relevant to the nation's strategic capabilities. These documents include the September 2001 *Quadrennial Defense Review*, the December 2001 *Nuclear Posture Review*, the most recent Defense Planning Guidance, and the September 2002 *National Security Strategy*. Taken as a whole, they lay out three key principles that are particularly relevant to the topic of future strategic strike:

1. The U.S. strategic posture should be tailored for a broad set of goals, not just deterrence. These include assuring allies and friends, dissuading potential military challengers, and defeating and defending against enemies.
2. Past dependence on nuclear weapons to achieve these goals should give way to a more balanced approach in which defenses (both active and passive) combine synergistically with a revitalized industrial infrastructure and a strike component broadened to include both nuclear and non-nuclear means—the so-called "New Triad."
3. Planning must shift from a focus on specific threats to a capabilities-based approach.

Below, we describe each of these and their implications for the future of strategic strike.

2.2.1 *Principle 1: From Deterrence to Broader Goals*

In the Cold War, the nuclear posture had one central purpose: to deter the Soviet Union. There were other benefits and in time of war other missions, but this was the single, overarching concept that organized U.S. thinking and investment. In the post-Cold War era, deterrence no longer has so central a place. To be sure, it remains an important objective, but it is not the only one. In dealing with U.S. adversaries, defense and defeat are also important objectives. In dealing with allies and friends, assurance is a top objective. In dealing with potential adversaries, dissuasion is a top objective.

As the United States thinks about how many of what types of strategic strike forces to acquire, it must bear in mind the different requirements of these different objectives. The requirements for deterrence, defense and defeat are the focus of the remainder of this study. Here we would like to offer a few observations about *assurance* and *dissuasion*.

Both the Quadrennial Defense Review (QDR) and the Nuclear Posture Review (NPR) list *assurance* as the first in the series of U.S. objectives. This top priority underscores the role friends and allies play in U.S. security strategy the risks the nation faces in an era of heightened weapons of mass destruction (WMD) proliferation. In the Cold War, assurance reduced essentially to the issue of extended deterrence—did the United States have the means to credibly extend the nuclear umbrella to its friends and allies and to safeguard their interests from the Soviet threat? In the post-cold war era, extended deterrence remains an important issue, as new and different threats emerge.

But assurance requires much more than credible extended deterrence. It requires also that U.S. friends and allies believe that the security relationship with the United States serves their long-term interests by promoting their security. Many if not most of these allies and friends have the ability from a purely technical perspective to develop nuclear weapons of their own (though their ready access to the necessary fissile materials is significantly constrained). Assuring U.S. allies in Europe and Asia that they need not develop nuclear arsenals of their own in anticipation of deterioration in their security environment remains an important U.S. objective. From the perspective of the strategic strike question of this study, it requires also that U.S. strike systems have the flexibility to protect those friends and allies.

Dissuasion focuses principally on potential adversaries. In particular, the United States seeks defenses to dissuade major powers from seeking peer military status. Encouraging Russia to continue down the path of partnership with the United States requires dissuasion to reinforce the perception in Moscow that there can be no benefit in seeking to return to a peer competitive military relationship with the United States. Likewise, encouraging China to deepen its cooperation with the international community and to pursue its program of military modernization without upsetting regional or global stability requires an element of dissuasion. From the perspective of strategic strike, dissuasion derives from the numbers of deployed and deployable weapon systems and also from an infrastructure capable of quickly producing new systems that can defeat any capability the adversary may choose to field. While a general reputation for producing greatly superior and innovative military capabilities can also dissuade the competition, the need to dissuade seems unlikely to drive the particular technical details of new systems.

In sum, assurance requires flexibility in strategic systems, and dissuasion requires the ability to out-pace a potential competitor in order to prevent or preclude some future advantage they may seek. But the primary technical requirements of future strategic strike derive from the objectives of deterrence and defeat—the focus of the following analysis.

2.2.2 *Principle 2: Shift from Nuclear Weapons to the "New Triad"*

A second top-level principle elaborated in the QDR, NPR, and elsewhere is that the U.S. strategic posture should move away from depending heavily on nuclear weapons. Instead, the United States should employ a broad array of tools synergistically to achieve the desired strategic effects. These tools include strategic strike capabilities, both nuclear and non-nuclear. They also include the other elements of the New Triad: defenses (both active and passive) and a responsive infrastructure. This latter is particularly useful for signaling to other countries that there can be no material advantage gained in competing with the United States, since whatever capability an adversary may develop, the United States can rapidly counter it.

The desire to rely less on nuclear weapons reflects the conviction that nuclear deterrence may sometimes be ineffective in the emerging security environment. Its deficiency stems in part from the fact some potential adversaries, especially terrorists and rogue leaders, may be impossible to deter in at least some circumstances. A second deficiency stems from concerns that U.S. nuclear threats may not seem credible to adversaries, who might consider using their WMD assets in ways that they believe fall below U.S. nuclear response thresholds. Moving away from our heavy reliance on nuclear deterrence does not imply that we have abandoned nuclear deterrence altogether, only that we have tailored our "New Triad" capabilities in such a way that deterrence is likely to continue to be credible where and when it has the potential to be effective and proves necessary.

Defenses are obviously a key element of this new strategic approach. They ought to help the United States compensate for any weakness in deterrence and also achieve its objectives in crisis or war against adversaries who are willing and able to target the United States. The desired defenses are both active and passive. Active defenses include protection against attack by ballistic missiles and other standard military means of delivery (e.g., cruise missiles and aircraft). Active defenses of a different kind have a role to play in protecting the United States from unconventional modes of delivery (e.g., covert delivery). Passive defenses have a role, too (e.g., medical protection against covert biological attack).

Over time, the United States may develop full protection capabilities against all conceivable WMD adversaries. This will be easier against small adversaries with limited WMD and more vulnerable delivery methods. It will be more of a challenge against larger adversaries with more robust attack capabilities. As a first priority, we should develop defenses against the threats posed by terrorists and rogue states. Given the adversarial relationship of many of these actors with the United States, the need for improved defense is urgent. Over the longer term—measured in decades—the United States may move to field more complete defenses against the more robust threats, though this will depend on developments in technology and U.S. foreign relations.

2.2.3 *Principle 3: Shift to a Capabilities-Based Planning Approach*

The third major principal involves a change in the nature of the potential threat facing the United States in the 21st century. During much of the latter half of the 20th century, the United States faced a largely static security environment dominated by a single adversary. Under these circumstances, we could conduct long-term defense planning effectively by focusing on the known threat. This is what came to be known as "threat-based" planning.

Today, however, we find ourselves in a different world. A static environment has given way to a very dynamic one. A single adversary has been replaced by an array of adversaries, both present and potential. The resulting uncertainties combine to call into question the efficacy of a defense planning process that focuses on known threats. Instead, current thinking suggests that planning should lead to capabilities that would be effective against whatever specific threats emerge. This thinking lies behind the argument for a shift from threat-based to capabilities-based planning. As the QDR argues about the "capabilities-based approach":

> "That concept reflects the fact that the United States cannot know with confidence what nation, combination of nations, or non-state actor will pose threats to vital U.S. interests or those of U.S. allies and friends decades from now. It is possible, however, to anticipate the capabilities that an adversary might employ to coerce its neighbors, deter the United States from acting in defense of its allies and friends, or directly attack the United States or its deployed forces. A capabilities-based model —one that focuses more on how an adversary might fight than who the adversary might be and where a war might occur—broadens the strategic perspective. It requires identifying capabilities that U.S. military forces will need to deter and defeat adversaries who will rely on surprise, deception, and asymmetric warfare to achieve their objectives."[3]

If the United States is to operate successfully across the whole spectrum of modern conflict, it must develop a broad array of capabilities. When conjecturing about the types of capabilities required in the field a decade, two, or three from now, planners must begin to come to terms with the ability of U.S. defense industries to produce these capabilities with the requisite flexibility. Cold War planning relied on industrial capability to recapitalize large elements of the force routinely over many decades. The relatively slow pace of technological change and more clearly defined defense challenges of that era made this acceptable. Smaller force sizes, higher rates of technological change, and the substantial increase in the costs of modern defense programs have made this a more risky approach for the 21st century.

Modern defense planning requires the United States to develop acquisition programs that are more flexible and responsive. Such programs must build on and sustain the U.S. industrial base while factoring

- The lower production rates of modern weapons systems,
- Technology insertions/upgrades to increase the capabilities of these systems over time, and
- A highly responsive productive capacity to transition new technology and concepts rapidly into new capabilities.

Thus, a capabilities-based approach to planning seeks to exploit current U.S. asymmetric advantages to meet the twin challenges of the present security environment: the

[3] *Quadrennial Defense Review Report*, Department of Defense, 30 September 2001.

global war on terrorism and the future security environment. The goal is to apply an innovative technology base and a responsive industrial infrastructure to assure a readily available array of potential alternative solutions that could be quickly fielded to meet future requirements.

What does all this imply for future strategic strike? Although U.S. planners cannot know future requirements with precision—especially as they look out to 2030 and beyond—the requirements to maintain a robust variety of current capabilities and to field new capabilities tailored to future need are clear imperatives.

In speculating about the strategic strike requirements of future contingencies, it is important to recognize that U.S. adversaries are themselves thinking and adaptive planners. They are trying to anticipate what the United States will do, and the United States needs forces and concepts that are flexible enough to permit it to respond appropriately. It is a truism that conflict is a two-sided affair: each side adapts to, learns from, and anticipates what the other will do in order to foil it. We cannot plan for a static adversary or even a range of static adversaries; we are in a highly dynamic environment. Our forces are developed to hit various kinds of targets, but what the adversary expects of U.S. forces in turn shapes the targets that the United States will face in the future. By definition, this is not entirely predictable, but some points are clear:

- First, designing forces and strategies on the assumption that the adversaries will remain unchanged is obviously wrong. They are not only a moving target, but a target that moves in part to try to defeat our programs and plans. We need to try to think as many steps ahead as possible, realizing that there are large uncertainties here. Capabilities should be designed keeping in mind how adversaries might seek to foil them.

- Second, it is particularly valuable to combine capabilities that reduce the adversaries' ability to nullify any single capability or innovation. Adversary countermeasures that would be effective against a single capability may fail against a well-designed suite of capabilities.

- Third, asymmetric responses are most likely from rogues and terrorists but even from potential major power adversaries. The typical arms race dynamic in which the adversary seeks to match or emulate our capabilities is not now plausible. Rather, the danger is that adversaries will develop ways to work around our systems. Concealment and deception are perhaps the most obvious examples of this kind of a response. The basic point is that the great material superiority of the United States means that the adversary has extremely high incentives to try to develop responses that are different in kind. As the nation seeks to enhance its own asymmetric advantages over such adversaries, it needs to be mindful of protecting against the asymmetric advantages its adversaries seek.

- Fourth, adversaries learn from what we have done, and we need to understand if not influence this. Indeed, we should aim to teach them certain lessons—this is the essence of dissuasion and deterrence. But some lessons may be undesired, and we need to try to understand them as we design our capabilities. We produce "lessons learned" after each conflict; we also need to determine what lessons adversaries have learned in order to better estimate how they will act in the future. Our forces need to be flexible enough so that they will not be badly degraded by the changes that adversaries institute as a result of our activities.

2.3 THE FUTURE SECURITY ENVIRONMENT

The future security environment confronting the United States and its allies provides the overall context for identifying and assessing needed strategic strike capabilities. Contrasted with the more static Cold War security environment, the future security environment is considerably more fluid and complex. Three dimensions of the future strategic environment stand out: near-term U.S. objectives, medium term uncertainties, and longer-term uncertainties.

2.3.1 *Current U.S. Objectives*

Current U.S. objectives provide a starting point for defining strategic strike requirements. Since the terrorist attacks of 11 September 2001, defeating the terrorist threat to American life has become the top defense priority. The United States has applied military and paramilitary capabilities to remove the Taliban regime in Afghanistan, to disrupt ongoing terrorist attacks, and to achieve other ends. The war on terrorism, moreover, is likely to be prolonged, quite possibly measured in decades. It is likely to be characterized by a full spectrum of military actions, from tailored strikes against emerging terrorist targets to full-scale military operations against supporters of terrorism.

The United States today is also seeking to roll back and eliminate the threat posed by those rogue countries that possess or nearly possess nuclear, biological, or chemical weapons and the means to deliver them (from ballistic missiles to unconventional operations). These countries (and yet others that may emerge if proliferation cannot be checked) present a direct threat to the United States and its friends and allies and an indirect threat, in that terrorists or sub-state groups could possibly access WMD through one of these rogue countries.

U.S. policy also seeks to consolidate cooperation among the major powers to an unprecedented degree. A primary focus here is on deepening and strengthening the non-adversarial relationship with Russia. The aim is to replace Cold War-style military confrontation with new patterns of political, economic, and even military partnership in order to deal with 21st century security challenges and thus to create a more peaceful global environment. Though tensions over Taiwan linger beneath the surface, the United States also seeks to strengthen cooperation with a China that is still looking to define its future internal make-up and external role. Strengthening cooperation with other great powers, from the countries of the "new Europe" to more traditional allies in Europe and Asia, also is important, not least of all to help us prevail in the war on terrorism.

2.3.2 *Medium-Term Uncertainties*

Whether or not—or the extent to which—the United States is successful in pursuing these near-term objectives defines the critical medium-term uncertainties of the future security environment.

One such medium-term uncertainty concerns the war on terrorism. Over the next 10 to 20 years, will the type of "spectacular terrorism" characterized by the 11

September attacks gradually become a less dominant feature of the international security environment, or will today's radical Islamic terrorism be transformed by increasing access to WMD? Closely related to these questions is the question of whether the underlying social, political, and economic problems of many Islamic countries will provide the root for a transnational consolidation of radical Islam in a new multi-state movement. Or will a new sense of danger in many "weak societies" gradually lead to the type of internal political-economic-social change needed to reduce dramatically the recruitment pool of future terrorists?

Perhaps equally important, the scope and pace of WMD proliferation comprises a related medium-term uncertainty. Success in rolling back today's proliferation challenges would go far to lessen the dangers of more widespread proliferation, but failure would make it considerably more difficult to contain future proliferation pressures. A mix of the inability to roll back today's proliferators, the sale of WMD technology and materials, regional instabilities, and internal factors all could lead to runaway proliferation in the years ahead. Of particular importance in shaping these future proliferation outcomes may be whether nuclear, biological, and chemical (NBC) weapons are used again, by whom, and with what consequences. Successful use in pursuit of aggressive ambitions by a regional rogue, a use of nuclear weapons by the United States that was widely perceived to be illegitimate and disproportionate, or even a U.S. unwillingness to consider the use of nuclear weapons when such weapons might be the only way to prevent an adversary from overwhelming an ally could drive proliferation as well. At the least, the issue of NBC use comprises a key, if uncertain, factor.

The prospects for major power partnership and consolidation of cooperation also are a medium-term uncertainty. In part, the outcome depends on factors outside of U.S. influence, let alone control. This is particularly so with the great transitions now underway internally in Russia and China. But how effective will be today's strategy of dissuasion in convincing a China or a Russia not to compete militarily with the United States? A key here may be whether dissuasion is accompanied by sufficient measures to reassure such potential major power adversaries that the United States is not seeking to dominate them but is prepared to work cooperatively with others—if others are prepared to cooperate in return. Careful statesmanship will be an important adjunct to military preparations.

Contrasted with these medium-term uncertainties, the re-emergence of a peer adversary by 2030 appears highly unlikely. No other country has the economic and technical foundation to develop military capabilities fully comparable to the United States.

2.3.3 *Longer-Term Uncertainties*

Longer-term uncertainties also exist in the future international security environment. Most basically, if the medium-term uncertainties are resolved favorably for U.S. security interests, the longer-term security environment could well be relatively benign. Low-level internal violence, limited regional military conflicts, and internal instability all could still characterize international relations. Indeed, there could be considerably more effective cooperation among the great powers in dealing with underlying global security challenges. By contrast, if the medium-term uncertainties develop unfavorably, international politics could be considerably more dangerous and conflict-prone. Rather than a more orderly process, widespread proliferation, persistent WMD terrorism, and clashes among both small and great powers could arise. Not least, in this future world, use of WMD could no longer be an exception.

In the above environment, the United States still might not confront a peer competitor. Fundamental economic, political, energy, and demographic disparities could leave the United States out ahead of its adversaries. But a combination of a U.S. decline and unexpected growth on the part of another country also cannot be completely ruled out. Thus, still another longer-term uncertainty is the possible emergence of a true peer adversary.

The future long-term international security environment, however, will not spring forth in an instant. Rather, as time passes and the near-term gives way to the medium-term, it should become possible to identify broad trends and to assess better the likelihood of particular outcomes. From the prospects for success in the war on terrorism to the extent of cooperation among the great powers, the world of the future will send its own signals.

This final dimension has two important implications for determining future requirements and making choices about strategic strike investment. First, it suggests that a key priority must be to strengthen those strike capabilities that can support U.S. actions aimed at ensuring a favorable resolution of the medium-term uncertainties—especially in regard to the war on terrorism and countering rogue proliferators. Second, it suggests the importance of ensuring that, in hedging against future uncertainties, the actions taken do not unintentionally make it more likely that the international security environment will revert to great power confrontation and conflict.

Given the dynamic nature of the challenges the United States faces, programs and recommendations adopted today will have to be frequently reassessed in the years ahead to ensure they continue to provide the United States the necessary capabilities to meet evolving threats.

2.4 NOTIONAL CONTINGENCIES

The preceding discussion of the future security environment identifies a range of significant actors in that environment: terrorists, "rogues," and major powers. It also underscores the difficulty of predicting the dominant planning problems from among the list of many possible alternative futures given the fact that branches and sequels cannot be known in advance. But utilizing this structure, it is possible to identify a notional spectrum of contingencies that seem likely to encompass the full range of possibilities in 2030.

At one end of the spectrum are conflicts against states and terrorists that harbor aggressive intentions but lack weapons of mass destruction. Modern terrorism has been with us for more than a century (going back to the Russian anarchists) and even successful eradication of al Qaeda and its supporters will not mean the end of all terrorist actors. The international security challenges posed by aggressive states (and by weak and collapsing ones as well) seem a continuing condition of the anarchic international system. Indeed, this set of contingencies may well constitute the vast majority of contingencies facing the U.S. military in 2030.

Next along the spectrum are conflicts involving WMD-armed non-state actors. Whether these actors are terrorist organizations as we have known them, terrorist movements with revolutionary goals, or simply violent individuals pursuing some ultimate goal of their own, conflicts with such adversaries will be shaped significantly by the adversary's potential or actual use of mass casualty weapons. These risks will magnify concerns about the difficulty of targeting and thus also of deterring terrorist actors that do not have state structures that can be put at risk.

Farther along the spectrum are conflicts involving rogue states. In this category, it is useful to distinguish between two basic types of such states: those armed with modest WMD capability and those with more robust capabilities.[4] We can hope that the current campaign to deal with "gathering threats at the crossroads of tyranny and technology" will have a salutary effect in reforming the existing "rogues" and deterring the future emergence of new ones. But such threats clearly belong on a notional spectrum of contingencies.

We distinguish here between modest and robust WMD capabilities for various reasons. One is to draw attention to the difference between a state armed with large numbers of nuclear weapons deliverable by missiles and a state armed with only a handful of such weapons and perhaps reliant on covert delivery. Another is to draw attention to the difference between the nuclear threat and its biological counterpart—and the possibility that states armed with few nuclear weapons may be capable with biological weapons of inflicting significant damage on the United States (and perhaps of doing so covertly and without attribution).

Next along the continuum of notional contingencies are conflicts against major powers that possess WMD. If U.S. assurance policies are successful, there will continue to be a larger number of major powers without WMD—indeed, perhaps a growing number of such powers as some potentially powerful developing countries prosper. We focus here on contingencies against adversaries and believe that if the United States ever again finds itself in conflict with a major power, that power will have weapons of mass destruction. Dissuasion strategies ought to help make these contingencies unlikely.

Finally, then, we come to peer adversaries. The QDR emphasizes the possible reemergence of a peer adversary at some point in the future. Looking ahead to the 2030 timeframe, we see such a development as unlikely. Neither Russia nor China is likely to have the combination of capability and motivation to challenge the United States militarily at the global level. Although other major powers may well emerge, even at the military level, it is difficult to reasonably anticipate that any would seek to challenge the United States at the peer level. Hedging against that possibility is in the U.S. interest, however, particularly because the situation two or three decades into the future is even more difficult to predict.

This spectrum is defined here as notional. Reality will present us with a more specific set of problems, and we can tailor forces to meet future requirements, as and if they take more definitive shape. But such a notional approach is intended in the shift from threats to capabilities as the basis of U.S. planning. It helps to identify the range of capabilities that the United States should now be seeking to develop.

From this perspective, these contingencies fall into two basic groups. This analytical structure has proven contentious in our study process, on the argument that there are many important differences among the various contingencies. A conflict

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[4] We utilize the term "rogue" reluctantly, as it is a term that conveys many unintended meanings. Here we mean simply states run by regimes that show no respect for the usual norms of behavior, whether internationally or domestically. They are prone to commit acts of international aggression while also transgressing the rights of their citizens.

against a "rogue" armed with 50 nuclear-tipped missiles would inevitably be very different from a conflict against a terrorist loner armed with biological weapons, for example. Moreover, the spectrum seems to hint at relatively equal numbers of instances of actual conflicts against this set of possibilities—a suggestion that we have already rejected above. Hedging against that possibility is in the U.S. interest, however. The following slide lays out this logic in more detail.

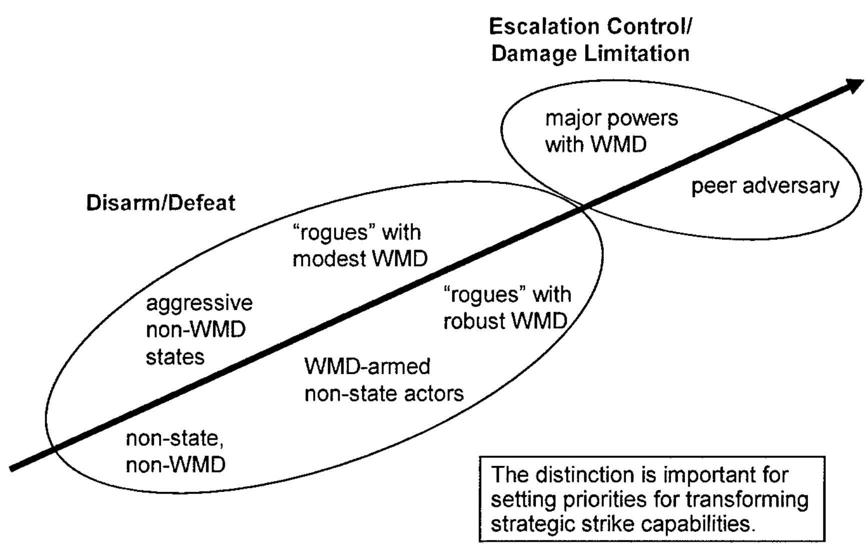

Figure 2-1: The different roles of strategic strike.

The focus here is *not* on describing all of the possible conflicts that the United States may encounter in 2020, 2030, or beyond. Rather, our purpose here is to elaborate a capabilities-based approach to planning future strategic strike forces. Thus the focus is on illuminating—by conceptually exploring the future security challenges facing the United States—how future U.S. strategic strike capabilities might best be shaped. In the past (and still to a significant extent today), strategic strike capabilities have been designed with a single focus: the peer adversary. Looking ahead to 2030, we see a broad range of contingencies for which strategic strike capabilities can play a valuable role.

Let us begin with the group depicted in the left-hand oval (see figure 2-1). This group encompasses all of the notional contingencies with the exception of the major power ones. In 2030 conflicts against rogue states armed with WMD, strategic strike will likely be asked to achieve a number of objectives, usually in conjunction with a broader military campaign. Such strikes would be asked to (1) nullify and, if possible, eliminate the adversary's WMD; (2) eliminate the leadership at minimum cost to the public; and (3) terminate as quickly as possible any war in which that adversary actually employs nuclear, biological, and/or chemical weapons.

The United States will also seek to use its strategic strike capabilities in ways that teach the right lessons about the war. By that, we mean that the United States will be concerned about how to win the peace as it chooses how to win the war, and winning the peace could be more difficult if the United States is seen to have been excessively heavy-handed in its operations or if it used nuclear weapons first. In such conflicts, U.S. leadership can be free to pursue such ambitious objectives assuming that it also has the means to protect the United States from acts of retaliation, whether the adversary retaliates with a missile salvo or through more covert means. This requires both a missile defense capable of defeating such strikes and a homeland defense capable of thwarting covert attack. It is the policy of the U.S. government that such capabilities will be well in place by 2030. If so, these defensive capabilities will enable the United States to deal with these threats and not to be blackmailed by them.

After some debate, we chose to include non-state actors in this first category. An obvious difference exists between state and non-state adversaries in terms of deterrence for the simple reason that non-state adversaries lack populations to protect and territories to safeguard—and they are more likely to "employ" suicidal operatives. However, from the perspective of specifying needed types of strategic strike capabilities (e.g., delivery platforms; payloads; and intelligence, surveillance, and reconnaissance—ISR), such non-state adversaries pose the same general set of targeting requirements as do rogue states with WMD. The United States must have the ability to target leadership and weapons of mass destruction and WMD-related infrastructure when it has the opportunity to do so. It also has ambitious objectives vis-à-vis these adversaries: to eliminate them and nullify their capabilities, and to win in a way that wins the peace.

We carefully considered whether the non-WMD threats—both state and non-state—belong in this group of contingencies. The imperative to target leadership and key capabilities exists regardless of the WMD aspect. After all, who would argue against use of a strategic strike capability to eliminate a key leader or critical attack capability of al Qaeda? To be sure, the numbers and types of strategic strike weapons employed in such an attack would differ substantially from a strategic strike against a "rogue" with robust WMD capabilities, but planners and policymakers would desire many of the same effects.

We have called this the "urgent, emerging" category because it seems likely to be more prominent in U.S. security strategy in coming decades and because it drives a distinct set of requirements for strategic strike. We elaborate these in a subsequent section, under a review of target types and targeting tasks.

But before turning there, let us consider the other main category described in the right-hand oval: future major power adversaries with WMD. This is not the peer category of old, and this fact alone has important implications for future strategic strike capabilities. As argued above, the peer category is a Cold War construct, derived from a bipolar world.

Over the next two or three decades, we can easily anticipate that other major powers will have conflicts of interest with the United States, conflicts that may even have a military aspect. But the emergence of states willing and able to contest U.S. influence on a global scale seems rather unlikely. Indeed, a central theme of the 2002

National Security Strategy is that we now face an unprecedented opportunity to consolidate cooperation among the United States, Russia, China, India, and others on the basis of common interests and common responsibilities.

The concept of dissuasion is intended to support this objective by persuading other major powers that no possible benefit can exist for them in competing with the United States for military advantage. The concept of assurance also plays a role in its objective of keeping friends and allies of the United States non-nuclear and closely aligned with us.

If somehow conflict were to emerge with another major power (for example, a confrontation between the United States and China over Taiwan), we would most likely find ourselves at war for limited, not survival, stakes. We would seek to secure our interest in the conflict and exploit our advantages—whatever they might be at the conventional and nuclear level—by projecting power and "winning" the issue at hand. To induce the adversary's restraint and to keep the conflict limited would also be a central U.S. objective. We also recognize that an adversary might seek to attack our allies and friends, whether to punish them, to persuade them to oppose U.S. operations, or to simply slow the flow of U.S. forces into the theater. Naturally, the United States would seek to limit such attacks.

These objectives are less ambitious than U.S. objectives in contingencies involving rogues/terrorists. As a first-order priority, the United States will not seek to eliminate a major power regime—rather, the United States desires its restraint. Nor is the United States likely to seek to eliminate an adversary's WMD fully—to do so could induce an adversary to unleash its full retaliatory potential—although the United States might seek to eliminate a portion of the WMD capability most threatening to a particular regional operation or ally. Adversary retaliation would, of course, be met by whatever defensive capabilities the United States would have fielded.

At the present time, the United States has no plans to field ballistic missile defenses capable of fully blunting the strategic arsenals of major powers; rather, plans are focused on blunting the strategic arsenals of the rogue states. To be sure, such plans may take shape, when and if policymakers conclude that one or more major powers are emerging as adversaries and these adversaries can strike the U.S. homeland with WMD-armed cruise and ballistic missiles. A competitive deployment of comprehensive missile defenses by the United States, driven by the emerging offense of the potential adversary, is conceivable under these circumstances. And while the United States seems likely to do well in any such competition, in the long term its capacity for full protection against such retaliation at any given time is unpredictable. Hence, looking to the year 2030, a key discriminator between this category (major powers) and the preceding one (rogues/terrorists) is the greater expectation that the United States will not have available to it the kind of protection capabilities that would allow it to ignore with impunity a major power adversary's threats to retaliate. If the United States has such a capability against any given country, then we can consider that country to be in the same category as WMD armed rogues—that is, a country whose WMD the United States can neutralize with acceptable risk.

In a later section of this report we return to the question of how improved strike capabilities, *in synergy with other components of the new triad,* can serve U.S. objectives in both war and peace vis-à-vis these two categories of contingencies. But our purpose here has been to elaborate the types of contingencies that ought to inform future planning of strategic strike capabilities. This analysis illuminates two key planning questions:

1. What types of targets must the United States be able to strike effectively in 2030?
2. How will the targeting tasks differ between these two categories?

We turn to these questions next.

2.5 TARGETING REQUIREMENTS

The targets of future U.S. strategic strike operations are similar across the two types of adversaries. Whether strategic strike is used, for example, in support of rapidly terminating a conflict in which a rogue has used WMD or in support of degrading a great power's power projection capabilities, the overall target set could include WMD targets, leadership targets, and other military assets—any of which can be located or deployed in such a way as to make them special targets. These special targets will be particularly difficult to attack. They may be buried deep underground and additionally hardened as well, or they may be mobile and so difficult to detect as to allow the United States only occasional fleeting opportunities to target them, or they may pose great dangers to surrounding areas if striking them risks release of dangerous materials or triggers other particularly large and damaging effects.

Though the target sets are similar across the two types of adversaries, the targeting tasks will vary across the two categories. These variations will largely be due to the different threat the two types of adversaries pose directly to the United States, but the different types of conflicts likely to arise also will be important.

More specifically, with regard to the regional rogues, the task of strategic strike (integrated with defenses) will be to nullify and eliminate that adversary's WMD capability. This could entail a mix of actions to (1) try to establish or strengthen a sense of deterrence on the adversary's part, (2) to degrade or destroy the adversary's means of delivery and WMD stocks, and (3) to sever the adversary's command, control, and communications (C3) linkages.

By contrast, in a conflict with a great power, escalation control will likely be the dominant WMD-related targeting task. This emphasis on escalation control reflects the fact that in great power conflicts, the mix of offense and defense is unlikely to suffice to limit damage sufficiently to the Untied States and U.S. allies should a great power adversary escalate to all-out conflict. The imperative of escalation control in great power conflicts would shape what targets are struck, the choice between nuclear and non-nuclear means, and communications and signaling.

In a conflict with a regional rogue, the purpose of targeting leadership would more likely than not be to remove the regime. Decapitating the regime would offer a potential means to end a conflict rapidly, especially once a regional adversary had used WMD. Removing the leadership could also be thought necessary in the event that the leadership had initiated the use of WMD or supported WMD terrorism—in effect putting itself outside the boundaries of acceptable international action. It would be important, however, to pursue any such efforts to remove a hostile rogue leadership in a manner that did not do disproportionate damage to the country's population, society, and economy. Lack of responsibility on the part of most of the public for the actions of a rogue regime, the laws of war, and the likelihood of U.S. post-war involvement in assisting the recovery and reformation of a defeated rogue are but three reasons for restraint.

Strategic strikes against leadership targets in a major power would have a somewhat different purpose. Such targeting would be intended to drive that leadership's decisions toward choosing not to escalate the conflict further as well as to signal the risks to them of continued military action. On a limited basis, strikes against leadership also could be a means to reestablish deterrence after initial WMD use. As in the case of restraint in strikes against the WMD capabilities of a major power, these limits on strikes against leadership would reflect U.S. interests in limiting the chance that the conflict might escalate out of control.

As emerging threats become more clear, the United States should tailor strategic strike options to reflect the context in which the threat is emerging and the nature of the decision makers who pose the threat. We can then combine the best capabilities for optimum effectiveness against the targets at hand with an emphasis on avoiding nuclear use, if possible. Thus, the consequences of strategic strike concepts of operation (CONOPS) emerge from how the strikes would be implemented in the operational and tactical context. Correspondingly, the characteristics demanded of ISR, weapons, delivery systems, and command and control arrangements are determined by operational and tactical steps that the United States anticipates it might want to take before, during, and after an actual physical strike on a facility. This includes non-strike activities and some activities that could take place even before hostilities.

Strategic strike, then, is more than just taking a shot at a target. If, for example, we were to strike a well hidden, underground nuclear site, we would have to bring an entire system of strategic strike and support capabilities to bear. Operational and tactical CONOPS would envision exploiting human intelligence (HUMINT) and overhead assets pre-war and pre-strike to find and confirm locations. Covert operations and SOF could be used, before or after the initiation of hostilities, to confirm or characterize the nuclear storage facilities. Information operations or special signals intelligence (SIGINT) may also be used to probe activities at the site. Remote sensors or autonomous sensors emplaced by hand or by air delivery could continue to monitor activity or even actively probe to determine the characteristics of the target complex.

Although weapons exist to destroy many underground targets, we cannot destroy all such targets with confidence. Indeed, battle damage assessment (BDA) may not be sufficient to determine if a target attacked were actually targeted. In the case of the above example, we might assume that the probability of kill would be low and, therefore, take supplemental measures to neutralize the target. Specifically, remotely deployed anti-vehicular landmines and other advanced munitions could be placed around the likely exits from the targeted facility to destroy vehicles seeking to leave the location. Then, special munitions designed to blast through hardened tunnel doors could be used to destroy known entrances. In this case, denial and functional kill might be substituted for physical kill because of the difficulty of achieving and knowing that you have achieved the latter against a high-value target. Because of the importance of the target in this example, additional sensors might be placed around the site either before or after its attack in order to monitor the facility for possible post-attack activity.

The concepts of persistent monitoring and tailored munitions employed through integrated tactics suggest that in the future, greater efforts should be made to blend simulations, training, and systems development to reflect the agile and yet more systematic approaches to strategic strike that are becoming necessary. The great challenge of strategic strike is that we must maintain versatile capabilities in the face of broad uncertainty, but then apply those capabilities precisely and discriminately in specific cases in which detailed differences may matter significantly.

2.6 SHORTFALLS

This capabilities-based approach points us to the following shortfalls between future requirements and the future capabilities that are presently planned.

Promptness. The number of targets potentially requiring prompt strike is increasing, and to the extent that ISR capabilities to find such targets is improved, even more of them will be of interest. As a planning objective for 2030 (assuming no dramatic improvements in ISR), we believe that the United States should have the ability to strike promptly 300 to 400 targets.

Accuracy. In the Cold War, strategic weapon accuracy on the order of hundreds of meters was adequate. For the future, we will require tactical accuracy of strategic weapons—often single-digit CEPs (*circular error probable*—in this case measured in meters.) The political need to reduce collateral damage seems likely to grow only more pronounced. Moreover, adversaries are adapting to U.S. airpower by going further underground and utilizing improved concealment and deception techniques. Accuracy will be especially critical when attacking hard and deeply buried targets (HDBT).

System reliability and assurance. The consequences of failure at the strategic level of warfare are dramatically higher than at the tactical level, yet the future strategic strike capabilities likely to be in place (if projected forward from current plans) seem in many ways no more likely to succeed in their missions than their tactical counterparts.

Operational effects assessment. This is BDA, but it isn't BDA. Bomb damage assessment typically pays inadequate attention to the understanding of operational and strategic effects achieved—yet these are the very purpose of strategic strike.

Strike options. The deficiency here will be in the eye of the president. With today's capabilities as projected into the future, the president may have an option or two against virtually every conceivable target type. But many of today's options will look virtually unusable—too uncertain of their effect, too likely to produce undesirable collateral effects, too slow, etc. It is the military's job to prepare the options that the president might reasonably be expected to demand. Much more must be done in this regard.

ISR. Systems designed for the Cold War are woefully inadequate for the range of notional contingencies sketched out above. Indeed, the Cold War systems contribute significantly to many of the deficiencies noted above. High-value targets are becoming more mobile, fleeting, small, buried, and dual-use. The opportunity to be much more aggressive, intrusive, and persistent with ISR is most obvious in dealing with the urgent, emerging categories of rogues and terrorists. Improved ISR is the single most important pacing factor in the future achievement of effective strategic strike. Success in making effective strategic strikes requires both innovative new sensor packages and improved means for bringing together and fusing the information provided by sensors, operatives on the ground, and HUMINT in a timely fashion.

Command and control (C2). Fleeting, high-value targets demand both very rapid response and the effective involvement of all critical elements in the national command authority—including, as appropriate, the president. The present system has already proven itself deficient on these counts—deficiencies only certain to grow more pronounced in the decades ahead. This requires a new approach to C2, one that begins with a more efficient collaboration among the broad set of partners.

Information operations and special operations. Both have a great deal to contribute to future strategic strikes. Both are underdeveloped relative to their potential future contribution. Neither can alone (or in combination) substitute for the more traditionally defined strategic strike capabilities.

Infrastructure. The Cold War approach to infrastructure focused almost exclusively on the nuclear weapons complex. In the emerging era, focus must shift to the industrial and technical base to support future strategic strike. This encompasses science and technology (S&T), research and development (R&D), and production of all of the capabilities germane to strike—not just warheads (and certainly not just *nuclear* warheads) but also their delivery systems and the associated command, control, intelligence, surveillance, and reconnaissance (C2ISR), etc. In many cases, this infrastructure remains undeveloped or is deteriorating and significantly constrains future progress. The necessary infrastructure should offer a broader array of capabilities and more agile responses to emerging requirements. Developing the variety of needed capabilities and responses will prove particularly challenging at a time when the global war on terrorism is producing so many new demands of its own.

Defenses, active and passive. Current defenses do not support future strategy. As the NPR rightly argues, improved strategic strike must be complemented by improved protection against ballistic missile attack and other, asymmetric forms of attack on the United States. Different types of WMD pose different threats, and different types and combinations of defenses will be required against each type of WMD. These combinations will develop at different rates and will likely continue to vary in their effectiveness as adversaries pursue countermeasures and alternative means of threatening and attacking us.

3. C3ISR Elements

We begin this chapter by reviewing the current state of affairs in C3ISR for strategic strike. We then identify the shortfalls or deficiencies for each C3ISR element (starting with ISR and concluding with C3), summarize the capabilities needed, and suggest the programs necessary to provide future leaders the options desired to support strategic strike. In the following chapter, we address the features of the whole system.[5]

3.1 INTRODUCTION

Fifteen years after the end of the Cold War, our intelligence, surveillance, and reconnaissance (ISR) programs continue to rely principally upon national space assets. Compared to the ISR that supported the Cold War, however, ISR for future strategic strike must be much more prompt and responsive, similar in many ways to the ISR that supports tactical strike. The future strategic strike mission, for example, requires us to find and identify elusive or hidden high-value targets, including individuals, small and dispersed WMD components, and buried or otherwise concealed objects.

Similarly, command, control, and communications (C3) for strategic strike requires the immediacy, collaboration, capacity, flexibility, and feedback of tactical strike. They must also exhibit the highest levels of assurance and may be required to interact with both strategic and tactical defense.

These requirements demand new capabilities. In particular, we must improve our ability to

- Understand other cultures and discern what our potential adversaries may value,
- Understand the ever-growing base of ISR information and transform this information into knowledge, and
- Conduct "intrusive," close-in ISR.

C4ISR

C4ISR is comprised of three distinct capabilities:

1. Command and control. Command *and* control *are functions.* Command *is the formulation of intent, including planning, and* control *is the feedback from the results of the actions taken in response and the assessment of whether the commander's intent was achieved.*
2. Communications *and* computers *refer to the hardware and software systems needed to implement the command and control.*
3. Intelligence, surveillance, *and* reconnaissance *are hardware and software systems of sensors, data collectors and platforms, and the exploitation tools needed to extract information from the data.*

[5] We did not assess *computer system* shortfalls, identify capabilities needed, or recommend programs. This is an area in which the commercial sector has often outpaced defense-oriented developments. However, ASCI, chip developments for advanced signal processors, and space borne computer systems are all examples of unique military developments. For the purposes of this report we assume that the necessary computer systems initiatives are addressed and supported by the respective C3ISR elements.

Among other things, these new capabilities will require us to develop and improve our data mining techniques as well improve how we acquire and utilize human intelligence (HUMINT).

Overall, we recommend that DoD evaluate current plans to improve tactical ISR and determine what additional investments will be needed to meet future strategic strike needs. A single global command and control (C2) operational architecture (consistent with features needed for both strategic strike and joint tactical operations) appear to be possible given (1) the communications initiatives on the horizon and (2) the possibility of utilizing many common ISR assets. Significantly, this will require a more coordinated and comprehensive C3ISR architecture and development process.

3.2 INTELLIGENCE[6]

3.2.1 *Shortfalls*

The U.S. intelligence community has not developed the resources to adequately understand the leadership culture and values of its potential adversaries, particularly rogue states and terrorist organizations. For example, U.S. decision makers have lamented how our understanding of North Korean goals and tactics under Kim Jong Il has eroded, and we do not understand the distinctions among the diverse elements of Al-Qaeda.

These shortfalls parallel (and to some extent are due to) the lack of in-place operational assets within these states and organizations. Following post-Vietnam national policy and concern over perceived historical Intelligence Community (IC) excesses, CIA's Directorate of Operations is far less effective than it needs to be in the post-September 11 environment.

On the collection side, current and programmed national imagery systems will produce a wealth of highly-detailed products, but will do so episodically from generally known ephemeris so that adversaries avoid actions in the open when these assets are overhead. Thus, we typically overload imagery analysts with potentially uninteresting images.

Another significant intelligence shortfall is the inability to identify and then track the location of adversary leadership and/or components of WMD. These physically small entities are essentially impossible to find without *in situ*, intrusive sensors and probably HUMINT as well. There has not been enough progress to date given the post-September 11 need for such systems.

Finally, whatever progress is made in individual intelligence disciplines, analysts lack an integrated base of information which they can access. Such a base should include the above disciplines as well as open-source information and measurement and signatures intelligence (MASINT). The IC endemically lacks processes for collaboration and sharing.

[6] This discussion addresses National Foreign Intelligence Program (NFIP)-funded systems and intelligence analyses. The surveillance and reconnaissance section to follow will address DoD-funded programs.

3.2.2 *Capabilities Needed*

Because space-based assets are relatively safe from active defenses and have a wide viewing area, we will continue to need their effective and persistent imagery, particularly for tracking movable targets and for cuing other assets. Space and airborne assets can also supplement other intelligence means for characterizing underground facilities and for helping to locate WMD development or storage facilities. Space and airborne assets, however, traditionally depend upon identifying targets or changes in the local environment by comparing data with a "template" derived by other means. Without the template, their effectiveness in real-time applications is limited.

We need a broad range of technical approaches to provide very close-in, intrusive intelligence collection against targets such as individuals, mobile launchers or submarines, WMD components, or functions of HDBTs. (Our ability to find, identify, or track these targets from space and air has limits.) This range includes tags (tagging, tracking, and locating them or their vehicles); robotics (increasingly smaller, disguised, and smarter); and cyberespionage (aggressive, intrusive data mining). When we have these close-in systems, we need to embed them in a multi-INT system that exploits synergies among them.

For example, the cyberespionage system ("cyberspy") can mine data about a terrorist's motor vehicle, inform a human asset in the area, and cue the human asset to place a tracking tag on the vehicle. (A similar cyberspy system can also operate on an adversary's database to fool him or to degrade his operations.) Each of these intrusive techniques offers promise for developing templates of targets and/or functions ascribed to targets that will make the evolutionary space and airborne assets more effective in today's (and tomorrow's) environment. Without a reinvented HUMINT capability, however, we lack the necessary understanding of key regional and terrorist adversaries to inform policy or track and locate small objects for targeting.

3.2.3 *Recommended Programs (Near-, Mid-, and Long-Term)*

In order to achieve the most leverage from individual systems, we recommend an integrated, multi-tier intelligence system encompassing space and air-based sensors linked to close-in and intrusive lower tiers. For the ISR system needed for future strategic strike to come to fruition, it is essential that the leadership view the multi-tiers as "a system." Accordingly, tradeoffs in capabilities needed across the tiers (or prioritizations of expenditures for development) are then conducted in an environment where the implications for future strategic strike are understood. The lower tiers are not only the critical source of intelligence, they can also serve as a key cueing device for other sensors, as described further under the surveillance and reconnaissance (SR) recommendations below.

Even with such a tiered system, however, we still need to improve our competencies in the related fields of HUMINT and cultural analysis. We can achieve this only by (1) recruiting, training and motivating human beings with extensive experience living in the culture; (2) developing centers of excellence within the intelligence community on these cultures; and (3) cultivating analysts with appropriate linguistic capabilities. We recommend an increased emphasis on "reinventing" our HUMINT and analysis competencies along these lines. Concurrently, crosscutting signal processor and data mining algorithm initiatives across the various intelligence programs are essential to implement effectively the pull of "knowledge" from "data."

All of these measures are components of the desired tiered system. We believe that emphasis on the bottom tier[7] and HUMINT should now be the primary focus of intelligence asset development to support future strategic strike. Clearly the bottom tier has not been funded aggressively and many of today's pursuits are at the 6.1 (basic research)/6.2 (applied research) state of maturity. However, we must push the attractive technologies into systems that we can integrate into the new multi-tier architecture. Defining the C3ISR architecture essential for future strategic strike and assessing the importance and value of each tier and its elements will force us to prioritize the necessary components of research, development, and implementation.

Capabilities needed from the evolutionary C3ISR architecture to support future strategic strike should be defined by STRATCOM.

3.3 SURVEILLANCE AND RECONNAISSANCE

3.3.1 *Shortfalls*

Current SR systems applicable to future strategic strike include the same national overhead assets and airborne sensors we have relied upon to provide intelligence information.[8] Our overhead assets have proved invaluable in recent conflicts, although they provide only periodic glimpses and not persistent surveillance. Unfortunately, their technical characteristics have become widely known, and they are vulnerable to defeat by simple countermeasures (not talking on cell phones, frequently moving or covering equipment, etc.). Since our space-based "surveillance and reconnaissance" and "intelligence" sensors are often the same, the fact that we depend upon these assets in times of crisis or conflict causes a potential shortfall for assured SR capability. In addition, the potential for global "surge" in a rapid fashion is not possible today.

Airborne assets have proved invaluable for SR as they offer a surge capability to compliment the persistence of the overheads. However, most airborne sensors are not covert and are vulnerable to air defenses. This is of particular concern for future strategic strike, where one may not have the luxury of time to degrade or destroy air-defenses prior to launching a strike. Even when we have established air supremacy, current or programmed airborne SR systems lack the numbers and area coverage rates required to provide persistent coverage. Current SR systems also lack hardness against nuclear effects, including electromagnetic pulse (EMP).

The current process of controlling SR assets and exploiting their products (often referred to as *task, process*, *exploit*, and *disseminate*—TPED) is stove-piped and human-intensive. The result is that it

- Cannot keep up with the volume of data that even the current SR systems provide,
- Cannot task and re-task sensors fast enough to help prosecute time-sensitive targets (TSTs),

[7] This tier includes tags, cyberspy, unattended ground sensors (UGS), mini-unmanned aerial vehicles (mini-UAVs), and so on.
[8] These include airborne radar (manned and unmanned), SIGINT, and electro-optical (EO)/infrared (IR) sensors.

- Does not allow users to "pull" imagery as opposed to having it "pushed" to them.

We believe that it is not prudent to invest in new SR assets without fixing the TPED problem first.

In addition to these general issues, we must note that certain classes of targets present particular difficulties for current sensors. These classes include moving targets; targets embedded in foliage; targets protected by camouflage, concealment, and deception (CCD) and electronic counter-countermeasures (ECCM); underground targets; and targets such as WMD and leadership which may be widely dispersed, might be very small, could be covertly deployed, or which lack unique signatures.

Finally, an increasingly important problem is the reliance of SR systems on prior intelligence data ("templates") to identify and track targets. This was feasible during the Cold War, when the Soviet Union would extensively test systems prior to employing them, but it is significantly more problematic with the more diverse threat we now face. A September 11-like "first time out of the box" threat is now far more likely to emerge rather than one that we have seen over the years on test ranges.

3.3.2 *Capabilities Needed*

The diversity of potential targets and countermeasures means that no single "golden bullet" SR system exists to provide all the needed capabilities. Rather a robust, tiered-sensor architecture is required. We believe it should include the following elements:

- Space-based platforms to provide global, persistent coverage;
- Penetrating airborne platforms to provide surge capability (and exploit the lower tier through connectivity and possible implementation of sophisticated multi-static receivers);
- Close-in airborne sensors to provide high-confidence target ID and tracking of WMD;
- UGS and tags to track key individuals and equipment; and
- Exfiltration of data from intrusive sensors—including cyberspy— in "real-time."

These elements are needed to exploit the diverse sensor phenomenologies that are required to detect and identify difficult targets and defeat countermeasures successfully. Thus, both active and passive sensors are needed. We also need to develop and deploy advanced sensing modes such as polarimetry and multistatics. Robustness against CCD and ECCM needs to be a key design criterion. Finally, even though fully protecting all SR systems against nuclear attack may be prohibitively expensive, it would be desirable to at least selectively harden assets to remove cheap shot options.

The development of a robust, tiered sensor architecture will pose additional difficulties for the TPED process. As we observed above, this process is inadequate even for today's SR systems. The Assistant Secretary of Defense for Networks and Information Integration, or ASD(NII), has proposed and is developing a *task, post, process, use* (TPPU) process to replace the TPED process. This will permit netted, collaborative, real-time, signal-level sensor exploitation, although, to close the loop, it needs to be supplemented by a coordinated sensor tasking process. Appropriate metadata standards must be developed and enforced to permit reliable use of posted sensor data. The posting process must include subtleties such as negative information (i.e., a sensor needs to report when it has looked at a region and detected no targets). Automated exploitation (automatic target recognition, fusion) and sensor planning will be needed to cope with the diversity of sensors and flood of sensor data. Likewise, advanced information management techniques such as software agents and "fuselets" (software agents that not only find data but fuse it) will be needed to make sure that users obtain sufficient information to garner knowledge and not just become swamped with data from the process.

Only a tiered, persistent sensor architecture will provide the potential for new and greatly improved approaches to processing and exploiting sensor data. For example, persistent sensing will provide data for very high-resolution site modeling, which will permit the use of techniques such as knowledge-based signal processing (using prior knowledge of the environment to modify the operations performed on the sensed data) and coherent and object-level change detection. The capabilities needed for this future strategic strike C3ISR architecture should be defined by STRATCOM.

3.3.3 *Recommended Programs (Near-, Mid-, and Long Term)*

A concerted effort is required to realize the needed SR capabilities. Much of the effort required to develop individual SR systems is already underway, but integrating these systems into a coherent, tiered architecture satisfying the requirements of strategic strike requires additional focus.

In the near term, strategic strike must be accomplished using currently available SR systems and those that are in the process of being deployed. However, it is feasible to network these systems to facilitate collaborative sensor exploitation and control. In addition, we must conduct an aggressive research program to develop the objective tiered architecture. The Services and the Defense Advanced Research Projects Agency (DARPA) are currently developing some component SR systems and technologies of this architecture.

What is missing and needed is a *program* to integrate these systems together, with the necessary sensor exploitation, planning, and control. Thus, we recommend that Special Operations Command (SOCOM), in conjunction with DARPA, improve close-in, intrusive surveillance capabilities (SOCOM), accelerate development and fielding of the lowest ISR tier (SOCOM), develop improved intrusive embedded sensors and tags (DARPA), and improve exfiltration connectivity (DARPA). Both SOCOM and DARPA should leverage STRATCOM's C3ISR test bed development.

This test bed would employ surrogate and prototype sensors, with appropriate attention on how the sensors would be deployed.[9] This test bed would also be used to (1) develop concepts of operation and algorithms for multi-tiered architecture(s), (2) refine sensor exploitation, and (3) assess sensor communications. The program objective should be to identify the elements of the multi-tiered ISR architecture of the future so that we can then develop the necessary components with clarity of purpose and within scheduled timelines.

Based upon success in the lower-tier test bed (which can also develop "templates" that will enhance the value of persistent and surge SR assets), overhead and

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[9] For example, an airborne radar could serve as surrogate for a space-based radar (SBR).

airborne SR systems should be targeted for mid-term development. These systems should include a space-based radar (SBR); a survivable, penetrating UAV (which might result from the current Joint Unmanned Combat Air System, or J-UCAS, program); and close-in UAVs (mini-UAVs) released from a penetrating UAV (akin to the current Low-Cost Autonomous Attack System, or LOCAAS). Close-in sensors such as UGS and tags are becoming available as the result of ongoing lower-tier development programs, and the testbed should identify those that should be pursued for implementing the ISR architecture. Tools currently in development for sensor exploitation and tasking will be ready for deployment, initially in a semi-automated mode acting as decision aids for operators. These capabilities would be upgraded over time in a spiral fashion.

Close-in sensors could be deployed by a penetrating airborne surveillance platform (e.g., J-UCAS). They might be recoverable—using air-to-air docking technology that is being developed in academic research—or expendable. They could carry a variety of payloads, including conventional EO/IR sensors or specialized sensors for detecting WMD materials. For example, DARPA is developing a ladar under its Jigsaw program for a small UAV. The Jigsaw sensor produces three-inch resolution, three-dimensional imagery to provide a capability for highly reliable target identification that is robust to all but extremely high-fidelity decoys. In addition, by imaging through gaps in tree cover and combining multiple views, the sensor is able to detect and identify targets in foliage.

Intrusive sensors such as UGS and tags may be air-delivered but more often have to be hand-emplaced. UGS are extremely limited in their detection range (a few hundred meters is typical, although detection ranges for acoustic sensors can be quite a bit farther under the right atmospheric conditions), and battery life is also an issue. Current tags are made in small quantities and are larger than desired for covertness. Future UGS and tags will be less expensive, so that they can be more widely deployed, smaller, and more covert. Innovative approaches to obtaining energy from the environment may be developed to reduce the problem of limited battery life.

The integration of the sensors in the multiple tiers provides a level of capability (far) greater than the sum of the individual sensors. For example, a transporter/erector/launcher (TEL) decoy that replicates the shape of an actual TEL to fool a ladar might be susceptible to discrimination based upon its radar signature. An UGS might cue an SBR to follow a vehicle from a WMD production facility to its destination. Clearly, data integration, or fusion, not simply "interoperability" is necessary for such concepts to be implemented.

In the longer term, even higher levels of integration and additional sensor modalities will evolve. For example, extremely wide receiver bandwidths will permit radars to function as SIGINT assets. Active modes will be added to passive EO/IR/HSI sensors. Sensor exploitation and tasking will evolve from machine-aided to automatic, with human operators assuming a supervisory role: human *on-* but not *in*-the-loop.

Immediate and continued attention through the mid and long terms must be placed upon sensor exploitation and control system. Today's legacy is a stove-piped, manual system based upon a TPED paradigm. The system is overwhelmed by data, is too slow, and is not responsive to users' tasking.

When the additional sensors and sensing tiers we recommend here are deployed, this situation will only become worse. What is needed is an aggressive technology development and transition program to provide a netted, machine-aided system based on a TPPU paradigm. Such a system will generate knowledge instead of data, meet TST targeting timelines, and provide users with a closed-loop capability in which they can quickly re-task sensors to optimize coverage of the evolving situation.

Areas to be emphasized in such a program include the following:

- Knowledge-based signal processing;
- Site modeling and change detection;
- ATR, fusion;
- Real-time sensor management;
- Knowledge-based systems;
- Agents;
- Machine translation; and
- Data mining.

3.4 FUTURE TIERED ISR SYSTEMS

Current surveillance and reconnaissance systems have limited capability to support future strategic strike. Our space-based assets lack persistence and our airborne assets lack survivable penetration capability. Control of these assets and the exploitation of their take is stovepiped and human-intensive. The assets are vulnerable to CCD and to EMP and other directed energy attacks. In addition, they often depend on advance knowledge of target signatures, thereby limiting their ability to deal with something new. The lack of persistence limits their ability to detect and track evasive targets.

The DoD is contemplating very significant investments to upgrade space and airborne surveillance and reconnaissance assets, but even if these investments occur and yield their predicted effects, the laws of physics will still seriously limit their capability to penetrate foliage, track individuals, identify WMD components, defeat camouflage, and identify decoys. Dealing with these surveillance and reconnaissance challenges will require lower tiers of close-in and intrusive sensors.

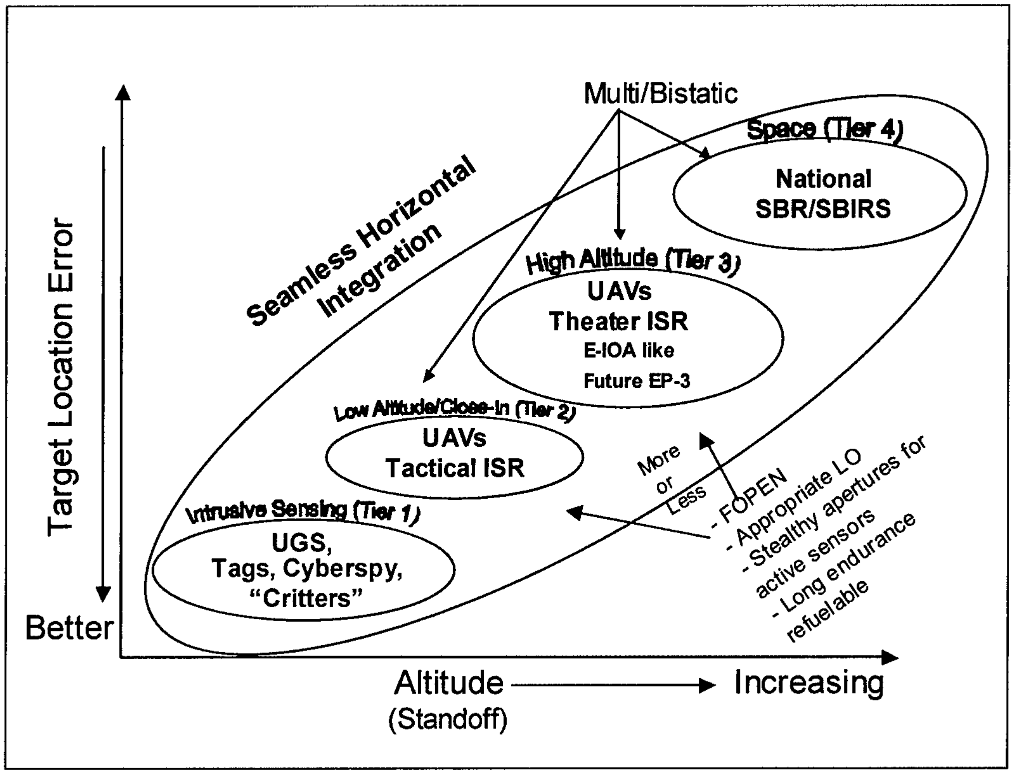

Figure 3-1: Future tiered ISR systems.

Figure 3-1 illustrates the set of surveillance and reconnaissance sensors that must be seamlessly integrated in near real time to produce timely and actionable intelligence for future strategic strike. Achieving effective horizontal integration will be not only a technical but also an organizational challenge; it will require changes in stovepiped practices in tasking sensors and exploiting their products.

The three upper tiers of sensors are largely contemplated in the Transformational Space and Air Program (TSAP), orchestrated by the Under Secretary of Defense for Intelligence—USD(I). The need to operate without air superiority prior to the strike must motivate attention to stealth and survivability. A penetrating ISR aircraft will probably have to operate passively, perhaps exploiting illuminators located in the relative sanctuary of space. However, hardening of space assets against probable near-peer threats cannot be ignored.

We are ambivalent as to whether the airborne sensors should be located on manned or unmanned aircraft. Some sensors may require large aircraft. However, the references to "E-10A-like" and "future EP-3" apply only to their sensor suites; we are very skeptical about the need for flying command/control and sensor exploitation personnel in forward aircraft in an era of net-centric capabilities.

What TSAP does not include is the tier of *in situ* sensors shown in the lower left portion of figure 3-1. These sensors, as well as a reinvented HUMINT capability and effective cyberespionage, will be indispensable for the production of actionable intelligence on fleeting and hidden strategic targets.

The value of the integrated ISR approach is shown in figure 3-2. This chart represents a subjective assessment of current and increasingly more integrated ISR capabilities against a broad range of threats. Current ISR systems do not provide adequate information for future strategic strike with assured confidence against leadership locations, elements the leadership may value, TELs, WMD components, or HDBTs. Programmed and planned space and high-altitude surge ISR elements promise improvements against TELs, and through perseverance, against some HDBTs. However, close-in/surge (e.g., mini-UAVs) and intrusive (e.g., cyberspy, tags) sensors, as well as feet-on-the ground agents or special operations forces (SOF details), are needed to improve the situation. When all of the assets in the tier are aggregated and integrated, the range of targets that we can hold at risk improves dramatically. As work commences in earnest on the lower tier and HUMINT is properly emphasized, we should expect performance to exceed the projections shown for the integrated system. Such a system could greatly benefit other military missions as well, particularly when allocating defensive assets against potential WMD threats.

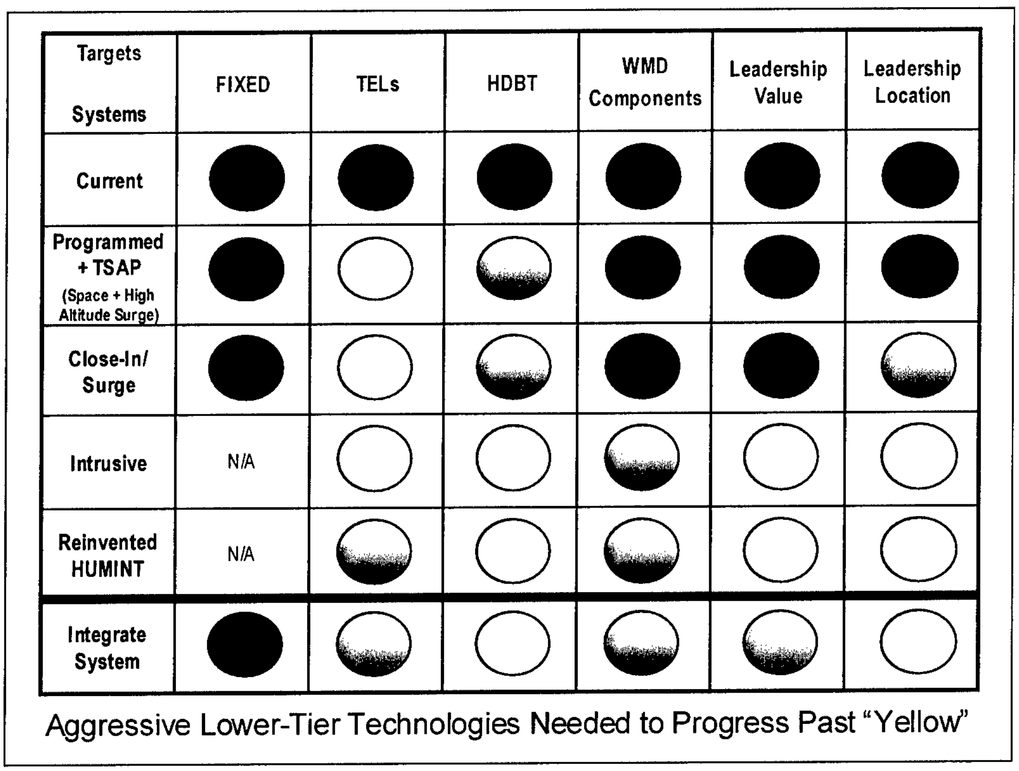

Figure 3-2: The value of an integrated ISR approach.

3.5 COMMUNICATIONS

3.5.1 *Shortfalls*

We currently experience shortfalls in all the principal areas of communications quality of service (QoS):

- *Bandwidth.* The future will require assured bandwidth for many more such imaging sensors as well as advanced sensors, e.g., multi-static radars requiring signal-level interactions. Today's systems have been designed to accommodate low bandwidth and choked communication links by (1) reducing the amount of data we share and/or (2) constraining the kind of information we transmit.
- *Connectivity and common protocols.* Connectivity will be needed for the increasing number and variety of C2 and ISR elements as well as connectivity to all the weapons delivery systems and the weapons themselves. To accommodate such a wide variety of users and sources, while providing for open architecture attributes, common network protocols are needed.
- *Timing.* The expected increase in the number of time-sensitive targets will require assured low latency, so that the cumulative timing within each strike's kill chain is well within the exposure time of the target. Fusion of data from multiple sensors is not possible without precise time-phased integration of the data.
- *Robustness/assurance.* High security and assured connectivity are needed in projected electronic environments that feature information attacks, electronic countermeasures, and electromagnetic pulses.

3.5.2 *Capabilities Needed*

The communications programs included in the Transformational Communications Architecture/Global Information Grid (TCA/GIG) vision (including evolving military communication satellites), promise to address the above-identified shortfalls to provide high-capacity, flexible, interoperable, and assured information transport that meets future strategic strike C3ISR needs. We identify the needs below and discuss how TCA/GIG can be made to satisfy them.

- *Flexible, high-capacity, networked communications.* The TCA can and must be leveraged to meet strategic C3ISR needs. The TCA features Transformational Satellites (TSATs), the Joint Tactical Radio System (JTRS), the fiber-optic Global Information Grid Bandwidth Expansion (GIG-BE), and Transformational Crypto. A notional data bandwidth analysis was performed for an intermediate-sized strategic strike scenario. This analysis indicated total data rates from 10s to 100s of giga-bits per second (Gbps), depending on assumptions regarding data compression and on-board processing. Such rates could be provided by the TCA, if planned and built into the present development.
- *Guaranteed connectivity, controlled latency, and the highest levels of security and assurance.* The TCA initiatives must be provided with quantitative requirements in these QoS categories to assure that TCA development is evolving to support the new future strategic strike capabilities.

- *Closed-loop control of weapons in flight from the network.* A new requirement is direct linking to individual strategic strike weapons. Weapons guidance modes may be needed that do not strictly rely on GPS; as a result, weapons re-direction, recall, and end-game guidance to seekers will require direct connectivity. This is currently anticipated in TCA for Tactical Tomahawk (which incorporates such a link) and would greatly increase the number of simultaneous nodes requiring assured connectivity.
- *Nuclear weapons release system operation in a nuclear exchange environment.* The nuclear weapons release system has long been specially managed to provide the highest levels of connectivity, security, and assurance possible in a nuclear exchange environment. This unique capability must be retained unless and until TC can provide equivalent connectivity and assurance.

In our view, TCA is planned to meet the communications requirements of future strategic strike; however, it is important to provide sufficient technical and programmatic input to the TCA authorities to assure that the needs of future strategic strike communications will be met as new capabilities are introduced.

3.5.3 *Programs Needed*

Programs currently outlined by ASD(NII) appear to be on a path to providing the communications structure needed to implement the future strategic strike C3ISR architecture. However, little evidence suggests that the Services are programming (through budgetary actions) the necessary elements of the communications structure. Further, even with the implementation of the visionary ASD(NII) programs, additional effort is required to assure that the "first mile" is assured, secure, survivable, and adaptable to changes necessary in the "fog of war."[10] Similarly, the "last mile" has significant implementation challenges. We therefore recommend the following near-term actions (through 2010). They influence the course of TCA in providing for future strategic strike communications requirements.

- *STRATCOM*
  - Define the needed, quantitative strategic strike communications QoS values phased to strategic strike capability introduction plans.
  - Maintain the requirement for the existing Emergency Action Message system as a hedge until it can be certified that the performance exists (as incorporated into TCA).
- *ASD(NII)*
  - Continue to ensure that programs of the Services and Defense Agencies adhere to the GIG standards and vision—e.g., assure that the Network-Centric Enterprise Services (NCES) are adopted.
  - Ensure that the network QoS, open-standard protocols, and redundancies (for robustness) meet requirements provided by STRATCOM.

[10] The "first mile" refers to the connectivity of the individual command with the envisioned communications grid. The "last mile" refers to the connectivity with and from lower-tier sensors and shooters in all stages of a potential conflict.

- *Services and the Under Secretary of Defense for Acquisition, Technology, and Logistics—USD(AT&L)*
  - Build strategic strike elements as GIG components to ASD (NII)-defined standards and services (e.g., NCES).
  - Ensure that weapons systems, including both the weapons carriers and the weapons in flight, are connected with the GIG.

In the farther term (2010-2030), the GIG must accommodate evolving and emerging advanced strategic strike elements and capabilities as they are scheduled to appear. This will require highly coordinated planning among STRATCOM, ASD(NII), USD(ATL), and the Services.

3.6 COMMAND AND CONTROL

Evolving national and DoD-level guidance mandate profound and transformational changes in strategic C2—changes that will bring about a global, integrated, and net-centric capability.[11] As the overarching operational concepts for strategic C2 are developed, the goals for the emerging net-centric architectures reflect an extremely agile C2 network. This network will enable the incorporation of sophisticated intelligence feeds, rapid and adaptive planning, collaboration at all levels, and superior decision making.

This ongoing transformation in C2 is complementary to and supportive of our efforts to define capabilities and requirements for future strategic strike. The global nature of future strategic strike requires precisely what the evolving C2 architectures are being designed to provide: rapid turnaround times for planning and course of action (COA) development; netted collaboration capabilities; on-demand, fused intelligence; and highly agile decision making. The mission success of new advances in delivery and payload systems, as described in this study, depend greatly on the agility of this netted, collaborative C2 system.

3.6.1 *Command and Control Shortfalls*

Today's capability to prosecute rapid, decisive global strategic strikes depends on a sluggish, stovepiped, Cold War-oriented C2 architecture. Current capability lacks bandwidth, is neither rapid nor adaptive, provides little collaborative planning and decision capability, and is insufficiently informed by ISR. Additionally, our present strategic capability lacks (1) a common planning and decision-making network and (2) the ability for all players to operate from a *common, relevant operational picture* (CROP). Maintaining the current architecture, without significant improvements, will preclude any future strategic strike capability from being successful.

On the other hand, challenges presented by WMD-armed adversaries continue to grow in terms of lethality and means of denial (e.g., mobility, concealment, deception, and HDBTs). Our out-of-date C2 architecture empowers determined adversaries to operate "inside our decision loop" and avoid being held at risk. This is clearly an unacceptable condition—one that will only worsen as adversaries evolve in capability.

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[11] This national and DoD guidance includes the Quadrennial Defense Review (QDR); the Nuclear Posture Review (NPR); the Unified Command Plan (UCP), Change 2; and the Transformation Planning Guidance (TPG).

This section addresses command and control in a future in which we may need to direct a strategic strike against an adversary located anywhere on the globe. Additionally, the context and purpose for such a strike (1) could vary (e.g., a strike against a near peer or terrorist, the need to prevent WMD use as part of a conflict among others, and so on), (2) could be carried out by a variety of weapons and platforms, and (3) may have to be executed rapidly. These characteristics imply that the C2 for strategic strike must operate in ways similar to that for tactical strike.

Because the adversary could be anywhere on the globe, a single or universal global command and control operational architecture (or global CONOPS) is needed for *all* the potential "players." In addition to the president, the players might include other national decision makers, the combatant commanders, Agencies, allies, and so on. These supporting players must be able to collaborate and support the command the president has designated to be the supported command.

The planning process and tools must help us analyze mission effectiveness and the risks of potential courses of action (which could include use of conventional or nuclear weapons, information operations, or defense). Plans may be generated pre-conflict, but we should be able to be modify them or re-generate them rapidly, collaboratively, and flexibly. This requires us to train and exercise the planning process continually. It also requires us to develop the appropriate tools.

A CROP is a basic need that will allow the players to see and understand the existing situation and collaborate on plans and decisions. Decision aids, which calculate or describe the effects of implementing various decisions, are also needed. Real-time effects assessment (the capability to understand the strategic effect after a strike) is critical feedback to allow commanders to know if their intent was achieved and to inform further courses of action.

The TCA initiative (coupled with GIG-BE and NCES) provides the opportunity to implement command and control functions in ways that were only dreams a few years ago.

3.6.2 *Capabilities Needed*

- *Netted Collaborative Network.* The primary element to support the new command and control architecture should be a netted, collaborative system that enables very rapid, adaptive planning as well as capabilities for informed, timely decision support and execution. It will ride on the bandwidth-expanded Global Information Grid (GIG), the Transformational Communications Architecture, and Net-Centric Enterprise Systems (NCES).

  This network will be more than a system—it will be a "web" of value-added relationships that will allow informed participants to be netted together throughout the kill chain. These netted relationships will add unprecedented speed and collaboration to the planning and course of action (COA) development process and make available to participants tools, modeling and simulation, and expertise heretofore unavailable.

- *Common, relevant operational picture (CROP).* Another primary feature of the netted, collaborative architecture is its capability to bring together fused and actionable intelligence, force status, and other operationally desirable information into one picture,. This CROP will be continually refreshed from 24/7 intelligence feeds and will tie players on the net together via a common view and perspective of any situation, regardless of location on the globe (see figure 3-3).

In a crisis, military commanders, senior-level national decision makers, planners, subject matter experts, and other key players will be able to review COAs collaboratively, view outputs of models and planning tools, see the latest ISR feeds, and deliberate and make high-confidence decisions regarding global strategic strikes.

The architectural construct for this strategic C2 should fall under the governance of the Unified Command Structure (UCS) under development in ASD(NII) (C2 Policy). UCS is charged with providing a new approach that will unify C2 capabilities across the national/strategic, operational, and tactical levels. This construct will provide senior leaders a unified, common national/strategic C2 capability above the combatant commander level. ASD(NII) is developing policy, concepts, frameworks and "rules of the road" for the UCS. Hence, there will necessarily be a strong linkage among the netted, collaborative communications architecture, STRATCOM and ASD(NII) in terms of oversight of both the UCS and the new C2 and communications architecture.

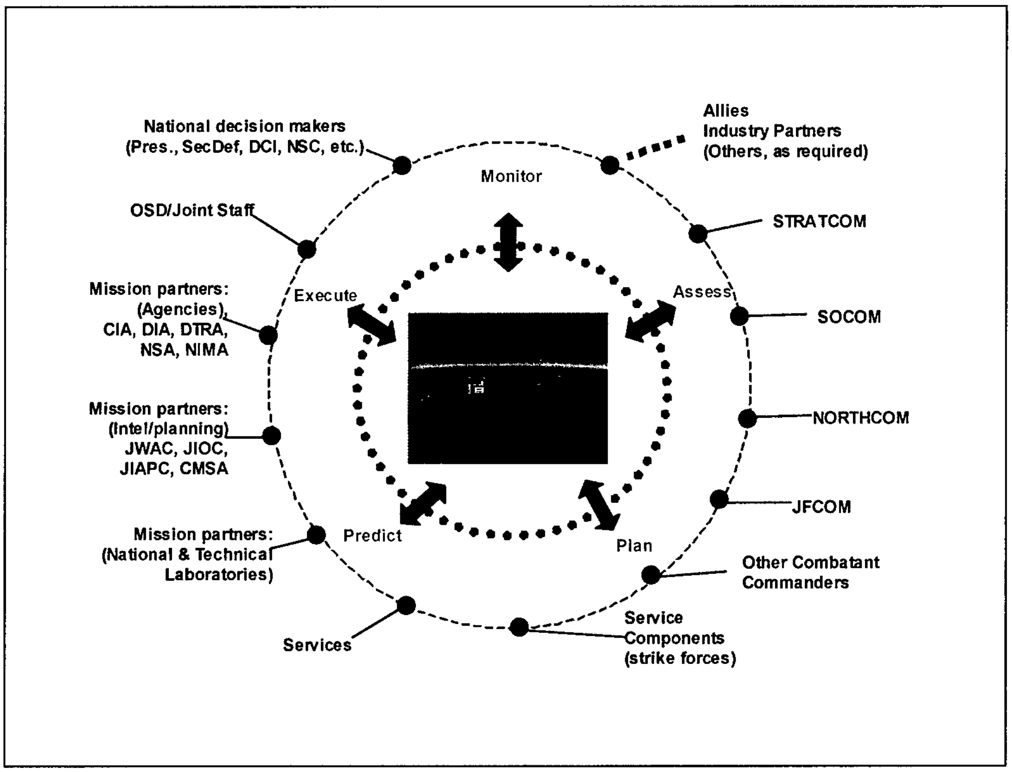

Figure 3-3: Netted, collaborative C2 architecture.

3.6.3 *Command and Control Recommendations*

- A critical step is for STRATCOM to develop the concept of operations (CONOPS) and operational architecture that describe the activities and relationships among the players required to accomplish the necessary C2 tasks. After making a first cut at the operational architecture, STRATCOM should develop a test bed for refining the CONOPS and roughly defining the hardware and software system needs. The initial test bed would be virtual, and include models and simulations, humans-in-the-loop, hardware-in-the-loop, and wargames. As the CONOPS and systems become increasingly well defined, the elements would become "more real" (prototypes or real systems) and include fewer models or simulations. Eventually, the test bed would be implemented on a test range.

- Critical to developing the global command and control construct is implementing the vision of the GIG (i.e., a net-centric communication system with bandwidth constraints removed that allows rapid information pull and develops NCES). The mission-specific applications should then build upon the NCES. STRATCOM should lead the implementation of the "first mile."
- USD(I) should oversee implementation of ISR planning, tasking, and exploitation capabilities; ASD(NII) should oversee implementation of the fused CROP.
- STRATCOM should lead the rapid move to initial operational capability of the netted, collaborative C2 architecture by implementing collaborative planning and decision capabilities using existing communications networks.
- ASD(NII) should continue to develop the C2 governance and policy construct for strategic C2 under the auspices of the Unified Command Structure (UCS) initiative. In terms of UCS, the NII C2 Policy Directorate is charged with developing "a common information environment for net-centric command and control (C2)" and "a future framework for national and strategic level C2 from the president through the combatant commanders to the joint task forces." ASD(NII) is developing policies, concepts, frameworks and "rules of the road" for the UCS. Hence, there will necessarily be a strong linkage among the netted, collaborative C2 architecture, STRATCOM, and ASD(NII) in terms of oversight of both the UCS and the new strategic C2 architecture for future strategic strike.

3.7 OTHER FEATURES OF C3ISR FOR FUTURE STRATEGIC STRIKE

The C3ISR architecture for future strategic strike should also offer a number of characteristics that should be "designed in" the evolving future strategic strike system from the outset. We identify those characteristics here.

3.7.1 *Effects Assessment*

Closed-loop dynamic control of future strategic strike requires prompt and accurate assessment of whether the strike has achieved the desired effect in the target area. However, past strategic doctrine contemplated a reliable but open-loop execution of the single integrated operational plan (SIOP), and past tactical bomb damage assessment was confined to image analysis, sometimes well after the fact.

National imaging sensors and the analysts who interpret those images introduce latency into the assessment, and tasking of national and theater sensors for assessment often competes unfavorably with tasking for surveillance and targeting. Furthermore, image analysts can see holes in buildings and the ground, but they cannot see the whole range of effects contemplated for future strategic strike operations.

We recommend that the Secretary of Defense (SecDef) and the Director of Central Intelligence (DCI) agree to a scheme that integrates the management of sensor and analytic assets for surveillance, reconnaissance, and effects assessment.[12] We further recommend that the Services give more attention to (1) kinetic weapons that can "self-assess," or report their probable effects to the network, and (2) the design of persistent and pervasive sensors that also serve the effects assessment function.

Assessment of non-kinetic effects deserves attention. Planners of a psychological operations (PSYOP) campaign should include an assessment plan that can be turned into tasking for human intelligence (HUMINT) collections. We should also use signals intelligence (SIGINT) to assess the effects of the attack.

3.7.2 *Offensive/Defense Integration*

In order for Strategic Command (STRATCOM) and/or the regional combatant commanders (RCCs) to assess and recommend a strategic course of action, the totality of available options must be "on the table" for consideration. In particular, there are synergies between ballistic missile defense systems (BMDS) and offensive actions that offer the possibility for different consequences when considered together. These include the following:

- BMDS has both defended area and "launch area denied" objectives, and in some instances an offensive strike is required to "deny launch area."
- BMDS could reduce the risk of some offensive options and thus permit a future strategic strike option with fewer detrimental consequences.
- The ISR associated with BMDS could identify adversary launch points (and may be the same ISR as used by the offense).
- The effects assessment of an offensive strike could eliminate the need to defend against launches from certain areas.
- The unwanted effect of having our BMDS intercept a U.S. or allied asset could be significantly reduced.

The National Command Authority should have the capability to take advantage of these synergies. The same players will likely be involved simultaneously in both offensive and defensive strike actions. One global *common relevant operational picture* (CROP)/collaboration mechanism/C2 system should be used for the command and control and ISR collection needed for both the defensive and offensive aspects of a strike.

The planning process and system should include tools that evaluate the effects of defense as well as the effects of defense in conjunction with offense and those effects that relate to offense only. The operational and systems architectures that are developed should incorporate both the offense and defense capabilities for C4ISR together, from the beginning.

Currently, the Missile Defense Agency (MDA) is deploying its own fiber network in the United States, a network that is not part of the Assistant Secretary of Defense for Networks and Information Integration's (ASD(NII)) Global Information Grid Bandwidth Expansion (GIG-BE), nor is MDA planning to connect to STRAT-

[12] We believe this should apply to both DoD and National Foreign Intelligence Program (NFIP) assets.

COM (the "first mile"). These two networks should be reconciled. Additionally, MDA is developing a battle management/fire control system (C2BMC) that needs to be compatible with the global C4ISR system. However, C2BMC essentially makes it possible for BMDS elements to interoperate rather than permitting the fusion of data from multiple sensors across the BMDS elements. Thus, the C3ISR architecture developed for future strategic strike should be the leader rather than the follower in eventual BMDS C3 development.

3.7.3 *Information Operations*

Information operations attacks can support future strategic strike in a variety of ways. Traditional electronic warfare—electronic attack against surveillance and targeting sensors—can protect attacking aircraft, as can computer attacks against the networks that control air defense. More generally, interference with other communications networks, either through electronic attack against wireless links or through computer attack, can disorganize an adversary's defenses. Even more generally, psychological operations and computer attacks against the industrial web can reduce the adversary's determination and capacity.

All of these information operations can support future strategic strike but are not by themselves decisive strategic strikes. The information operation that could most plausibly be a decisive, low-risk, surgical strike would involve the covert usurpation of a key computer. That computer could, for example, order individuals to assemble where they could be captured, weapons to be disassembled, or all defenses to be shut down.

Achieving such a capability would require extended access to the target computer (perhaps remotely through a network) to gain detailed understanding of its function. Launching the attack would require faith that an unrehearsed operation would have the anticipated effect and would be worth sacrificing future intelligence from the computer access if an unsuccessful attack were detected.

We recommend, therefore, that a reinvented HUMINT service give priority to understanding the probability of undetected usurpation and to the consequences of successful usurpation, including whether adversaries will obey bizarre orders and what remedial actions they will take when they discover the usurpation. We also recommend seeking new info ops methods as a complement to active SIGINT.

With respect to those information operations that play supporting roles, we recommend that (1) the reinvented HUMINT service seek to understand better an adversary's societal mores and values so that more effective PSYOP can be launched, and (2) we continue to identify sensor and wireless communications systems to guide the development of the apparatus and concept of operations (CONOPS) for electronic attack.

SUMMARY: C3ISR ELEMENTS	
Topic	*Recommendation (agent)*
C3ISR architecture	• Define capabilities needed for future strategic strike (*STRATCOM*)
Intelligence	• Develop an integrated, multi-tier intelligence system encompassing space and air-based sensors linked to close-in and intrusive lower tiers • Improve HUMINT and cultural analysis (*DIA*) • Orchestrate development of automated data mining and fusion of sensor products, databases, HUMINT, and cyberspy for the future strategic strike C3ISR architecture—(*coordinated by USD(I) and ASD(NII)*)
Surveillance and reconnaissance	• Improve close-in, intrusive surveillance capabilities (*SOCOM*) • Accelerate development and fielding of the lowest ISR tier (*SOCOM*) • Develop improved intrusive embedded sensors and tags (*DARPA*) • Improve exfiltration connectivity (*DARPA*) • Develop an integrated, multi-tier intelligence system encompassing space and air-based sensors linked to close-in and intrusive lower tiers for the future strategic strike C3ISR architecture (*USD(I)*)
Communications	• Define the needed, quantitative strategic strike communications QoS values phased to strategic strike capability introduction plans (*STRATCOM*) • Maintain the requirement for the existing Emergency Action Message system as a hedge until it can be certified that the performance exists (as incorporated into TCA) (*STRATCOM*) • Continue to ensure that programs of the Services and Defense Agencies adhere to the GIG standards and vision—e.g., assure that the Network-Centric Enterprise Services (NCES) are adopted (*ASD(NII)*) • Ensure that the network QoS, open-standard protocols, and redundancies (for robustness) meet requirements provided by STRATCOM (*ASD(NII)*) • Build strategic strike elements as GIG components to ASD (NII)-defined standards and services (e.g., NCES) (*Services and USD(AT&L)*)

Summary: C3ISR Elements	
Topic	*Recommendation (agent)*
Command and control	• Develop the CONOPS and operational architecture that describe the activities and relationships among the players required to accomplish the necessary C2 tasks (*STRATCOM*) • Eventually, implement the test bed on a test range (*STRATCOM*) • Implement the vision of the GIG (i.e., a net-centric communication system with bandwidth constraints removed that allows rapid information pull and develops NCES) • Oversee implementation of ISR planning, tasking, and exploitation capabilities (*USD(I)*); oversee implementation of fused CROP (*ASD(NII)*) • Lead the rapid move to initial operational capability of the netted, collaborative C2 architecture by implementing collaborative planning and decision capabilities using existing communications networks (*ASD(NII)*) • Continue to develop the C2 governance and policy construct for strategic C2 under the auspices of the Unified Command Structure (UCS) initiative (*ASD(NII)*)

4. C3ISR Development

In this chapter we describe the spiral development process that we believe will best implement the C3ISR architecture. We then discuss the advantages of integrated C3ISR development. We close with our recommendations.

4.1 C3ISR DEVELOPMENT PLAN

Our vision for future strategic strike C3ISR requires phased fielding of new capabilities in the form of implementation spirals. The C3ISR architecture features desired (we believe that they should be identified by STRATCOM) should

- Include those elements of a multi-tier system designed to provide intrusive and persistent intelligence against any potential global adversary,
- Offer the capabilities for surges of surveillance and reconnaissance assets against targets identified through intelligence, and
- Assure that netted, collaborative command and control across ISR assets and weapons and their supporting sensors is achievable throughout any foreseen conflict.

The strategic C3ISR architecture has not been viewed as a system or an entity and development of such a system for future strategic strike will require a systems engineering program approach for successful implementation. Figure 4-1 illustrates the key development processes and tasks required to field the necessary capabilities.

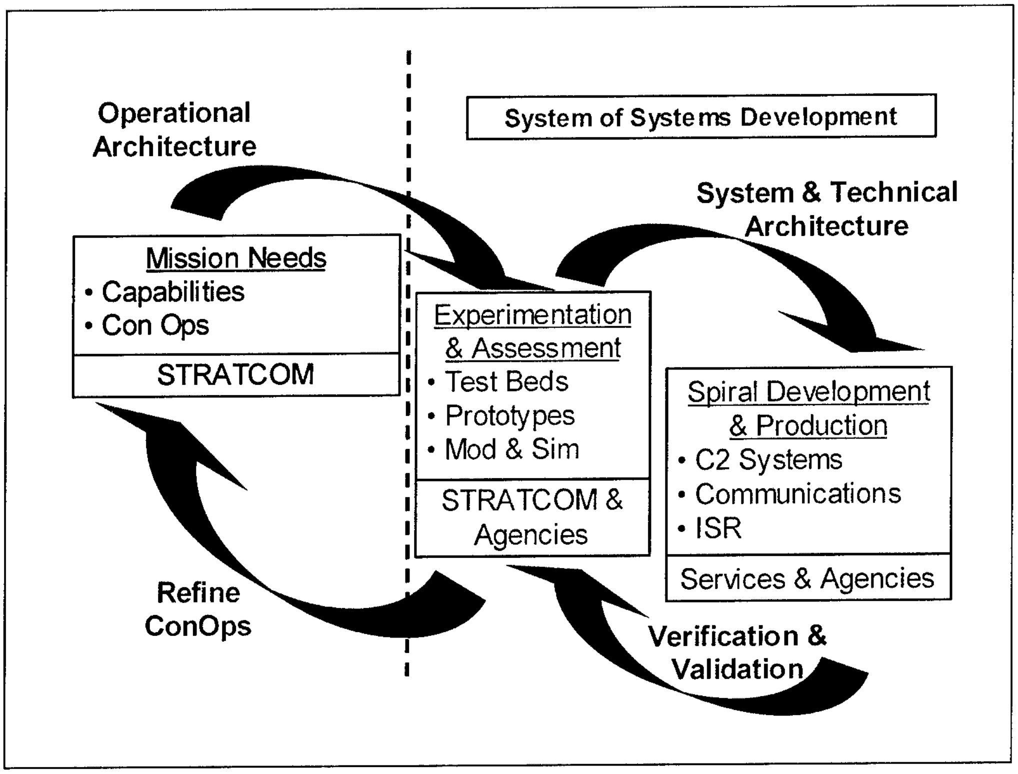

Figure 4-1: Evolutionary C3ISR system development.

As shown in figure 4-1, STRATCOM is responsible for defining the mission needs. These include *capabilities* (with quantified requirements where applicable—e.g., communications quality of service) and the CONOPS. The capabilities include descriptions of activities to be performed, information to be exchanged, and rules to be followed.

Next, STRATCOM and the Defense Agencies develop the system capabilities required to support the operational architecture. These system capabilities are allocated across the C3ISR architecture for development of the key integral elements, managed by STRATCOM. The complexity of this "system of systems" requires the implementation of an objective test bed for experimentation and assessment (see figures 4-2 and 4-3).

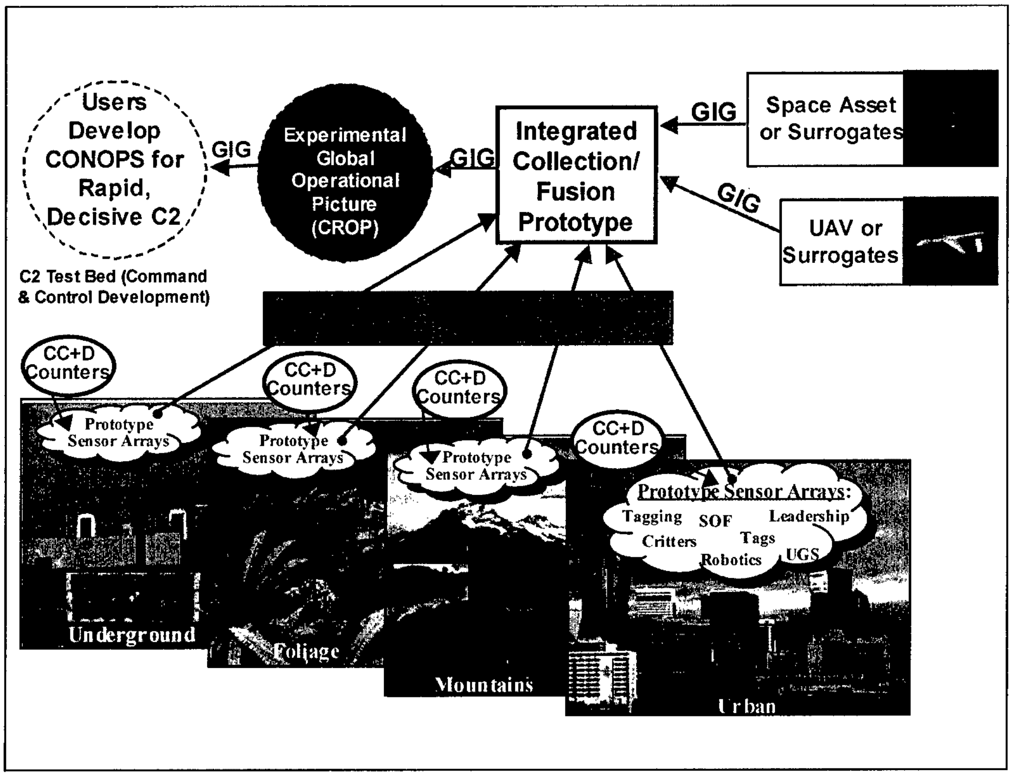

Figure 4-2: C3ISR test bed—virtual and on various U.S. test ranges.

The test bed should be configured to host all the elements of the C3ISR architecture, to include actual elements, surrogate elements, or simulated elements (depending on the architecture's use at any time). The initial virtual test bed will be used to assess and refine CONOPS using humans in the loop, hardware in the loop, and models and simulations. STRATCOM, in association with the Agencies, will also use the test bed to manage development risk. They will do so by inserting prototype elements as a basis to complete the system and technical architecture and to plan each implementation spiral.

This phase will allow STRATCOM to investigate how it should configure the next developmental spiral within the command center (e.g., mock-up changes). The culminating use of the test bed will be to host integration of deployable elements developed by Services and Agencies to verify and validate integrated capabilities in concert with final operational testing prior to fielding each new implementation spiral. Each cycle through a spiral will provide feedback to the next spirals.

Figure 4-2 depicts the test bed collecting ISR data from real or surrogate sensors, fusing the data, creating the CROP, and feeding this picture to the prototype C2 system on which STRATCOM can test and refine their CONOPS. Note that the arrows to the sensors are bidirectional; control of the sensors through the integrated collection/fusion prototype will be an essential part of the CONOPS.

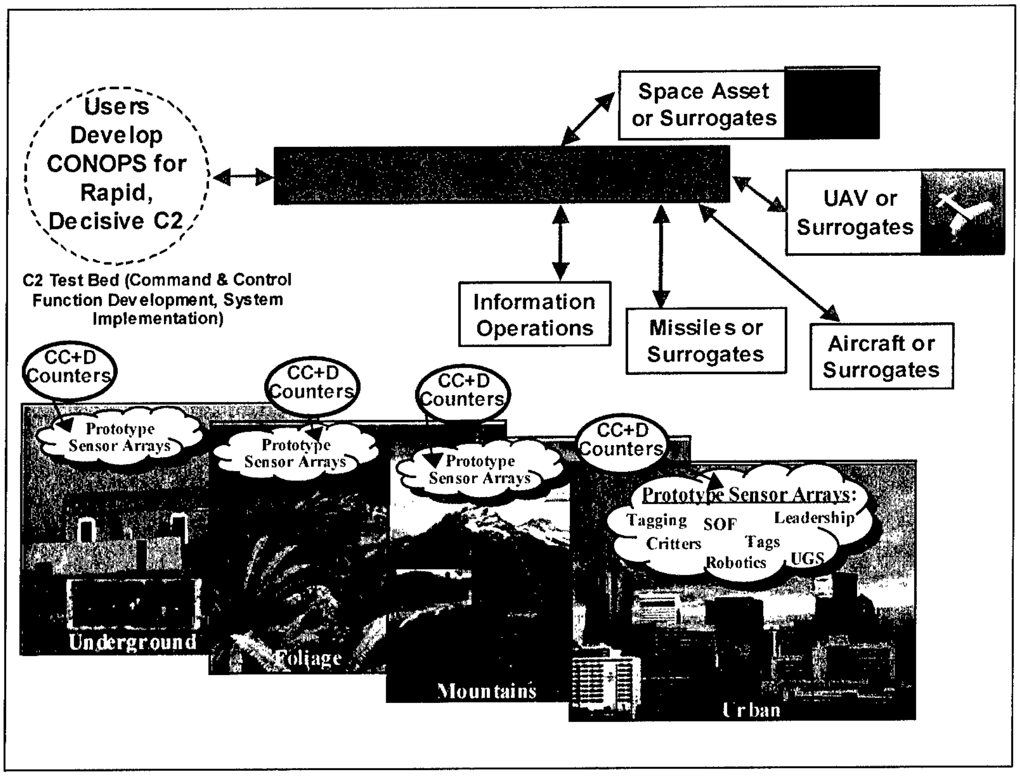

Figure 4-3: C3ISR test bed controlling strike assets—virtual and on various U.S. test ranges.

Figure 4-3 further depicts the test bed with the developmental C2 system controlling strike assets or their surrogates (information operations, missiles, and aircraft).

Figure 4-4 illustrates a notional sequence of spirals. The various small triangles in the figure represent CONOPS, risk reduction, and integration testing events via the test bed. The large triangles depict the delivery of distinct capability (that is, Spirals 0 through 5). We list two dates next to each spiral: the first represents the date of the "initial testing" (via the test bed) at STRATCOM; the second date represents the STRATCOM certification for going "operational"—generally a year or two later after being subjected to CONOPS evaluation, performance testing, and maturing. The following paragraphs describe the notional spiral deliveries:

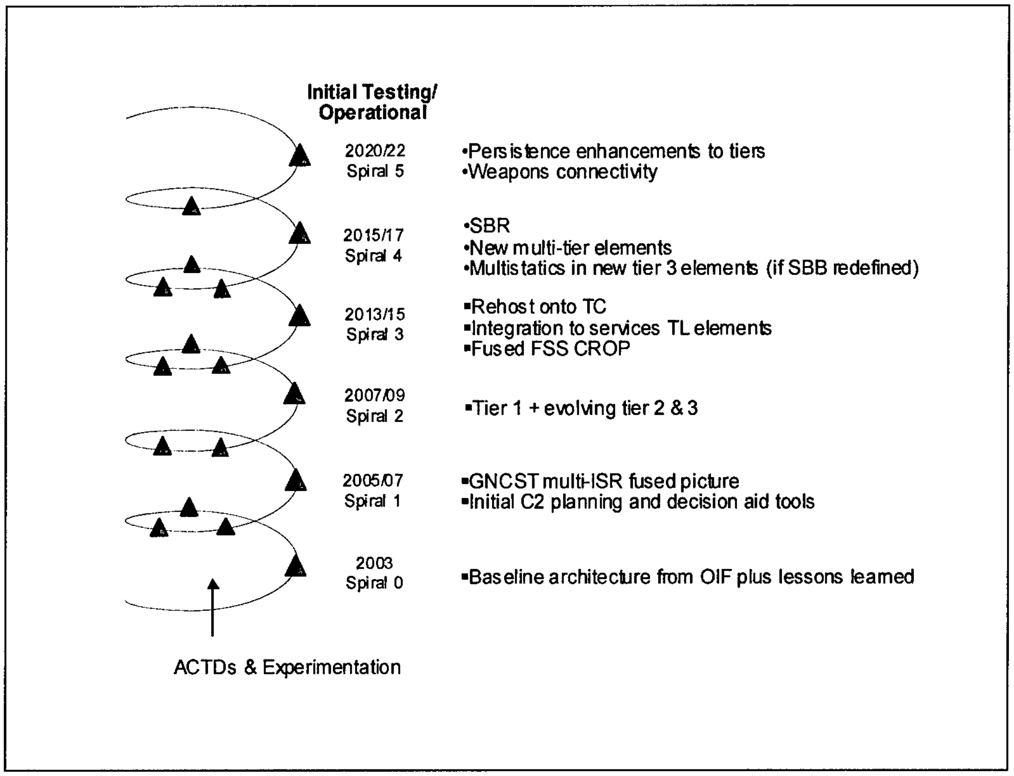

Figure 4-4: Notional C3ISR architecture implementation spirals.

Spiral 0: Baseline fromOperation Iraqi Freedom (OIF) plus lessons learned. OIF motivated the armed forces to implement/ the most capable ISR architecture to date. Much of it was ad hoc, and a significant effort to capture lessons-learned is underway. A consolidated OIF architecture incorporating lessons learned could represent a foundational capability (Spiral 0) upon which to advance the C3ISR architecture.

Spiral 1: Global Strike Force Network-Centric Surveillance and Targeting (GNCST) multi-ISR fused picture and C2 planning/decision aids. A key element in the C3ISR architecture is the multi-ISR fused picture that forms part of the basis for the CROP. At present, the GNCST capability is under development as an ASD(NII) Horizontal Fusion Initiative (HFI) in order to provide such a capability. The initial phases of GNCST focus on data-level networking of present national assets (Tier 4) and tasked airborne (Tier 3) sensors (including present UAVs, U-2, and J-STARS). (While other integration approaches may be under consideration, we selected GNCST as a point of departure for our assessment.) Later phases anticipate broader target classes and the networking of additional sensor types. The initial GNCST implementation is featured in Spiral 1.

Initial command and control planning and decision aids are also introduced in this spiral. This is also a foundational function of the CROP. We anticipate that an ASD(NII) HFI initiative known as D-SIDE (Defensive Strategic Integrated Decision Environment) will act as the basis for this new capability. D-SIDE provides tools that allow decisions to be disseminated through the different levels of security (and seniority), from the president to the assigned combatants. D-SIDE can also incorporate planning and decision aids.

Spiral 2: Tier 1 and evolving Tier 2 and 3 elements. A high-payoff, near-term addition to the architecture is the class of first-tier, intrusive ISR sensors (UGS, tags, robotics, re-invented HUMINT, and cyberspy). Although the more advanced forms of such sensors may not appear until later spirals, the near-term sensors can certainly be integrated into the architecture (this would include the infiltration and exfiltration communications). Existing high-altitude (Tier 3) sensor platforms (e.g., Predator, J-STARS, Global Hawk) will be incorporated into the C3ISR architecture, as will new low-altitude Tier 2 vehicles.

Spiral 3: Rehost onto the Transformational Communications Architecture (TCA), integrate to Services' TC elements and the fused future strategic strike CROP. The timeframe for Spiral 3 corresponds to the initial TC fielding of Transformational Satellites (TSATs) and the Joint Tactical Radio System (JTRS), in conjunction with other products such as GIG-BE and NCES. The C3ISR architecture will be re-hosted onto this GIG backbone. Initial versions of Service initiatives such as Navy FORCEnet and Army Future Combat System will be implemented as members of the GIG by this Spiral.

Also by Spiral 3, an integrated, distributed collaborative implementation (the CROP) will be incorporated, comprised of distributed and interactive C2 planning and decision aids operating from a robust multi-ISR picture (evolved GNCST and D-SIDE). All weapons platforms will have been connected via either JTRS or the TC satellite communications (SATCOM) backbone.

Spiral 4: Space-based radar (SBR), new multi-tier elements, and multi-statics in new Tier 3 elements. The architectural implementation will incorporate a new Tier 4 elements, such as the SBR (an MTI/SAR with bistatic capability—if the present SBR concept is redefined to provide for multi-statics, then this capability can also be integrated with Tier 2 and 3 platforms). Adding the signal-level network interaction of multi-statics can assist SBR by providing a surge sensor capability and potential counters to camouflage, concealment, and deception. Additional tier platforms may also be integrated into this build.

Spiral 5: Persistence enhancements to tiers, and weapons connectivity. Spiral 5 is likely not the final spiral, but it represents future spirals. It features enhanced forms of sensors and weapon systems and implements signal-level sensor network interactions. With this tier, all strategic weapons will have been connected to the GIG to provide robust re-direction (as needed) and to provide input to alternative seeker-based homing as a backup to use of GPS.

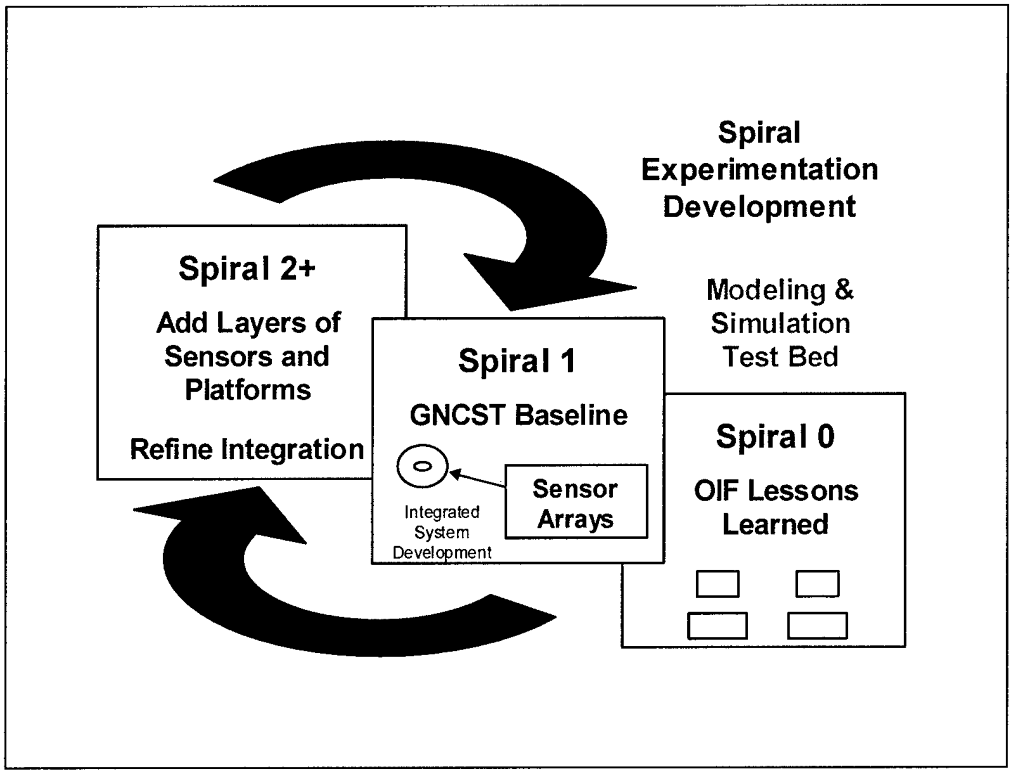

Figure 4-5: Development spiral and test bed.

Figure 4-5 depicts how the test bed would be used in successive spiral implementations. Even as the initial spiral (Spiral 0) is completing validation and operational testing prior to deployment, the next spiral (Spiral 1) would be under risk reduction and integration testing in the middle of the development cycle. Finally, the spiral after-next (Spiral 2) would be entering its initial development by undergoing definition and CONOPS exploration, perhaps using some elements of the previous spirals (with simulations of the anticipated new features of the new spiral). This example applies generally for nth, $n+1^{st}$, and $n+2^{nd}$ spiral sequential developments.

The multiple use of the C3ISR test bed illustrated in the figure requires some parallel application of test bed features to support simultaneous configurations and/or the ability to rapidly reconfigure the test bed to the different implementations within a full (probably weekly) schedule.

The schedule shown in figure 4-6 illustrates an example development schedule using the test bed for Spiral 2. The example features the CONOPS development, risk reduction experimentation, integration, and verification/validation of new tier 1 sensors for Spiral 2.

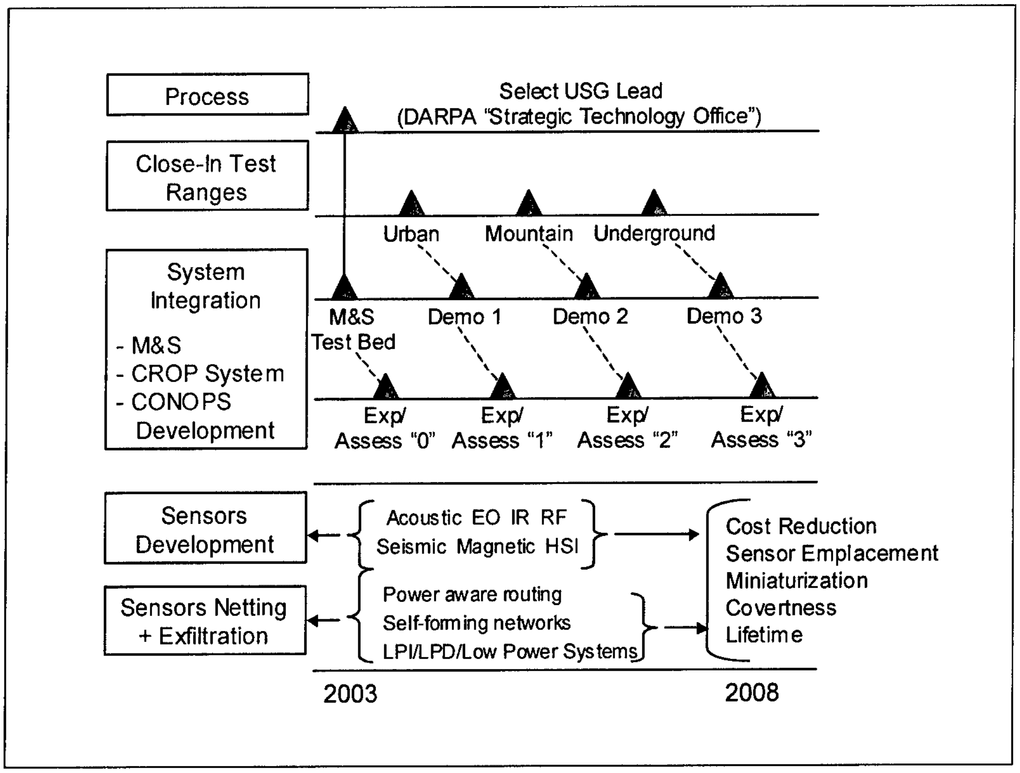

Figure 4-6: Initial test bed development.

4.2 THE IMPORTANCE OF C3ISR DEVELOPMENT

Value of Integrated ISR. We considered scenarios against *regional adversary/terrorists* and *peers* (or near-peers) in 2030, with the assumption that today's programs (mostly classified) evolved as previously planned. In addition, we compared the effects resulting from implementing our recommendations to the effects possible with today's evolved systems as shown in figures 4-7 and 4-8.

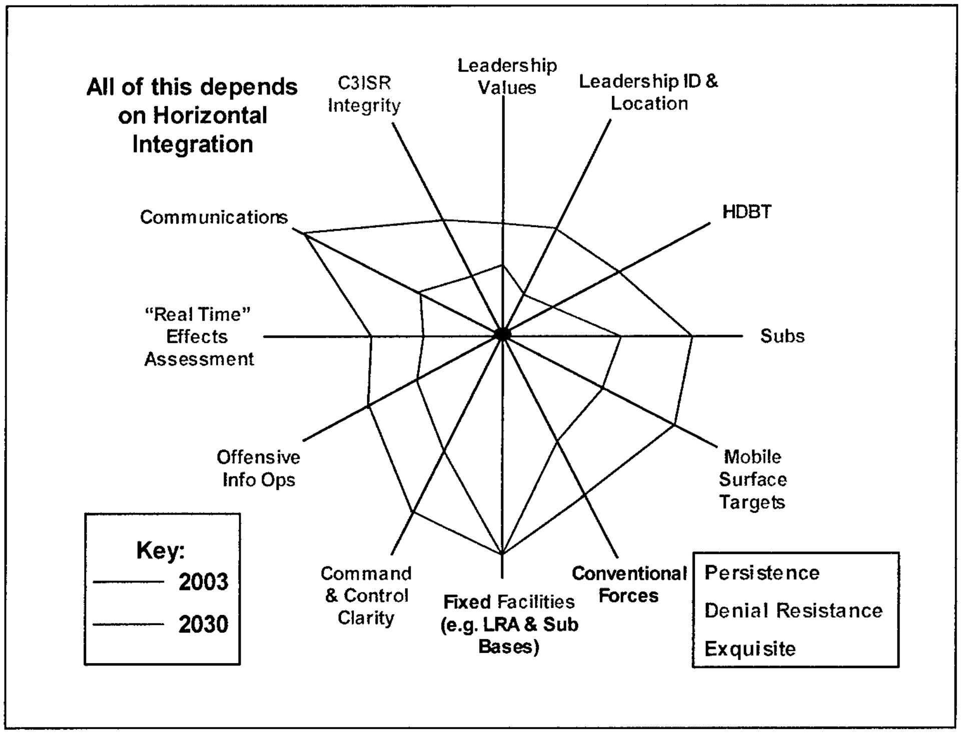

Figure 4-7: C3ISR capabilities for future strategic strike (regional adversary/terrorist).

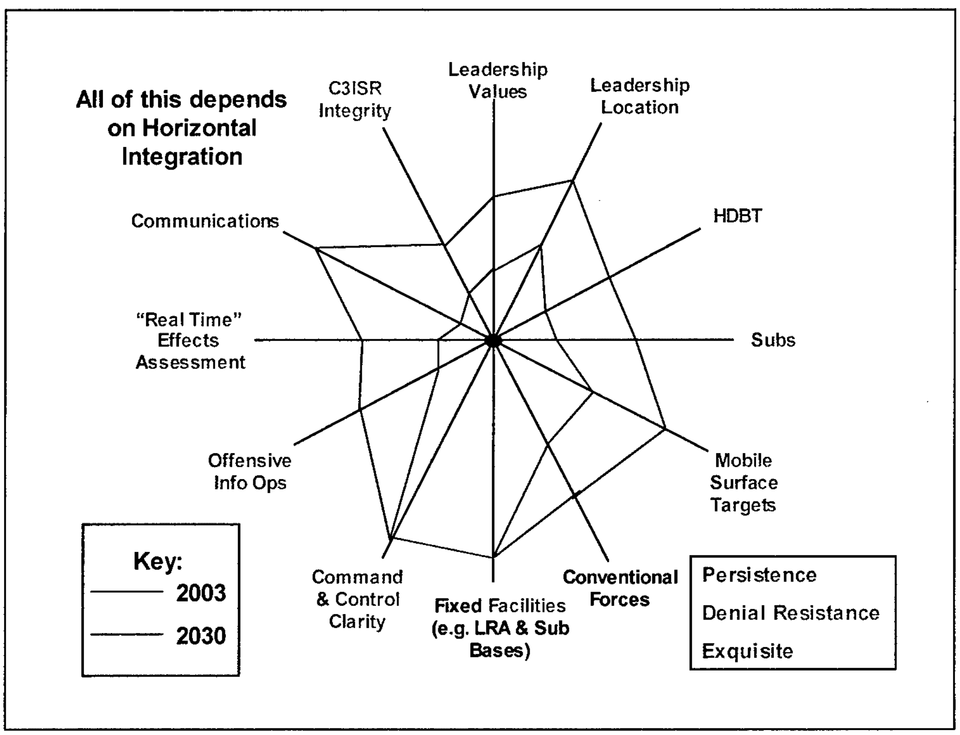

Figure 4-8: C3ISR capabilities for future strategic strike (peer).

Presently planned capabilities will continue to meet projected needs for the fixed targets of the future. However, leadership location, mobile targets, facilities in buried or tunneled targets, and WMD elements that can be covertly deployed will remain difficult challenges. These targets will necessitate a vigorous emphasis on HUMINT and intrusive sensors to improve the confidence in placing those targets at risk in the future. In addition, mobile and elusive targets require extraordinarily responsive and adaptive planning which can be achieved through the recommended C2 and communications developments. Performance of the integrated C3ISR system of the future can exceed the projections only if integration; lower-tier sensors; data mining; and responsive, adaptive planning and execution are pursued with vigor.

The C3ISR architecture, when developed, should also offer the potential for

- "Real-time" effects assessment,
- The C2 clarity needed for offense/defense integration, and
- The building block for future offensive information operations.

Summary: C3ISR Development	
Topic	*Recommendation (agent)*
Effects assessment	• Agree to a scheme that integrates the management of sensor and analytic assets for surveillance, reconnaissance, and effects assessment (*SecDef and DCI*) • Give more attention to (1) kinetic weapons that can "self-assess," or report their probable effects to the network, and (2) the design of persistent and pervasive sensors that also serve the effects assessment function (*Services*)
Information operations	• Give priority to understanding the probability of undetected computer usurpation and to the consequences of successful usurpation • Seek new info ops methods as a complement to active SIGINT • Continue to identify sensor and wireless communications systems to guide the development of the apparatus and concept of operations (CONOPS) for electronic attack
C2 architecture and test bed	• Move away from current or programmed program/operational concepts not essential to the newly defined C3ISR architecture for future strategic strike; e.g. those that (1) are not interoperable, (2) limit the flow of data to the operators, (3) cannot be made survivable, (4) are not designed for threats of the future, and (5) require sophisticated data assessment and are vulnerable to CCD (*SecDef and DCI*) • Define future strategic strike C2 operational architecture (*STRATCOM*) - Incorporate ISR - Incorporate global defense system - Incorporate information operations • Assign and fund STRATCOM to manage the acquisition and implementation of the future strategic strike C3ISR test bed (*SecDef*) • Configured the test bed to host all the elements of the C3ISR architecture, to include actual elements, surrogate elements, or simulated elements (depending on the architecture's use at any time (*STRATCOM*)
Red teaming	• Establish concurrent, aggressive red teaming that addresses computer network defense (CND); camouflage, concealment, and deception (CCD); electromagnetic pulse (EMP) security; and other potential system vulnerabilities (*Under Secretary of Defense for Acquisition, Technology, and Logistics—USD(AT&L)*)

5. Delivery Systems

We begin by reviewing current strategic strike delivery systems, both Air Force and Navy. Next, we discuss the capabilities and shortcomings of these systems. We then offer some approaches to improving delivery systems in the future. We conclude by recommending a number of steps that we believe will improve our ability to deliver strategic strikes in the future.

5.1 CURRENT AIR FORCE ICBMS

The long-range power of the intercontinental ballistic missile (ICBM) force continues to deter all types of conflict. Unique, time-critical characteristics of this force include its responsiveness, speed, range, precision, lethality, and freedom of maneuver. In operational terms, today's ICBMs provide a reliable and low-cost force on continuous alert with a high readiness rate and the capability to immediately react under strict control of the National Command Authority.

The U.S. currently utilizes two types of ICBMs to carry nuclear warheads. The older of the two is the Minuteman III (LGM-30). The DoD has directed the Air Force to extend the life of the current Minuteman III ICBM force and maintain weapon system reliability through 2020. The newer, more capable missile is the Peacekeeper (LGM-118A). However, the Peacekeeper is being taken out of service, leaving only the Minuteman III by 2005. Looking beyond the 2020 timeframe, the Air Force is already conducting studies and planning to maintain the ICBM force for another 20 to 40 years, or as needed for national security. In response to a 1998 Defense Science Board Task Force on Nuclear Deterrence, the Air Force drafted a mission need statement for a land-based strategic nuclear deterrent in the 2020 to 2040 timeframe. The system(s) resulting from this analysis of alternatives (AoA) will provide the Air Force strategic strike capabilities after Minuteman III.

5.1.1 *Minuteman III*

The Minuteman III (MM III) was deployed in June 1970, and production ended in December 1978. The MM III is a three-stage, solid propellant, inertial-guided ballistic missile with intercontinental range. The missile is capable of carrying up to three independently targeted reentry vehicles. A liquid-propellant rocket engine provides post-boost maneuvering prior to reentry vehicle deployment.

MM III has been refurbished several times and is currently undergoing another life extension that includes five major flight components and five ground equipment systems. The flight (missile) components include upgrades to the propulsion system, guidance system, and warhead. The propulsion system upgrades remanufacture all three stages of the MM III weapon system to address age-related degradation discovered during surveillance and flight-testing. The upgrades also refurbish or replace components of the single-axial-engine liquid propulsion system used for MM III post-boost maneuvering prior to reentry vehicle (RV) deployment. It is anticipated that this will be the last time these solid rocket motors can be remanufactured. Guidance system modernization efforts replace the 1960s-era flight computer, amplifier, guidance set controller, and inertial measurement unit electronics and change the operational software for the new processor. All of these life extension efforts will extend the operational service life through 2020.

The final portion of the MM III upgrade deals with the warhead. The Safety Enhanced RV Program upgrades the hardware and software to re-deploy the Mk 21 RV (a newer, safer RV) from Peacekeeper onto the MM III. It also retains the Mk 12A multiple-RV capability, although all MM IIIs are being converted to a single-RV configuration. There are 500 MM IIIs in launch facilities spread across three bases in Montana, Wyoming, and North Dakota.

To ensure the long-term viability of the research and development and manufacturing infrastructure for strategic nuclear systems, the ICBM Demonstration/Validation Applications Program was instituted. This program ensures that critical skills and unique industrial base manufacturing capabilities are preserved in the areas of guidance, RV, propulsion, and C2. These programs are also closely coordinated with corresponding U.S. Navy submarine-launched ballistic missile (SLBM) efforts in order to avoid duplication and maximize return on research and development investment.

5.1.2 *Peacekeeper*

Peacekeeper (PK) is an inertial-guided ICBM capable of delivering ten independently targeted warheads with accuracy greater than MM III. The missile is deployed in specially configured MM III silos. The PK is a four-stage ICBM system, consisting of two major sections: the boost system and the post-boost vehicle system (see figure 5-1). The boost system consists of three rocket stages that power the missile into a sub-orbital trajectory. Following the burnout and separation of the boost system's third stage, the liquid propellant post-boost vehicle system maneuvers the missile in space, deploying the RVs in sequence. The post-boost vehicle system also contains the guidance and control system.

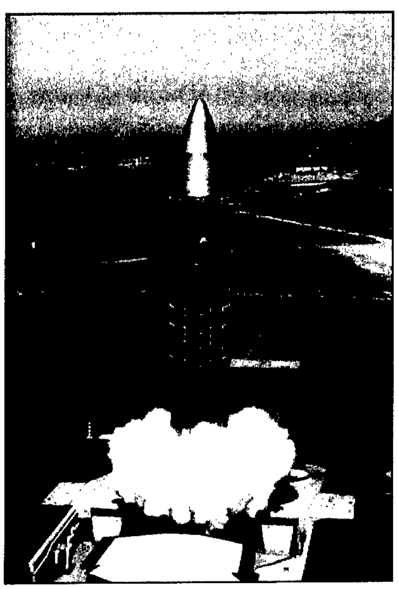

Figure 5-1: LGM-118 Peacekeeper intercontinental ballistic missile (ICBM).

The PK payload capacity is approximately 4 to 5 times that of the MM III, and its payload section is approximately 2 feet wider and 10 feet longer than MM III. With the higher payload mass, the full payload range of the PK is approximately 1,000 miles less than the MM III, although trade-offs among range, re-entry angle, and mass are possible. The PKs are being removed from their operational silos and are being stored in environmentally controlled facilities under the purview of the Rocket System Launch Program. Under this program the missiles are monitored, and any of the four stages of the missile could be reused for another project within the government. There are approximately 70 PKs that will eventually be available.

A possible use of these missiles is to convert them for conventional delivery. It would be possible to replace the post-boost vehicle system and shroud with ones that are compatible with a particular conventional warhead. For instance, a 9,000-pound kinetic energy weapon or four to five 2,000-pound conventional weapons would be feasible.

5.2 CURRENT AIR FORCE CRUISE MISSILES

There are two nuclear-capable cruise missiles in the Air Force inventory: the Air Launched Cruise Missile (ALCM) and the Advanced Cruise Missile (ACM). These subsonic air-to-surface missiles carry the same type of warhead and are carried on the B-52. The ALCM is the older of the two Air Force cruise missiles. The ALCM, ACM, and their associated warhead are all undergoing life extension. A follow-on cruise missile program is anticipated to start in approximately 2015, to be able to have an initial operational capability (IOC) prior to the 2030 end-of-service-life for the ALCM and ACM.

5.2.1 *Air Launched Cruise Missile (AGM-86B)*

The Air Launched Cruise Missile is an air-to-surface, strategic, nuclear-armed cruise missile (W80 warhead). It is designed to evade air and ground-based defenses to strike heavily defended targets within an enemy's territory. Its delivery platform, the B-52H, provides internal and external carriage for the current inventory of 975 missiles. The ALCM fleet exceeded its design service life in 1994 and has been operational since 1982.

A service life extension program (SLEP) was developed to meet the Air Force's Long-Range Plan requirements to extend the ALCM's service life to FY2030. The SLEP identifies missile and support equipment that is becoming unsupportable and system components that cannot be sustained beyond their designed service life. The life extension activities for the ALCM include a Conventional/ALCM Test Instrumentation Kit, Inertial Navigation Element, Functional Ground Test Facility, and W80 Life Extension Program Integration. These activities will continue through 2011.

There are several versions of the ALCM aside from the nuclear one. The AGM-86C or CALCM (conventional air-launched cruise missile) carries a 3,000-pound-class high-explosive, blast-fragmentation warhead and a GPS receiver for improved inertial navigation. The conversion of some AGM-86Bs to AGM-86Cs began in 1986. The AGM-86D version of the missile utilizes an advanced penetrating warhead to destroy hard and deeply buried targets (HDBT).

5.2.2 *Advanced Cruise Missile (AGM-129)*

The Advanced Cruise Missile is a low-observable, air-launched strategic missile. Like the ALCM, it is armed with a W80 warhead and is designed to evade air- and ground-based defenses to strike heavily defended targets within an enemy's territory. It incorporates significant improvements over the ALCM in terms of range, accuracy, and survivability. Its delivery platform, the B-52H, provides for the external carriage of 12 missiles. It has been operational since 1992, and its design service life expires between 2003 and 2008.

A SLEP was developed to meet the Air Force's Long-Range Plan requirements to extend the ACM's service life to FY2030. The life extension activities for the ACM include a Joint Test Instrumentation Kit Modification, Subsystem Simulator/Advanced Missile Simulator, Functional Ground Test Facility, Aging and Surveillance Program for aging components, and W80 Life Extension Program Integration. These activities will continue through 2010.

5.3 CURRENT AIR FORCE BOMBERS

Two nuclear-certified bombers currently serve in the U.S. inventory: the B-52 and the B-2. In addition, the B-1 was a nuclear carrier in the past, but is no longer nuclear-certified; currently it is certified to deliver only conventional weapons. All of these bombers are undergoing upgrades and modernization.

5.3.1 *B-52*

Although the B-52 is an old airplane, it has been continually upgraded. Currently, the avionics are being improved and include upgrades to the Inertial Navigation System, Avionics Control Unit, Data Transfer System, and Offensive Aviation System (OAS). These upgrades are for both hardware and software, providing increases to reliability, maintainability, supportability, and capability. Improvements to the defensive systems will provide better standoff jamming and electronic countermeasures. Improvements to the communications systems (which will include LINK-16) will give the B-52 the full beyond line-of-sight connectivity for nuclear and conventional operations, allowing machine-to-machine capability.

5.3.2 *B-1*

The B-1 is a conventional weapons delivery system. There are a number of efforts underway to modernize this bomber. The Block E will increase the conventional weapons capability and improve the wind-corrected munitions dispenser bomb module kits. Block F is a defensive system upgrade that will include electronic countermeasures and decoys and will explore other options for later inclusion. The capability to carry the 2000-pound class Joint Air-to-Surface Standoff Missile (JASSM) with Global Positioning System (GPS)-aided inertial navigation system (INS) to strike both fixed and locatable targets from ranges outside enemy air defenses is being added. Radar improvements address reliability and maintainability. Communication system improvements are also planned, including LINK-16, beyond line-of-sight ultra-high frequency satellite communications (UHF SATCOM), and aircraft-to-aircraft/command and control (C2) communication. These modernizations will provide real-time situational awareness to the aircrew and the capability to relay C2 information (including in-flight targeting as well as interoperability between joint U.S. and allied military services).

5.3.3 *B-2*

Near-term modernization efforts are underway for the B-2 (see figure 5-2). As with the B-52 and B-1, LINK-16 is being added. A new center instrument display with an in-flight replanner to handle large amounts of threat information is being added. The radar's operating frequency is being changed to avoid significant frequency interference. The conventional weapons capability is also being increased. The 500-pound Joint Direct Attack Munition (JDAM)—an all-weather, GPS-aided, general-purpose bomb—is being integrated; the B-2 can carry 80. The B-2 will also be able to carry the enhanced GBU-28 (a 5,000-pound GPS-aided/INS-guided, all-weather weapon). With the GBU-28, the B-2 will be capable of attacking HDBT.

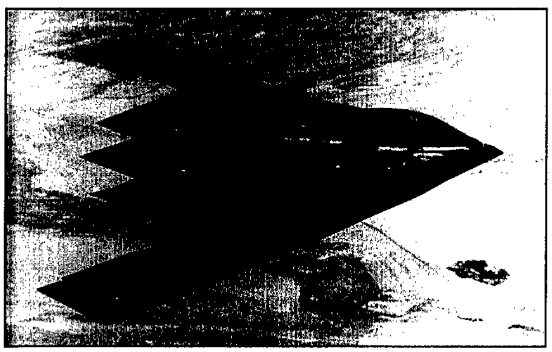

Figure 5-2: B-2 Spirit bomber.

5.4 CURRENT NAVY SYSTEMS

The Navy currently employs several strategic strike systems. These include the Trident II (D-5) SLBM, the *Ohio*-class nuclear-powered ballistic missile submarine (SSBN) and cruise missile (SSGN) conversions, and the Tomahawk Land Attack Missile-Nuclear (TLAM-N).

- To achieve an all-Trident II (D-5) SSBN force, backfit of four of the *Ohio*-class SSBNs from the Trident I (C-4) to the D-5 has begun and will be completed in FY2007.
- The Nuclear Posture Review (NPR) outlined the strategic submarine force structure: 14 *Ohio*-class SSBNs in two oceans outfitted with the D-5. In accordance with the NPR, the remaining 4 of the original 18 *Ohios* are being converted to SSGNs. Refueling and conversion has begun. IOC is scheduled for FY2007.
- Finally, the TLAM-N, a sea-based, nuclear-armed cruise missile, is funded through FY2009; however, DoD is expected to revisit the future of TLAM-N in FY2004.

5.4.1 *Trident II (D-5) Life Extension*

The Trident II D-5 life extension program extends the life of the D-5 out to 2042 and matches the *Ohio* SSBN hull life, which was extended from 30 to 45 years. The SSBN hull life extension is significant in that it delays the replacement of these platforms by 14 years. A follow-on SLBM and SSBN program is anticipated to start in approximately 2015, to support an IOC of 2030 (when the *Ohios* start to retire).

With respect to flight hardware, D-5 life extension requires procurement of an additional 115 Trident II D-5 missiles, revising the total D-5 procurement objective from 425 to 540. In addition, the guidance system and missile electronics are being replaced because of age and obsolescence issues.

The service life extension for flight hardware follows a strategy that effectively addresses two key issues: (1) supporting the existing systems, recognizing that some parts will fail due to age or become obsolete, and (2) producing the additional flight test missiles required to assure credibility and safety of the deterrent. These flight test missiles support qualification of new or modified components, as well as the additional annual reliability tests required due to extended program life.

The Navy has increased research, development, test, and evaluation (RDT&E) investment in strategic programs to enable changes articulated in the new strategic framework outlined by the NPR. The Trident program makes significant contributions to the offensive and infrastructure legs of the "New Triad" described in the NPR. These contributions are achieved by (1) "applications" programs in specific technology areas and (2) focused development programs for specific capabilities.

Applications programs have the major goal of sustaining unique strategic technology, design talents, and infrastructure. The strategic guidance and reentry body applications programs have existed for about 8 years. New applications program starts in strategic propulsion and radiation-hardened electronics are contained in the FY2004 budget. The Navy and Air Force coordinate technology areas and critical skills to obtain maximum synergy. The Navy has four major applications program efforts included in the FY2004 budget request: Reentry System Applications Program (RSAP), Strategic Guidance Applications Program (GAP), Strategic Propulsion Applications Program (SPAP), and Radiation Hardened Applications Program (RHAP).

5.4.2 *D-5 Enhanced Effectiveness Program*

Separate from the applications programs, a specific technology solution, D-5 Enhanced Effectiveness (E2), has been identified and included in the FY2004 budget. The E2 program is designed to provide the D-5 SLBM force enhanced capability to conduct prompt, highly accurate strike; defeat hard and deeply buried targets; and reduce collateral damage with selective nuclear options.[13]

The E2 program is a 3-year effort culminating in a flight test of a Trident reentry body with dramatically improved accuracy. The approach is to integrate existing

[13] Desired capabilities of nuclear weapon systems for use in a limited strike include, among others, high accuracy (precision guidance), minimized collateral damage, and very high reliability. The possibility and extent of collateral damage must be minimized as much as feasible. One method of reducing collateral damage is to improve accuracy, which allows the use of lower-yield existing warheads for comparable effectiveness.

GPS and inertial measurement unit (IMU) technologies with a flap steering system and a reentry body extension. The extension would attach to the existing Mk 4 (W76) warhead, giving it the size and weight of the larger Mk 5 (W88) warhead. Since the current D-5 missile is capable of carrying either the Mk 4 or Mk 5 warhead, the changes to the missile are minimal. The concept is to initialize the E2 IMU with the missile guidance system, apply a GPS update during reentry body exoatmospheric flight, and use the IMU and control flaps to steer the warhead with GPS-like accuracy during atmospheric reentry. Although strategic systems do not traditionally rely on GPS for their operation, the usefulness of a limited number of these highly accurate warheads reflects new NPR-articulated strategic strike missions. The demonstration will culminate in flight tests and will provide a final demonstration assessment report and recommended transition plan to the Navy and Strategic Command (STRATCOM) in early FY2007.

5.4.3 *SSGN*

The SSBN-to-SSGN conversion involves removing four *Ohio*-class submarines from strategic service, refueling their reactors to permit an additional 20 years of operation, and converting them into conventional strike platforms. The first SSGN will be operational in FY 2007. Notably, the Navy is ensuring flexibility in the SSGN strike design to support the integration of future payloads and sensors.

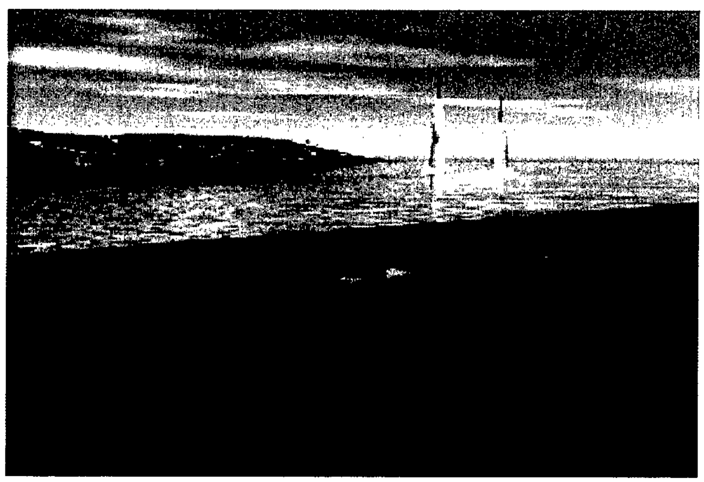

Figure 5-3: An artist's concept of the SSGN.

The SSGN will provide a range of capabilities:

- *Volume*. Future SSGN forces will provide large-volume, clandestine strike with cruise missiles.
- *Persistence*. The SSGN will bring persistence to the theater; four SSGNs can provide, on the average, 2.6 SSGNs full-time in a single theater.
- *Special operations forces (SOF) support*. The SSGN will have the capability to support SOF for an extended period, providing clandestine insertion and retrieval by lockout chamber, dry deck shelters, or the Advance SEAL Delivery System.

- *ISR*. The SSGN will be arrayed with a variety of unmanned systems to enhance the joint force commander's knowledge of the battlespace.
- *Flexibility*. The flexibility provided by the SSGN missile-tube volume supports payload adaptability to meet emerging mission requirements. Although 22 of the 24 missile tubes are today being configured to support Tomahawk conventional strike, in the future these tubes could be reconfigured, for example, to support up to 66 intermediate-range ballistic missiles per SSGN (see below).

5.4.4 *Tomahawk Land Attack Missile-Nuclear (TLAM-N)*

The TLAM-N provides an at-sea nuclear cruise missile strike capability, and is currently funded through FY2009. DoD is expected to evaluate whether to continue the program. Currently, the TLAM-N weapon is stored ashore, maintained and ready for issue, but requires a significant generation time before the submarine can deploy with TLAM-N. DOE requires two annual operational Quality Assurance Surveillance Testing test launches be conducted to track reliability. The only deployed TLAM-N-capable delivery platforms currently are a limited number of *Los Angeles*-class (SSN-688) attack submarines that have the Combat Control System (CCS) Mk 1 installed. Several minor operational improvements through FY2009 are funded, including the AN/BSG-1 TLAM-N Weapon Launching System, which will provide increased flexibility and retargeting capability. Beyond changes to the current TLAM-N cruise missile, developing a nuclear variant of the new Tactical Tomahawk missile, which is currently under development, has been proposed.

5.5 CAPABILITIES AND SHORTCOMINGS

As outlined in chapter 1, the objectives of our strategic forces (as expressed in the NPR) are to (1) deter adversaries from aggression against our homeland, our forces abroad, and our allies and friends; (2) dissuade competitors from actions inimical to us; (3) defeat those who would initiate aggression; and (4) assure allies and friends that we are both willing and able to accomplish the foregoing.

5.5.1 *Capabilities of Existing Delivery Systems Against Major Power Adversaries*

The strategic forces which served to deter the Soviet Union during the Cold War, though considerably reduced in numbers, can still deter major power adversaries from a major attack by holding at risk that which their leaders hold dear: their own personal survival, their government infrastructure, the forces which are the source of their military strength, and ultimately their industrial and economic infrastructure.[14] This situation will likely persist for the foreseeable future.

But potential major power adversaries are developing more resilient forces, and absent confidence in their friendship, we must be prepared to deter—militarily—any military threat they may pose. We must also be prepared to deter threats from other emerging major powers—powers that may act from a much different perspective of risks and benefits than those that pertained in the past. It will therefore be necessary for us to maintain many existing systems, and to extend their lives and upgrade them

[14] Escalation control is a lesser included case.

with reliability and maintainability improvements and such performance improvements as are readily available. At the same time, we may also be required to develop new systems and capabilities as well as new approaches for supporting deterrence.

5.5.2 *Shortcomings Against Major Power Adversaries*

Our present strategic forces are characterized by capabilities developed several decades ago for the Cold War: large warhead yields, accuracies appropriate for large nuclear weapons, and very survivable basing modes. Some are vestiges of the Cold War (e.g., dual-capable tactical aircraft) and some have already been, or are about to be, converted to non-nuclear use (e.g., B-1, Conventional ALCM, SSGN). Although the remaining forces are highly lethal, the growing ability of our enemies to conceal their activities, bury them, or go mobile, requires not only improved ISR to locate and understand them, but also improved C3 to rapidly target our forces and even retarget them after launch. Moreover, high-yield nuclear weapons detonated on the ground are not the best way to attack many such targets. Fortunately, as we reduce the number of existing nuclear warheads in our arsenal, we can convert some of their delivery systems to payloads, either nuclear or non-nuclear, that address new missions and targets.

There is an underlying problem, however, which applies to existing forces and, even more so, to new successor forces. That is the dwindling industrial base for strategic systems. Although some components (e.g., certain reentry bodies) are available in large numbers, and D-5 production is continuing, these are exceptions. We have not designed a new strategic ballistic missile or strategic bomber for 20 years. Non-nuclear weapons have gained sufficient lethality to allow a greater use of them for strategic strike. However, Service acquisition plans are for the most part focused on shorter-range, tactical systems, such that the deterrent and warfighting potential of our highly advanced conventional weapons technology is not being fully exploited for strategic strike. This situation cannot be viewed with equanimity.

5.5.3 *Required Capabilities of Existing Systems Against Rogue States/Terrorists*

Conflict management and deterrence of rogue states/terrorists require a broad range of strategic strike capabilities. These include both nuclear and non-nuclear strategic weapon systems with capabilities for global reach, rapid retargeting, very high reliability, penetrativity, and lethality. Notably missing in today's arsenal is the ability to (1) achieve the effects desired while limiting unintended collateral damage and (2) confidently predict consequences of execution. Hard and difficult targets such as HDBT and some weapons of mass destruction (WMD) pose particular challenges. Not only do they require accuracy on the order of a few meters, they also require physically large and heavy payloads, a must for earth penetration (or for clean nuclear warheads).

Realistic ISR limitations impose demands for rapid targeting and retargeting systems, and even perfect ISR would require in-flight retargeting against moving targets. Delivery systems having these capabilities must be designed, developed, produced, and tested to provide our national leadership with the highest possible assurance of mission success.[15]

[15] Other desiderata include minimal reliance on foreign bases and foreign-based support packages, to reduce dependence on wavering allies.

5.5.4 *Shortcomings Against Rogue States/Terrorists*

We can meet some of these requirements using existing long-range delivery systems. For the most part, however, no current systems exist to meet several, much less all, of the requirements simultaneously. As noted above, certain classes of difficult targets—HDBT and some WMD—are particularly challenging and require accuracy on the order of a few meters. Such accuracy serves to reduce the warhead yield required and also limits collateral damage.

Mobile targets are also challenging, and only ballistic missiles—land- and sea-based—do not take hours to reach targets after being tasked, and even these have half-hour flight times. For many moving and fleeting targets, even these times are too long. Furthermore, until decision-making times are made commensurate with flight times, the advantages of short flight times cannot be fully exploited.

Current long-range ballistic missiles have only high-yield nuclear warheads, as do nuclear bombers; the accuracies of the missiles are commensurate with such weapons, although bomber-carried weapons can, in principle, achieve accuracies of a few meters. Of our current bomber force, only the B-2 is survivable in extreme environments.

Even long-range bombers become much less effective without bases outside the continental United States (CONUS) for tanker support. That said, tanker bases supporting long-range bomber operations can be located well outside a theater of conflict, making them less susceptible to political or military access constraints. Fighter aircraft, and the tankers supporting fighter operations, require bases within the theater of operations, and thus are more subject to base access constraints.

ICBMs as currently based must overfly CONUS and drop stages there or in Canada. They may also overfly non-participating countries, depending on the location of the target. SLBMs have more flexibility in this regard and may be able to avoid undesirable overflights and drop early rocket stages into the sea.

During the Cold War—when massive arsenal exchanges were anticipated—assurance of success was to be achieved statistically. Even though the probability of success of individual weapons was high, we still planned to allot multiple weapons—generally to be delivered by different platforms—to each target. Under the new paradigm, where one or two weapons may be launched against each of a small number of targets, very high assurance of success is necessary. This includes a requirement for near real-time BDA and additionally demands high functional reliability and confidence in target location accuracy.

5.6 POTENTIAL APPROACHES

Strategic strike platforms must be capable of delivering a variety of nuclear and non-nuclear payloads promptly and precisely with a high probability of mission success. Affordability will necessarily require that near-term strategic strike delivery system solutions leverage existing platforms where possible. Where that is not feasible or cost-effective, new capabilities must be developed. The potential approaches discussed range from the integration of highly accurate payloads into existing deployed systems to the development of new systems that can provide capability for the mid- to far-term. Some version of most of these approaches appears in the final recommendations, although we have excluded those that are technically immature.

5.6.1 *Life Extensions and Modified Payloads*

The only existing systems capable of delivering payloads promptly from out of theater (i.e., to intercontinental ranges) are the existing Trident II (D-5), MM-III, and Peacekeeper ballistic missile systems. They are perceived to be expensive, but in some cases, large sunk costs can be leveraged. The use of SLBMs and ICBMs is most appropriate for dissuasion and destruction or function defeat of high-value time-sensitive targets. A limited number of life-extended missiles with non-nuclear payloads would provide a near- to mid-term capability for this purpose.

As advanced warhead and payload concepts develop, a program to explore weapon-system-level architecture concepts, perform military utility assessments, conduct experiments, and formulate implementation planning and budgets would be required. Insertion of new payloads into delivery systems will require a systems engineering effort to understand and implement a reliable and effective enhanced strategic strike capability.

Peacekeeper. The planned retirement of Peacekeeper provides an opportunity for a highly leveraged option. Rebased on both coasts, Peacekeepers could provide an affordable, near-term, and prompt strike capability. Several payload options considered in this study will require missile throw weights in the Peacekeeper class. Treaty issues will have to be addressed, and some refurbishment of components will be necessary if usable service life is required much past 2020.

Trident II (D-5). The D-5 SLBM force is currently committed to the nuclear deterrence mission, but could contribute to other missions in the near term with a shift in priorities or in the longer term with procurement of additional missiles. The planned production of D-5 missiles through 2011 is committed to the nuclear deterrence mission. A decision on procuring additional missiles therefore must be made by 2008 in order to avoid a break in production. The ongoing D-5 life-extension program is consistent with the Nuclear Posture Review and is essential for ensuring that the D-5 service life matches the *Ohio*-class SSBN hull life.

D-5 missiles with 40 years of remaining service life provide a highly leveraged option for conventional strategic strike. In order to fully exploit the D-5 as a delivery system for some of the larger payloads proposed in this study, modifications to the missile to remove the third stage motor would be necessary to maximize payload area. Although the proposed E2 high-accuracy "back pack,"—designed for use with the Mk 4 reentry body—is for nuclear deterrence, it can also be applied to conventional payloads.

Minuteman III (MM III). The MM III force is currently committed to the nuclear deterrence mission, but could broaden its contribution to include strike in the near term if requirements dictated. The MM III, with its existing clear-deck configuration, would support integration of a wide range of highly accurate nuclear and conventional payloads. However, its current basing mode is problematic due to overflight and potential debris impact in the United States and Canada. Significant numbers of MM III assets could be made available. The life-extension program will provide usable assets until approximately 2020.

The land-based strategic nuclear deterrent AoA scheduled to start in FY2004 provides an opportunity to define possible mid- to far-term solutions, if it is broad enough to include conventional payloads and advanced offensive strike concepts.[16]

5.6.2 *In-Kind Replacement*

Moderately prompt, precision strategic strike from within or near a theater can be achieved by replacing existing cruise missiles with improved-capability missiles. A new air-launched, stealthy, long-range ALCM/ACM-class cruise missile, for example, could provide a significant capability when deployed on ships and both manned and unmanned aircraft.

5.6.3 *Intermediate Range Ballistic Missile*

The issues associated with launching existing long-range ballistic missiles—overflight (ICBM), mixing nuclear and conventional missiles in the same platform (SLBM), and misinterpretation by other nations—could be mitigated by a smaller, intermediate-range ballistic missile deployed from the sea (first from submarines and later from surface ships). Such a missile—with a ~2,000 pound payload, a 1,500 mile range, and a CEP of less than 5 meters—could strike targets nearly 1,500 nm inland accurately in less than 15 minutes, thereby providing the reach and prompt response required to hit time-sensitive targets. Potential payloads include penetrating interrogation rounds and 2,000 lb. GPS/INS-guided penetrating reentry bodies with HE, electronic-defeat, and agent-defeat payloads. In addition, submarine basing makes this system one of the most survivable long-range, prompt strike options available.

5.6.4 *Combined ISR/Strike Airplane*

Throughout the battlespace, using persistent surveillance and strike to deny sanctuary is a key objective of U.S. forces. Current and planned forces cannot achieve this in the presence of modern air defenses. A near-term approach for achieving persistent surveillance/strike throughout moderately defended battlespace is to develop and deploy a family of stealthy, refuelable, subsonic, unmanned, global surveillance/strike systems (UGSSS). This family could include both a land-based variant and a somewhat smaller carrier-based variant. UGSSS could be fielded at moderate risk by 2015 to 2020. UGSSS variants could have the following performance characteristics:

- Long unrefueled range (~3,000 to 4,500 nm for the carrier-based variant, depending on payload; ~6,000 nm for the land-based variant);
- Advanced survivability (passive and active);
- Aerial refueling;
- Extremely long-endurance subsystems (e.g., propulsion, control surface power, flight control avionics, thermal management, etc.) permitting air-refueled sorties of up to ~100 hours in duration;
- Large weapons payload (sea-based: ~3-6 klb; land-based: ~20 klb);
- Highly autonomous/adaptive unmanned operations;

[16] To clarify, the planned AoA covers ballistic missiles, not bombers.

- Multi-sensor surveillance payloads (EO/IR, SAR, A/GMTI, hyperspectral, ESM) with on-board sensor processing and exploitation; and
- Advanced kinetic and electronic attack payloads.

5.6.5 *Other Concepts*

Some farther-term delivery means are discussed in the chapter 7, Future Systems and Technologies.

5.7 RECOMMENDATIONS

5.7.1 *Extensions of Current Systems*

Strategic nuclear systems. DoD should maintain and extend the ICBM, SSBN/SLBM, bomber, and ALCM/ACM programs as currently planned. These programs are adequately funded and are necessary to maintain nuclear deterrence with respect to major power adversaries. With life-extension programs, the current systems are viable until the 2020 to 2040 time period. DoD should also continue ongoing programs to improve capability, including the D-5 Enhanced Effectiveness Reentry Body program. STRATCOM should consider utilization of the Trident D-5 system with a loadout of a few reentry vehicles for selective high-priority missions.

The Air Force should keep Peacekeeper for use with potential large, heavy payloads. Peacekeeper is planned to be retired in 2005. However, it still has substantial remaining service life, and the rocket motors may well last till 2020 and possibly beyond. A sustainable, lower-cost guidance system would be required. Peacekeeper's combination of long range, large payload, and relatively short time of flight would provide a unique capability to deliver, for example, very large conventional payloads against buried, time-urgent targets. To minimize problems with misinterpretation of launches and stage-dropping areas, basing on the coasts is desirable. There would be Strategic Arms Reduction Talks (START) Treaty issues associated with maintaining Peacekeeper, including potential restrictions on deployment locations that could make it desirable to wait until START expires before deployment.

The Navy, with Air Force participation, should initiate a program for high-accuracy ballistic-missile delivery of alternate payloads. This program would explore weapon-system-level architecture concepts, perform military utility assessments, conduct experiments, and formulate implementation planning and engineering to understand and implement reliable and effective enhanced strategic strike capability.

The Office of the Secretary of Defense (OSD) and the Navy should study the potential use of two additional Trident SSBNs exclusively for delivery of conventional payloads. The completion of overhaul cycles on Trident submarines will be completed in about 2018. Those submarines will still have about 10 years of service life remaining. Possible uses could be conversion to SSGNs (bringing the total to six); or outfitting with a two- or three-stage conventional variant of the D-5 SLBM.

Non-strategic nuclear systems. OSD Policy should consider eliminating the nuclear role for Tomahawk cruise missiles and for forward-based, tactical, dual-capable aircraft. There is no obvious military need for these systems, and eliminating the nuclear role would free resources that could be used to fund strategic strike programs of higher priority. To a great extent, their continuation is a policy decision.

Reliance on GPS. OSD and the Services should accelerate programs to make GPS more robust. We rely heavily on GPS, and that reliance will increase as we field more precision weapons. GPS guidance is susceptible to jamming, and DoD has programs underway to reduce that susceptibility, with changes both to the space segment and to the user equipment. The changes to the user equipment are lagging the space-segment improvements, however. The installation of anti-jam antennas and M-code receivers should be accomplished faster.

Also, DoD must continue to examine alternatives to GPS, in particular reducing the cost of high-quality inertial systems and terminal seekers. Alternatives could include digital terrain elevation data (DTED)-based map-matching systems and optical satellite tracking for INS update.

5.7.2 *Near-Term New Starts*

Non-nuclear, intermediate-range ballistic missile. Navy should develop a non-nuclear, intermediate-range ballistic missile for use on SSGNs and potentially surface ships. Such a missile could (1) provide short-time-of-flight strikes against time-sensitive targets from the sea, and (2) mitigate overflight concerns. It would have a range on the order of 1,000 to 1,500 nm, a payload of about 2,000 pounds, and a CEP of less than 5 meters. Preliminary designs indicate that three such missiles could be carried in each Trident D-5 mount tube on the SSGN. Such a missile could also be used from available land bases. However, there would be arms-control issues associated with development and deployment on surface ships and land. The START Treaty, which expires in 2009, bans the production, testing, and deployment of ballistic missiles with range greater than 600 km for installation on surface ships. The Intermediate-Range Nuclear Forces (INF) Treaty, which is of indefinite duration, bans the production and flight-testing of ground-launched ballistic missiles with ranges between 500 and 5,500 nm.

Prompt strike capability. The Air Force, with Navy participation, should initiate an analysis of alternatives for a prompt strike capability, followed by concept definition of one or more selected alternatives. Among the alternatives to be considered are the following:

- A refuelable, stealthy, unmanned, global, surveillance/strike system (UGSSS). This program would be time-phased to build on the demonstration and operational assessment phases of the Joint Unmanned Combat Air System program. A Navy carrier version could follow, having the same system characteristics except for reduced payload.
- A stand-off arsenal airplane armed with high-speed missiles.
- A supersonic or hypersonic missile or unmanned airplane.
- A ballistic missile.

This AoA activity would integrate the planned Air Force land-based strategic nuclear deterrent AoA. It would consider combining this strike system with an operationally responsive space launch vehicle. It would consider both nuclear and conventional payloads with terminal seeker capability. Finally, it would also explore common missile component development with the Navy, which will have completed the Trident D-5 life-extension program, including redesigned guidance and flight electronics systems.

Conversion of ACMs for non-nuclear use. Accelerate a follow-on for ALCM and ACM to permit the conversion of existing ACMs for non-nuclear missions. The stealthy ACM provides a unique capability for delivering relatively heavy non-nuclear warheads with high penetration effectiveness. Some of the ACMs (a few hundred) could be freed from their nuclear role and made available for non-nuclear use by about 2015 (14 years before their end of service life) by accelerating the development and deployment of a follow-on air-launched cruise missile such that its IOC would be 2012 instead of 2029.

Summary: Delivery Systems	
Topic	*Recommendation (agent)*
Strategic nuclear systems	• Maintain and extend the ICBM, SSBN/ SLBM, bomber, and ALCM/ACM programs, as currently planned (*DoD*) • Keep Peacekeeper for use with potential large, heavy payloads (*Air Force*) • Initiate a program for high-accuracy ballistic-missile delivery of alternate payloads (*Navy, with Air Force participation*) • Study the potential use of two additional Trident SSBNs exclusively for delivery of conventional payloads (*Office of the Secretary of Defense (OSD) and Navy)*
Non-strategic nuclear systems	• Consider eliminating the nuclear role for Tomahawk cruise missiles and for forward-based, tactical, dual-capable aircraft (*OSD Policy—OSD(P)*)
Reliance on GPS	• Accelerate programs to make GPS more robust (*OSD and Services*) • Continue to examine alternatives to GPS (*OSD and Services*)
Non-nuclear IRBM	• Develop a non-nuclear IRBM for use on SSGNs and potentially surface ships as well (*Navy*)
Prompt strike capability	• Initiate an analysis of alternatives (AoA) for a prompt strike capability, followed by concept definition of one or more selected alternatives (*Air Force with Navy participation*)
Conversion of ACMs for non-nuclear use	• Accelerate a follow-on for ALCM and ACM to permit the conversion of existing ACMs for non-nuclear missions *(Air Force)*

6. Payloads

We begin by outlining the way ahead, after which we discuss generic shortfalls in payloads for strategic strike. We then address the background and context for non-nuclear payloads and present our associated recommendations. We close by doing the same for nuclear payloads.

6.1 THE WAY AHEAD

We begin our discussion of payloads by noting a point that cannot be overemphasized: although many of the payloads for strategic strike can be used in other military operations, strategic strike imposes special demands. If a strategic strike succeeds, it can by definition be decisive. If it fails, however, the results can be equally spectacular, albeit in a damaging way to the national interest. Throughout our consideration of payloads for strategic strike, we kept in mind the high demands for reliable performance on the first try that are part of this mission.

One of the new thoughts introduced in this study is that sensors delivered by payloads can make a unique contribution to strategic strike. High-fidelity information acquired at the target just before, during, and after a strategic strike can

- Support presidential attack decisions where confirmation of the target is at a premium,
- Guide last-minute changes to strategic targeting choices, and
- Help assess damage through and after the strike.

Another major idea is that tailored weapons are required to help minimize collateral damage while carrying out sequenced attacks that draw on the special effects of different kill mechanisms to "defeat" (destroy or otherwise neutralize) the most difficult strategic targets including hard and deeply buried targets (HDBT), weapons of mass destruction (WMD), and mobile systems. Where special forces are employed in support of strategic strike operations, future payloads can support their stealthy ingress, engagement or containment of the targets, and secure egress from the target area.

The payloads we considered for strategic strike included both nuclear and non-nuclear options. The major objective of the nuclear forces we describe is to maintain deterrence. For deterrence to be credible, an adversary needs to believe that, should deterrence fail, we would be willing to use the weapons and the weapons would be effective against the intended target. It is, and will likely remain, American policy to keep the nuclear threshold high and to pursue non-nuclear attack options wherever possible. Nothing in our assessment or recommendations seeks to change that goal. Nevertheless, in extreme circumstances the president may have no choice but to turn to nuclear options. It is the duty of the Defense Department to insure that if and when that happens, the president has credible nuclear options in place.

The legacy nuclear stockpile consists of weapons that were designed and optimized for the world of massive, arsenal exchange that dominated strategic thinking during the Cold War. These weapons were superb for that task and helped sustain deterrence during difficult times. They had the large yields and special characteristics (e.g., multiple, independently targeted reentry vehicles—MIRVs) needed to penetrate defenses, operate in an environment of nuclear fratricide, engage hardened targets like Soviet intercontinental ballistic missile (ICBM) silos, and achieve the desired effects—all without being able to rely on accuracy improvements like Global Positioning System (GPS) guidance because of operational concerns.

If something like the Cold War challenge were to emerge in the future, some of these legacy systems would be part of a highly accurate and discriminate strategic deterrent, but in general, they have characteristics unsuited to the threat environment envisioned by the Nuclear Posture Review (NPR), as elaborated in this study. We thus join the growing consensus across a number of expert communities that the current Stockpile Stewardship Program (SSP)—which is primarily oriented toward sustaining the stockpile by refurbishing legacy weapons—is not leading to nuclear options relevant to the different, more diffuse threat environment that already is emerging. The future nuclear stockpile envisioned in this study—a mix of legacy weapons, modified legacy weapons (mainly for lower yield), and new weapons based on previously tested designs and devices—should provide options that produce tailored effects at much lower collateral damage. This would threaten an adversary's critical assets with a credible stockpile. We also must improve our understanding of nuclear possibilities in order to hedge against strategic surprise.

In light of the above, we see the way ahead to be a combination of non-nuclear and nuclear payloads that

- Fill critical, time-urgent target information gaps;
- Greatly reduce collateral damage;
- Greatly improve effects-based attack sequences;
- Provide robust approaches to "defeat" difficult strategic targets;
- Provide special forces with the tools to augment their strategic strike operation;
- Substantially strengthen the relevance and credibility of future strategic strike; and
- Operate effectively in nuclear environments, including electromagnetic pulse (EMP).

If appropriate priorities are established and prudent resource decisions made, future payloads should provide a much wider range of options to perform a number of tasks critical to strategic strike than currently are available.

6.2 SHORTFALLS

Several categories of problems create shortfalls in payloads for strategic strike. First is the category we choose to call "enterprise problems," namely, overarching organizational problems and standing patterns of activity that hinder acquiring the proper inventories and types of strategic strike weapons.

- For non-nuclear payloads, the current system is oriented toward— indeed finely tuned to—acquiring weapons slowly and deliberately for largely tactical campaigns. As was the case in Operation Iraqi Freedom, it takes intervention by the SecDef to force the issue with the Services on quickly acquiring the types of leading-edge munitions that are best adapted to strategic strike missions, and once the campaign is over, the current system has no incentives for maintaining small inventories of niche weapons (i.e., small builds of weapons with advanced, special capabilities) that are available on very short notice for strategic strike.

- In the nuclear arena, the current Stockpile Stewardship Program (SSP) and the supporting Department of Energy/National Nuclear Security Administration (DOE/NNSA) infrastructure for designing and producing nuclear weapons are on the wrong track, partly because of political constraints and partly because of a lack of clear requirements, organizational arrangements, and the will to change direction. We address these issues in greater detail later.

A second category of shortfalls arises because there are some extremely difficult types of targets—hard and deeply buried facilities, WMD, mobile systems, and strategic targets embedded in urban areas—that are difficult to detect, characterize, engage, and defeat. Part of the problem is that the high-fidelity information is often lacking for the presidential decision to attack, last-minute adjustment of targeting, and assessment of battle damage—issues discussed earlier in this section. Concepts of operations exist in which close-in sensors delivered by payloads for pre-, trans-, and post-attack can remedy these shortfalls, if such payloads were made available.

A third category of shortfalls involves payload characteristics that are currently lacking or insufficient. These fall into two generic areas:

Conventional payloads:

- Lack sufficient lethality.
- Cause excessive collateral damage when attacking WMD.
- Are less robust to inadequate target information and less forgiving to delivery inaccuracies than desired.
- Have uncertain system reliability in nuclear and EMP environments.
- Cannot penetrate deeply enough.

Nuclear payloads:

- Have excessive thermal and blast effects.
- Produce too much radioactivity.
- Lack the tailored effects needed to attack electronics and defeat WMD.
- Cannot penetrate deeply enough.

Finally, we lack payloads designed for "special forces," which may be engaged in strategic strike operations in support of Strategic Command (STRATCOM).

6.3 NON-NUCLEAR PAYLOADS

6.3.1 *Background and Context*

Operation Desert Storm demonstrated the evolving effectiveness of conventional precision strike weapons. Laser-guided weapons carrying 2,000 lb. steel penetrators proved to be devastating against hardened underground bunkers designed to resist even the largest general-purpose bombs. The Iraqi leadership soon recognized that, instead of providing sanctuary, in many cases their bunkers actually increased the risk substantially for the occupants and contents. Indeed, the post-war, on-site bomb damage survey teams discovered that many of the bunkers had been emptied, apparently during the war, and large caches of weapons, including some chemical weapons, were dispersed and buried in the desert. One of the lessons of this experience, especially pertinent for strategic strike, is that capable adversaries are quick to react with countermeasures. Future strategic strike missions, both to achieve the element of surprise essential to decisiveness and to achieve mission objectives, cannot succeed unless we anticipate and stay ahead of potential countermeasures to our technology developments.

We found after Operation Desert Storm from on-sight inspection that some of the bunkers, judged to have been destroyed based on overhead imagery, actually survived the attack. Other bunkers and hardened aboveground shelters (some struck several times) showed almost no external signs of damage, yet the contents were found totally destroyed. A key lesson to be learned is that overhead imagery alone is not adequate to interpret the often-ambiguous signatures of conventional weapon attacks.

We found in Operations Desert Storm and Iraqi Freedom that certain categories of targets (HDBT, WMD, fleeting targets like mobile SCUDs) were especially difficult to defeat. During Desert Storm, for instance, not a single SCUD launcher was killed. Despite our ability to detect the launch coordinates almost instantaneously, we simply could not generate a strike sortie fast enough to interdict the launcher before it returned to safe haven. This continues to be a problem, as does the fact that as we gain better means to attack underground targets, our adversaries dig deeper, disperse wider, and practice deception more skillfully.

6.3.2 *Recommendations for Non-Nuclear Payloads*

The planning and programming cycle. To ensure that the specialized payload needs for strategic strike applications receive the proper visibility in the planning and programming cycle and to expedite the demonstration, development, production, and deployment of new payload capabilities the following actions should be taken:

- STRATCOM should recommend to the SecDef on an annual basis, the size/mix of non-nuclear payloads for strategic strike.
- The Under Secretary of Defense for Acquisition, Technology, and Logistics—USD(AT&L)—should assume planning and oversight responsibility for development of non-nuclear warheads and integration of payload-delivered sensors/warheads.
- The Defense Threat Reduction Agency (DTRA) should serve as executive agent for joint technology demonstrations and prototype development.
- The Services should procure limited numbers of successfully demonstrated special purpose payloads.
- The Services and Agencies should intensify testing and operational training for special purpose payloads.

Given its new global strike mission, STRATCOM is the logical combatant command to identify and advocate the required size and mix of payloads for strategic strike. STRATCOM's culture of continuous peacetime planning and operational exercises is key to identifying capability shortfalls for holding strategic targets at risk. We believe that STRATCOM should provide its recommendations on an annual basis to the SecDef to ensure high-level visibility in the programming and budgeting process. While important changes in the requirements and acquisition process appear to be underway, we are concerned that the current process continues to emphasize general-purpose applications and devalues the niche capabilities needed for many strategic applications. STRATCOM's advocacy and the SecDef's visibility together will ensure that a stable, balanced investment strategy will be pursued.

To ensure a joint perspective and facilitate centralized planning and programming, AT&L should sponsor (budget) and oversee the development, demonstration, system engineering, and production of new payload capabilities for strategic strike applications. Specific non-nuclear payload development programs should be executed by various DoD agencies and Service components, preferably integrated and coordinated by an executive agent for AT&L. We believe that the executive agency role assumed by DTRA in several post-9/11 quick-reaction, joint weapon demonstration/development projects, which led to new, niche strike capabilities, serves as an excellent model. DTRA's mission responsibilities in WMD and expertise in both nuclear and conventional weapons effects makes it a logical choice to continue in such a role. The Services should continue to have the lead responsibility for procuring a contingency arsenal of successful non-nuclear, strategic strike systems, both current and future, but with increased emphasis on simulation, testing, and operational training.

Investment strategy. The extant Capstone Requirements Document (CRD) and the S&T Master Plan for Hard and Deeply Buried Targets are particularly relevant for guiding the investment strategy for strategic strike. These documents should be updated and expanded to cover other strategic target sets.

We believe that the 2001 Capstone Requirements Document (CRD) for Hard and Deeply Buried Target Defeat (HDBTD), which provides full operational context, including quantification of key performance parameters (KPPs) that span intelligence, planning, and systems, is an excellent guide for the payloads investment strategy. It would be useful to update and expand the CRD to encompass all strategic strike applications. Also, if we are to continue the trend of technology breakthroughs witnessed during the last decade, we must place higher priority on maintaining a robust S&T program. The HDBTD S&T Master Plan, issued in 2001 by AT&L, provides a comprehensive S&T investment template to enable the needed warfighting capabilities identified in the CRD. We recommend that AT&L, in coordination with all stakeholders, update and expand the HDBTD S&T Master Plan to guide the S&T investment for all strategic strike payloads.

In the years ahead, we anticipate continued technological options to emerge that, when combined with operational experience, will open up new opportunities for non-nuclear payloads for strategic strike missions. With that in mind, we propose that:

Sensor payloads. USD(AT&L) should initiate an S&T program to develop payloads capable of delivering and emplacing highly intrusive sensors and sensor arrays in support of adaptive strike planning and trans- and post-strike battle damage assessment.

While the broader topic of intelligence, surveillance, and reconnaissance (ISR) was covered earlier in this report, we believe that payloads are key to delivering the critically important, intrusive sensor assets that can fill in critical information gaps just before, during, and just after strategic strikes. It is important to recognize that the inclusion of sensors, communications, and destructive capabilities in payloads introduces a new challenge to both those involved in payloads and the ISR community.

Weapons with high explosive payloads generally must detonate inside an underground facility in order to be effective. Even a small miss distance can render the attack ineffective. Accordingly, it is important to know the precise location and layout of an underground bunker and the penetrability of the surrounding geologic medium. This can be achieved by an initial salvo of "interrogation rounds" packed with sensors. The sensors stay in place to provide performance information on follow-up weapon strikes. With a sufficient number of sensors and array processing techniques, it may even be possible to construct a tomographic image of the underground facility (see figure 6-1).

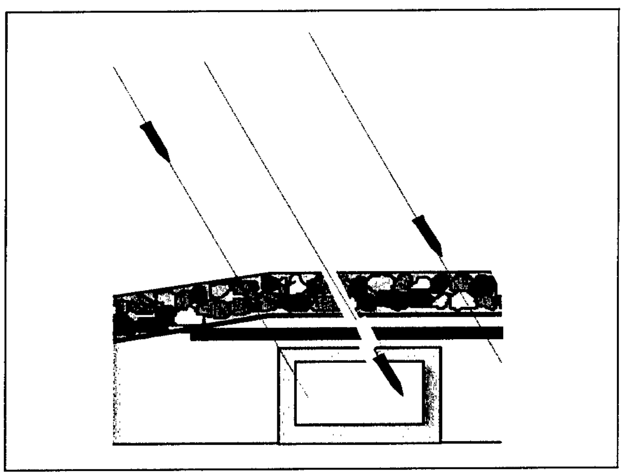

Figure 6-1: Interrogation rounds.

Unattended ground sensor (UGS) arrays can also be integrated with co-located, *in situ*, smart weapons systems to perform certain access denial missions autonomously. For example, in the case of a SCUD launcher exiting from a tunnel, an acoustic sensor array would detect egress. This information would then be conveyed to a pop-up smart munition, which would search for and destroy the launcher (see figure 6-2).

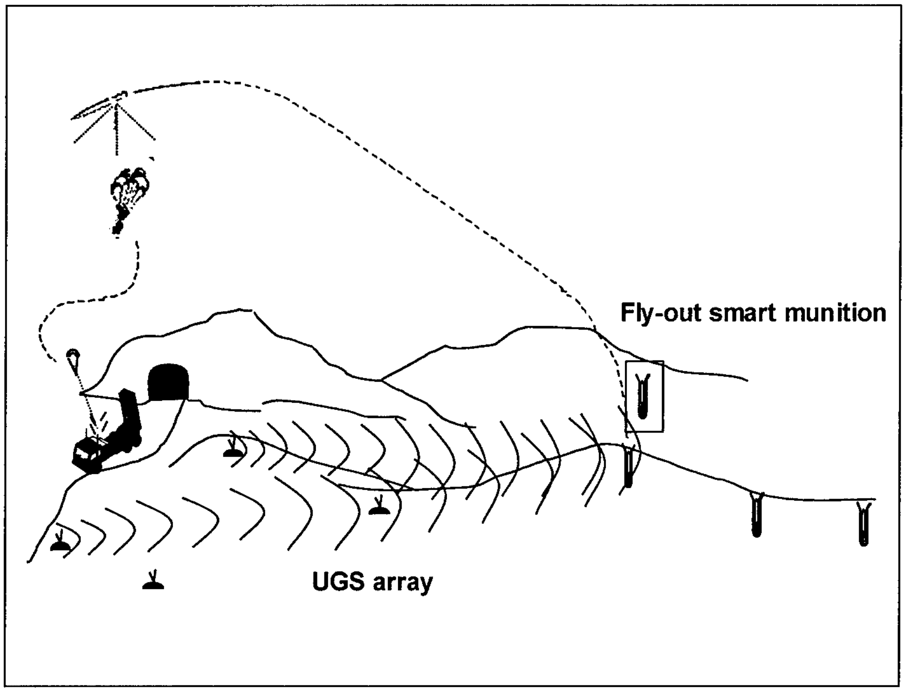

Figure 6-2: *In situ* sensor/shooter array egress denial.

Massive Penetrator. USD(AT&L) should immediately undertake an Advanced Concept Technology Demonstration (ACTD) for a bomber-delivered massive penetrator. A family of massive ordnance payloads (20-30 klb.), both penetrator and blast variants, should be developed to improve conventional attack effectiveness against deep, expansive, underground tunnel facilities.

A deep underground tunnel facility in a rock geology poses a significant challenge for non-nuclear weapons. Such a target is difficult to penetrate, except possibly near an adit, and the likelihood of damaging critical functional components deep within the facility from an energy release at the adit is low. Our past test experience has shown that 2,000 lb. penetrators carrying 500 lbs. of high explosive are relatively ineffective against tunnels, even when skipped directly into the tunnel entrance. Instead, several thousand pounds of high explosives coupled to the tunnel are needed to blow down blast doors and propagate a lethal airblast throughout a typical tunnel complex. This can be achieved either by an accurate blast weapon situated in front of the tunnel entrance or a penetrator that has burrowed directly into the tunnel. In both cases, the munition must be on the order of 20- to 30- klb. to couple a sufficient amount of energy to the tunnel. The penetrator requires the weight for penetration; the blast weapon requires the weight for carrying high explosives. Optimized penetrators of this size may penetrate about 5 to 8 times farther than an existing 2,000 lb. class weapon and may also be suitable for housing a clean, low-yield nuclear weapon. Using the tactic of optimum dual delivery, where a second penetrator follows immediately behind the first, and boosting the penetrator velocity with a rocket motor, a depth of up to 40 meters can be achieved in moderately hard rock. In view of the promise of such a massive penetrator for both conventional and nuclear payloads, we recommend an immediate start on an ACTD-like demonstration of this capability (see figure 6-3).

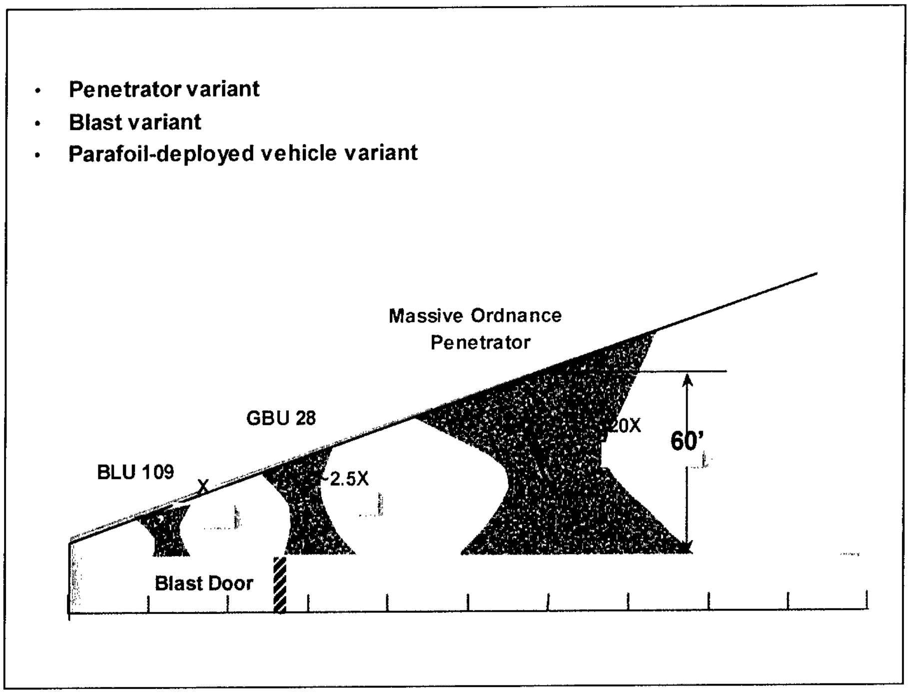

Figure 6-3: Massive penetrator (20-30 klb).

Energetic materials. The Director of Defense Research and Engineering (DDR&E) should focus, enhance, and accelerate Service/Agency programs to achieve new and novel energetic materials suitable for aircraft- and missile-delivered payloads with energy densities up to 10 times that of TNT within the next decade.

Enhanced energetic payloads will increase the lethality of current and future weapon systems and provide more credible, non-nuclear options for the hardest and deepest targets. DoD investments in advanced energetics are vastly outpaced by our foreign competitors. We advocate an investment strategy for advanced energetics that simultaneously pursues three tracks.

The first (near-term) track includes fuel-rich explosives and dispersed fuel-air combustion bombs (both are sometimes referred to as thermobaric systems). An example of the former is a nano-structured matrix of metal hydrides and explosive particles, capable of achieving energy densities 2-3 times that of TNT. Combustion bombs release their energy more slowly than an explosive, but in confinement, as in a tunnel or bunker, the energy release results in a rapid, quasi-static pressure build up. Energy densities for combustion bombs are related to the heat of combustion, which can be as high as 10 times the heat of detonation for TNT. The second (mid-term) track involves the class of geometric/excited metastable states. One example is the N_8 molecule, which can have a boat-like geometry that is highly energetic with theoretical energy densities of up to 10 times TNT. Other candidates in this class have theoretical energy densities as high as 100 times TNT. The third (long-term) track consists of the class of excited nucleon states, such as nuclear spin isomers. These are energetic metastable states of the nucleus with possible energy densities approaching a few percent of nuclear fission. While only the first track is expected to yield some near-term practical candidates, we recommend a balanced investment in all three tracks.

Collateral effects. Some targets—mobile or fixed targets containing WMD (especially bioagent), targets imbedded in urban population centers—pose the potential for significant collateral effects if an explosive payload is used against them. Such targets require more discriminate payloads capable of degrading, disrupting, or destroying the function of the target while minimizing collateral effects. Promising candidates include electronic defeat payloads using high power microwave sources packaged in various configurations and delivered to the target location by cruise missiles, UAVs, ballistic missiles, bombers, or fighters (see figure 6-4). The source could be integral to the delivery vehicle or configured as a munition. Another example is the use of carbon fiber as a replacement for the normal steel case of the high explosive. In some applications, the steel fragments cause undesirable collateral damage.

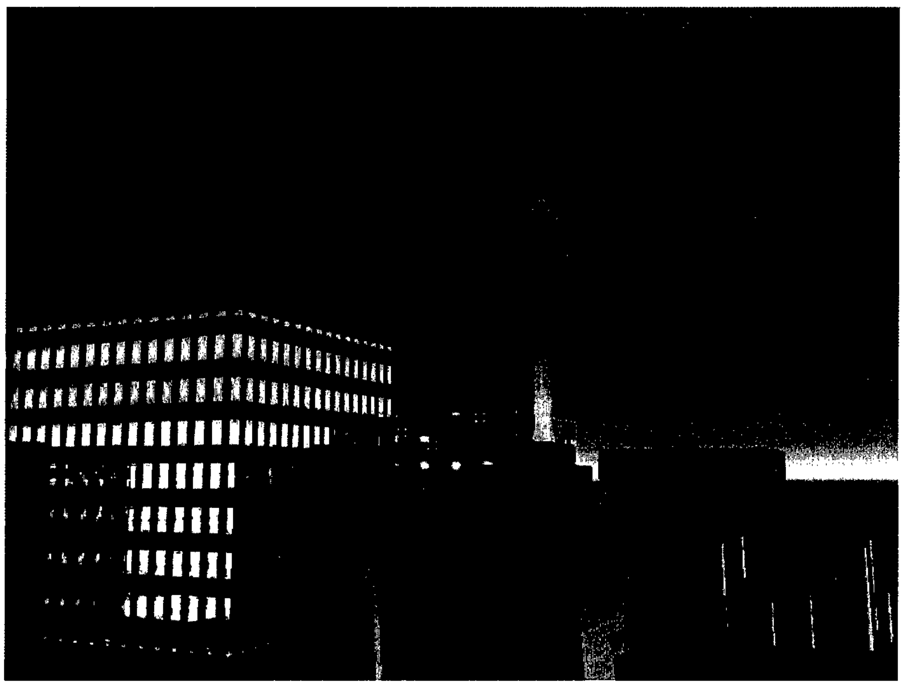

Figure 6-4: Airborne electronic attack.

Bioagent defeat. Bioagent defeat payloads must be able to disrupt or neutralize the agent without significant dispersal. For above ground, soft production, and storage facilities, one recommended solution is the equivalent of a "poison dart." The warhead is designed to disperse the darts in a patterned array. Each dart is capable of penetrating bioagent containers without causing significant release. Each dart also carries a biophage culture, released on impact and capable of neutralizing and/or contaminating the facility (see figure 6-5). For agent stored in underground bunkers, a more robust kill mechanism is possible. One example would be a penetrating multi-stage warhead that sequentially lights off an incendiary and then breaks open the containers with a blast-frag submunition. The basic idea is to render the agent unusable while neutralizing essentially all of the aerosolized agent created during the break-up of the container.

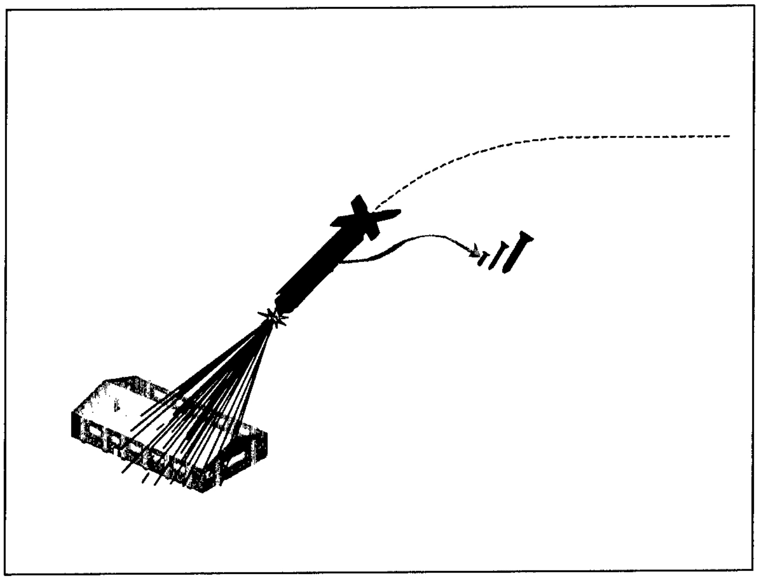

Figure 6-5: KE flechettes with biophage.

Smart, semi-autonomous weapons. USD(AT&L) should adopt a sound investment strategy to develop smart, semi-autonomous weapons with integrated sensor/shooter functions for locating, identifying, and engaging mobile and relocatable targets.

Mobile targets, with or without WMD, continue to pose a significant challenge. The experience in Afghanistan using the Predator-Hellfire combination underscores the importance of pursuing smart munitions with integrated sensor and shooter functions. The technology for developing smart and even brilliant weapons is available today. However, while we have numerous precision strike weapons, we have almost no smart, semi-autonomous weapons in today's inventory. Several promising candidates such as LOCAAS (the Low-Cost Autonomous Attack System) continue to be underfunded. DoD should review the situation and adjust priorities to ensure that an appropriate, increased funding level can be sustained for the near term.

6.4 NUCLEAR PAYLOADS

6.4.1 *Background and Context*

Over a decade ago, new nuclear weapons production ended. Plutonium fabrication—a key requirement for making nuclear weapons—came to an abrupt halt when Rocky Flats shut down in 1989 and is just now planned to be restored at very modest levels. Nuclear testing stopped in 1992 and the U.S. continues to observe a testing moratorium. A sense of "nuclear drift" characterized the early post-Cold War period, with falling budgets, personnel upheavals, no clear mission for the nuclear complex, and the like.

The Stockpile Stewardship Program (SSP) was created in 1995, largely to try to halt this drift. The SSP re-oriented the design laboratories toward a science-based approach to sustaining a safe, secure, and reliable nuclear weapons program—an approach based on massive computational and simulation power and new experimental facilities, with a strong message to seek to avoid returning to nuclear testing. The situation was further complicated by the need to reconcile American commitments in the non-proliferation arena with its legitimate needs to sustain a safe and reliable nuclear stockpile. The Congressional prohibition on work on low-yield nuclear weapons reflected the tensions in these circumstances.

In this highly charged political environment, compromises were struck to permit "stockpile stewardship." The result of this complicated set of intersecting pressures (a story that is more complex than can be captured in a brief discussion) is the situation we find ourselves in today. The SSP is producing essential knowledge and understanding relevant to maintaining a safe, secure, and reliable nuclear stockpile for the long-term. There are identifiable risks associated with not returning to nuclear testing, but thus far, an assessment of those risks has not been required in the annual certification process. The current vision for the nuclear stockpile is focused on refurbishing legacy nuclear weapons from the Cold War, and modifying some to lower yield. What has been severely curtailed, however, is work to push the envelope in nuclear design.

For deterrence to be effective, we at a minimum must be seen as having the capability to destroy what an adversary values most, as well as having the will to use this capability. We join others in judging that a credible force should include, for example, some nuclear weapons that cause much less collateral damage to achieve their desired effects against the highest priority targets. The problem is that the current plan embedded in the SSP consumes virtually all available resources simply to sustain the aging stockpile of declining relevance. The sole exception is the proposed Robust Nuclear Earth Penetrator (RNEP), including the low-yield options, which is a step in the right direction.

Changing this plan requires, in the first place, leadership from DoD to state clearly and persuasively the specific requirements for a different nuclear stockpile. Absent such explicit requirements, the National Nuclear Security Administration (NNSA) will not transition to the agile, properly sized nuclear design and production infrastructure needed in the future, and stockpile stewardship will continue on its present course.

We are well aware of the political barriers that must be overcome to change direction. Our recommendations are crafted to provide the Secretary of Defense with actionable items to begin to effect changes, recognizing that ultimately the issue requires deep White House involvement and the difficult creation of a consensus in Congress that can be sustained over a number of years if not decades.

6.4.2 *Recommendations for Nuclear Warheads*

An updated arsenal. We envision a future nuclear stockpile that retains (1) some legacy weapons (by which we mean the high-yield weapons that were designed for the Cold War threat), (2) some legacy weapons modified for lower yields, and (3) some number of new weapons based on previously tested nuclear devices and designs. Currently the plan is almost exclusively oriented toward refurbishing the legacy weapons through life-extension programs and the more recent RNEP activity. We would significantly scale back on the former effort in order to shift focus, and free up resources, for acquiring weapons based on previously tested devices and designs that have quite different characteristics than the legacy weapons: lower yields, special effects (all with greatly reduced fission yield), robust performance margins, and ease of manufacture and maintenance under today's conditions.

The final characteristic was not a major concern during the Cold War since the legacy weapons were introduced into the stockpile when we had a large, continuous nuclear production process and frequent nuclear testing. The intent of this vision, it should be stressed, is not to return to nuclear testing if at all possible. We also recommend a much greater effort at the national laboratories on hedging against strategic technological surprise by ensuring that our designers are at the leading edge of understanding what might be possible in nuclear weapons physics and concepts. This also provides an environment that is more attractive to the best scientists and engineers.

With this vision and its associated requirements in place, we see an evolution of the nuclear production complex toward a more agile, responsive system. Consistent with the pace and character of the shift to the new nuclear posture, it would be appropriate to revisit the question of how many non-deployed weapons should be retained as a responsive hedge (some number always will be required for stockpile surveillance purposes and for other such needs).

Stockpile stewardship. Here we propose three related recommendations:

- The SecDef should direct STRATCOM to provide an annual needs and risks statement concerning the future nuclear weapons stockpile.
- The SecDef should direct the Chairman of the Nuclear Weapon Council to take the actions necessary to ensure the Nuclear Weapons Stockpile Memorandum to the President addresses these needs and risks.
- The SecDef should appoint the Under Secretary of Defense for Policy—USD(P)—as a formal member of the Nuclear Weapons Council.

These actions need to be taken immediately to enable the DOE to reformulate their Stockpile Stewardship Program to be consistent with future stockpile needs. The statement should address the issues of numbers nuclear weapons (deployed and undeployed) needed, the weapons characteristics needed for strategic strike, and the risks assessed by STRATCOM to be associated with the nuclear stockpile. DoD should coordinate with NNSA the technical efforts needed to (1) provide tailored nuclear devices and the infrastructure capable of satisfying DoD needs and (2) ensure that the stockpile memorandum has a strategic vision and the technical details consistent with the Nuclear Posture Review and the STRATCOM statement of needs and risks.

Taken together, these recommendations are designed to

- Provide a more persuasive and appropriate strategic context for the annual Nuclear Weapons Stockpile Memorandum,
- Place STRATCOM in a clear position with a strong mandate to establish the needs that translate to requirements for the nuclear stockpile,
- Provide a strong policy perspective to the Nuclear Weapons Council deliberations, and
- Insure that those officials who typically testify to Congress on nuclear matters—USD(P) and his direct subordinates with nuclear responsibilities and the combatant commander at STRATCOM—are closely associated with the nuclear stockpile decisions.

Hard and deeply buried targets. DTRA should examine and demonstrate concepts to defeat hard and deeply buried targets with minimal collateral effects.

Massive (10-20 ton) payloads and high temporal-spatial accuracy delivery systems enable deep penetrators. Penetration to more than 30 meters may be achieved by use of a sequence of optimally timed chemical explosions to blast a very deep crater or by use of massive shaped charges. Ten to 20-ton mass high-density/high-velocity rod penetrators may also be capable of penetrating several tens of meters. Directional arrays of buried explosions may be used to disable very deep targets.

Penetration to a depth of 30 to 50 meters would enable containment of 100-ton nuclear explosions and disablement of surface and near-surface hard targets. Surface targets would be disabled by violent, large-scale surface displacements extending more than 50 meters from the explosion.

Penetration to a depth of 50 to 55 meters would enable disablement of 100-meter deep underground facilities by contained 400-ton explosions. At these depths, the explosion would generate more than a half kilobar shock at depths up to 100 meters. This chock can disable the contents and functioning of a hard facility (e.g., a missile silo). Higher pressures are required to crush super strong structures. Several near-simultaneous explosions may be used to increase the shock pressure and attack larger target areas. For the specific 100-meter depth near-urban facility noted above, use of low-yield contained explosions may avoid nearly all collateral casualties.

Several promising approaches to achieving deep penetration in hard rock have been identified. DTRA has conducted an operational-scale experiment with an optimally timed sequence of penetrator explosions in a crater. Since a crater partially filled with rubble will not completely contain radioactivity, a minimum radioactivity warhead would be required. Another proposal is for a massive (10 to 20 ton) maximum-density, optimum-velocity rod. To reduce sensitivity to angle of impact, a precursor blast could be used to clear surface obstacles and fracture surface layers. Massive/multiple shaped charges also should be evaluated.

Approaches to attacking targets at a depth of 200 meters in hard rock have been identified. Innovative schemes have been suggested for penetrating to depths of 100 meters, sufficient to contain the 3 kt explosions required to disable targets at a depth of 200 meters.

For targets buried deeper than twice the maximum depth of penetration, a deeply buried array should be evaluated. (For example, ten warheads exploded in a large diameter pancake region.) This array attack may require the use of payload sensors. After penetration, sensors and pingers located in the array of penetrators would be used to locate the target area, adjust relative detonation times in order to compensate for different distances to the target area, and possibly to achieve significant focusing of the multiple blast waves.

The Nuclear Effects Program. We recommend that DTRA be funded to reinvigorate the Nuclear Effects Program. Understanding weapons output—including temporal, spectral, and spatial characteristics—and placing this understanding in the broader context of how the weapon interacts with and damages the target, are missing pieces of our nuclear effects expertise. During the Cold War, acquiring such understanding was not essential to prosecute a massive single integrated operational plan (SIOP) exchange, hence little effort was expended in acquiring the information. For the future, knowing the effects of even a single nuclear weapon is of great importance. Treatment of this problem in a systems fashion—i.e., looking at all of the interactions—would help guide evolution of the stockpile of the future. DTRA should work with NNSA to ensure that each organization is properly executing its respective chartered responsibilities in providing the best weapons effects information to STRATCOM.

Non-nuclear warheads:

- *The planning and programming cycle*—
  - STRATCOM should recommend to the SecDef on an annual basis, the size/mix of non-nuclear payloads for strategic strike.
  - The Under Secretary of Defense for Acquisition, Technology, and Logistics—USD(AT&L)—should assume planning and oversight responsibility for development of non-nuclear warheads and integration of payload-delivered sensors/warheads.
  - The Defense Threat Reduction Agency (DTRA) should serve as executive agent for joint technology demonstrations and prototype development.
  - The Services should procure limited numbers of successfully demonstrated special purpose payloads.
  - The Services and Agencies should intensify testing and operational training for special purpose payloads.
- *Investment strategy*—The extant Capstone Requirements Document (CRD) and the Science and Technology (S&T) Master Plan for Hard and Deeply Buried Targets are particularly relevant for guiding the investment strategy for strategic strike. These documents should be updated and expanded to cover other strategic target sets.
- *Sensor payloads*—USD(AT&L) should initiate an S&T program to develop payloads capable of delivering and emplacing highly intrusive sensors and sensor arrays in support of adaptive strike planning and trans- and post-strike battle damage assessment.
- *Massive penetrator*—USD(AT&L) should immediately undertake an Advanced Concept Technology Demonstration (ACTD) for a bomber-delivered massive penetrator. A family of massive ordnance payloads (20-30 klb), both penetrator and blast variants, should be developed to improve conventional attack effectiveness against deep, expansive, underground tunnel facilities.
- *Energetic materials*—The Director of Defense Research and Engineering (DDR&E) should focus, enhance, and accelerate Service/Agency programs to achieve new and novel energetic materials suitable for aircraft- and missile-delivered payloads with energy densities up to 10 times that of TNT within the next decade.
- *Smart, semi-autonomous weapons*—USD(AT&L) should adopt a sound investment strategy to develop smart, semi-autonomous weapons with in-

tegrated sensor/shooter functions for locating, identifying, and engaging mobile and relocatable targets.

Nuclear warheads:

- *An updated arsenal*—Scale back the stockpile life extension programs and transition to an arsenal consisting of (1) fewer legacy weapons; (2) modified legacy weapons; and (3) some number of new, robust, lower-yield, and/or special-effects weapons with reduced radioactivity and collateral damage based on previously tested devices and designs.
- *Stockpile stewardship*—
  - The SecDef should direct STRATCOM to provide an annual needs and risks statement concerning the future nuclear weapons stockpile.
  - The SecDef should direct the Chairman of the Nuclear Weapon Council to take the actions necessary to ensure the Nuclear Weapons Stockpile Memorandum to the President addresses these needs and risks.
  - The SecDef should appoint the Under Secretary of Defense for Policy—USD(P)—as a formal member of the Nuclear Weapons Council.
- *Hard and deeply buried targets*. DTRA should examine and demonstrate concepts to defeat hard and deeply buried targets with minimal collateral effects.
- *The Nuclear Effects Program*. DTRA should be funded to reenergize the Nuclear Effects Program. It should also work with the National Nuclear Security Administration (NNSA) to ensure that each organization is properly executing its respective chartered responsibilities in providing the best weapons effects information to STRATCOM.

SUMMARY: PAYLOADS	
Topic	*Recommendation (agent)*
Planning and programming cycle	• Recommend the size/mix of non-nuclear payloads for strategic strike to the SecDef on an annual basis (*STRATCOM*) • USD(AT&L) assume planning and oversight responsibility for development of non-nuclear warheads and integration of payload-delivered sensors/warheads • DTRA serve as executive agent for joint technology demonstrations and prototype development (*DTRA*) • Procure limited numbers of successfully demonstrated special-purpose payloads (*the Services*) • Intensify testing and operational training for special-purpose payloads (*the Services and Agencies*)
Investment strategy	• Update and expand the extant Capstone Requirements Document (CRD) and the Science and Technology (S&T) Master Plan for Hard and Deeply Buried Targets to cover other strategic target sets
Sensor payloads	• Initiate an S&T program to develop payloads capable of delivering and emplacing highly intrusive sensors and sensor arrays (*USD(AT&L)*)
Massive penetrator	• Immediately undertake an Advanced Concept Technology Demonstration (ACTD) for a bomber-delivered massive penetrator (*USD(AT&L)*)
Energetic materials	• Focus, enhance, and accelerate Service/Agency programs to achieve new and novel energetic materials suitable for aircraft- and missile-delivered payloads (*DDR&E*)
Smart, semi-autonomous weapons	• Adopt a sound investment strategy to develop smart, semi-autonomous weapons with integrated sensor/shooter functions (*USD(AT&L)*)
An updated arsenal	• Scale back the stockpile life extension programs and transition to an arsenal consisting of (1) fewer legacy weapons; (2) modified legacy weapons; and (3) some number of new, robust, lower-yield, and/or special-effects weapons (*DoD and NNSA*)

SUMMARY: PAYLOADS	
Topic	*Recommendation (agent)*
Stockpile stewardship	• Direct STRATCOM to provide an annual needs and risks statement concerning the future nuclear weapons stockpile (*SecDef*) • Direct the Chairman of the Nuclear Weapon Council to take the actions necessary to ensure the Nuclear Weapons Stockpile Memorandum to the president addresses these needs and risks (*SecDef*) • Appoint USD(P) as a formal member of the Nuclear Weapons Council (*SecDef*)
HDBT	• Examine and demonstrate concepts to defeat HDBTs with minimal collateral effects (*DTRA*)
The Nuclear Effects Program	• Fund DTRA to reenergize the Nuclear Effects Program (*DoD*)

7 Future Systems and Technologies

In this chapter we summarize the results of our assessment of a wide range of future technology and system concepts. These results were used to help develop the recommendations presented in chapters two through six. A more detailed version of these assessments will be printed separately as a supplemental report.

7.1 INTRODUCTION

We assessed a wide range of system, technology, and concept options beyond those that are likely to (1) involve technologies and concepts that are already well in hand, or (2) evolve from current programs. We addressed some of these technologies in previous chapters; many are logical research and development (R&D) adjuncts to our recommended near- to mid-term paths. Some are more speculative, but could still offer important new options for strategic strike. Both sets of ideas are collected in this chapter to provide guidance to the defense R&D community.

We have organized our findings to correlate with the principal strategic strike functions addressed in the overall study:

- Intelligence,
- Surveillance and reconnaissance,
- Command and control,
- Communications,
- Delivery,
- Payloads, and
- BDA.

7.2 SUMMARY OF FINDINGS

In this section, we summarize the many technologies, systems, and concepts that we reviewed and discussed over the course of the study.

7.2.1 *Intelligence: Understand adversary values and behaviors to anticipate actions.*

Understanding adversary culture, values, and behavior characteristics is critical to anticipating their actions and developing strategies and operational concepts to counter their objectives. Only when we effectively penetrate adversary organizations and cultures can we gain the proper insight into their strategic motivation and likely operational tactics.

The obvious first line of understanding comes from human interaction and penetration into adversary organizations to generate a continuous and insightful flow of human intelligence (HUMINT). The second avenue is the penetration with "listening devices" to monitor and understand the adversary. This penetration data and understanding is used to (1) form the comprehensive understanding of the adversary over the long term and (2) identify, track, engage, and destroy them in conflict.

The long-term understanding combines human behavior modeling, cultural understanding, and comprehensive network analyses of adversary leadership interactions with each other, outside sympathizers, and the rest of the world. In conflict, understanding the culture, the human networks, and the behavior modeling, combined with real-time tracking of targets, permits decisive actions against the adversary. To achieve these objectives, the Department of Defense (DoD) must invest in the following:

- HUMINT (for penetrating adversary organizations and cultures; see prior DSB studies for recommendations on this topic);
- Strategic motivation and human behavior modeling;
- Systems for network analyses (communication, financial, etc.); and
- Tagging, tracking, and identification technologies (discussed more fully in the next section).

Topic	*Purpose*	*Notes*
Strategic motivation analysis	Better understand the nature of an enemy's will	• Requires careful analysis of leaders, leadership structures, civil-military dynamics, the structure and character of conflicts, etc. • This is not a job for the Intelligence Community (IC) alone but for a larger analytical community that can help to build cumulative knowledge based on deep insight • It is properly the responsibility of USD(I) working with the Joint Staff and the IC • The proper medium term goal is the building of a generation of analysts and a body of knowledge useful to the military planner
Individual behavior modeling	Predict how individuals will behave given certain motivations	• An adjunct to strategic motivation analysis • Relatively immature and extremely difficult but potentially achievable within the time horizon of this study • USD(I) should "own" this area

Topic	Purpose	Notes
Comprehensive network analyses	Identify and understand the functional relationships of adversary networks	• Would involve analysis of the enemy's organization, leadership relationships, resources, membership, motivations, and so on • The 2002 DSB summer study on special operations and joint forces in support of the war on terror recommended increased support for such efforts (e.g, those being undertaken by the Joint Warfare Analysis Center), and we believe that this recommendation still holds

7.2.2 *Surveillance and Reconnaissance: Find, locate, identify, and maintain cognizance.*

In this section we assess the potential for various existing and postulated technical systems to perform surveillance and reconnaissance (SR) against future strategic targets. Two key SR challenges are (1) finding, identifying, and tracking strategic targets and (2) finding and tracking weapons of mass destruction (WMD).

While all layers of the intelligence, surveillance, and reconnaissance (ISR) constellation add value, we believe that we can achieve important gains for strategic strike through a networked surface-based layer consisting of tags, unattended ground sensors (UGS), and the required communications and control necessary to exfiltrate the data that they gather. In the longer term, the reduced signatures of strategic targets, their ability to better blend with the background, and the increasing reliance on camouflage, concealment, and deception (CCD) will make the capability to achieve close-in sensing even more important.

The depiction of all the sensor and communications elements working together to produce a common, relevant operational picture (CROP) is shown in figure 7-1. Again, the close-in sensing elements—the tags[17] and unattended ground sensors (UGS)[18]—are of particular importance.

[17] Tags are electronic, optical, chemical, biological, or other devices that are emplaced upon an object of interest. Tags produce, augment, or induce a signature that can be remotely observed. Tags and tagging represent perhaps the most powerful new technique for detecting, locating, and tracking individual strategic targets, although the potential effectiveness of tagging systems will be limited by the difficulties in covertly applying tags and keeping them covert for long periods of time. These difficulties are particularly formidable when the object being tagged is a person rather than a piece of equipment. The ability to provide or harvest the energy required for long-term tag operation and the ability to exfiltrate tag data will also pose significant challenges.

[18] Unattended ground sensors are sensors that monitor some physical phenomenon in a local region and exfiltrate key data. UGS may be networked or stand-alone. As with tags, the significant challenges posed by UGS include covert emplacement and operation, energy storage/harvesting, and data exfiltration. Since UGS may be located in the vicinity of the target

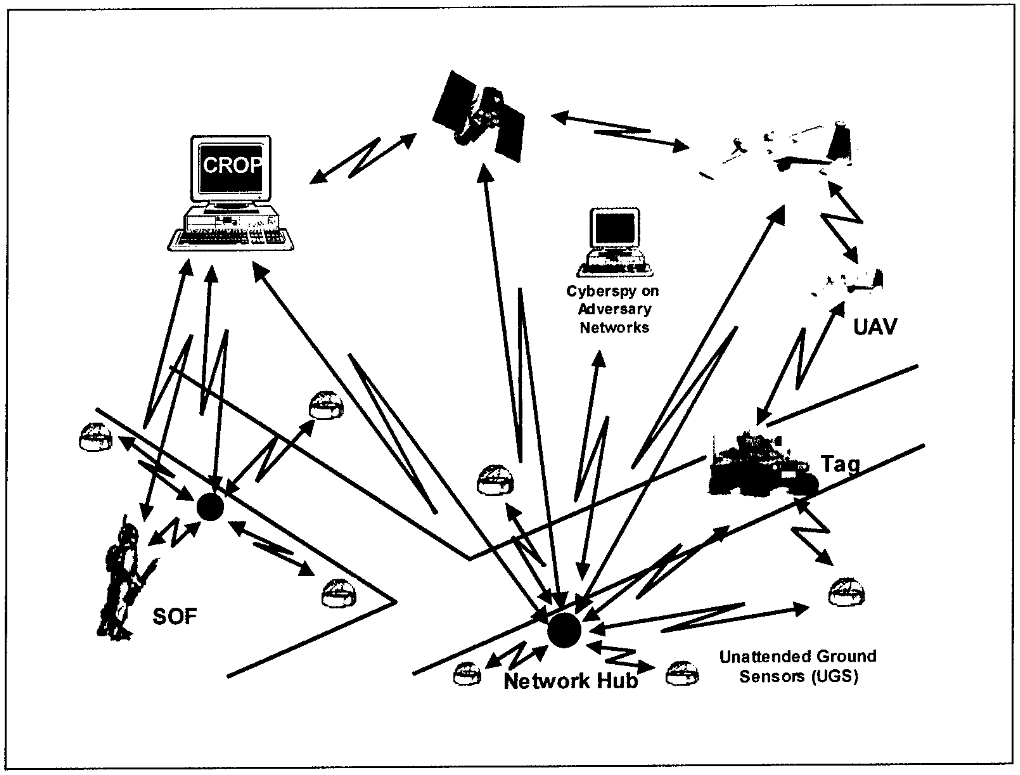

Figure 7-1: Producing the "close-in" CROP.

Tags (or markers) can also be used to track WMD components. The idea of "tags" and "markers" is used here in a broad sense and could be either passive or active devices or special chemical or metallurgical mixtures that can be detected with special instruments. Proper use of tags or markers will depend on the nature of the WMD element of concern.

Topic	*Purpose*	*Notes*
Integrated, networked, surface-based sensors	Improve close-in sensor capability and enhance long-term, strategic ISR	• Includes tags, UGS, and the required communications and control required to exfiltrate their data • SOCOM should take the lead in developing an integrated architecture and demonstration system

(versus on the target), it is assumed that UGS will be easier to both emplace and hide than tags. As they are more easily hidden, it is likely that UGS can be more capable due primarily to their larger physical size and weight. It is also possible that UGS might be able to serve as a platform for tag delivery.

Topic	*Purpose*	*Notes*
Large-scale, high-resolution automated site modeling	Exploit persistent sensor data to create a dynamic database made available via the global information grid (GIG) to users worldwide	• Would replace the static databases available today • Requires renewed research
Optimal asset allocation algorithms with automated cross cueing	Dynamic management of sensors across tiers (space-based platforms, standoff and penetrating airborne sensors, close-in sensors)	• DARPA is working on the Advanced ISR Management (AIM) program • STRATCOM should work with DARPA to ensure that such programs address the global ISR mission

7.2.3 *Command and Control: Make timely decisions and convert them to actions.*

Once the adversary's values and behaviors are understood and critical targets have been found, identified, and tracked as part of the kill chain, the next challenge is to establish a plan of action and make timely, informed decisions to execute this plan.

Topic	*Purpose*	*Notes*
Adaptive planning tools	Enable adaptive and responsive planning	• The Air Force's Time Critical Targeting-Functionality (TCT-F) capability represents the state of the art • DARPA has been conducting a series of programs to develop planning technologies • STRATCOM needs to work with DARPA to ensure that strategic strike requirements are addressed in these programs

Topic	*Purpose*	*Notes*
Weapons effect models and deconfliction tools	Improved modeling of nuclear weapons for three aspects of an engagement: lethality, fratricide, and collateral damage	• Particularly needed for HDBT, biological material • Need to understand problems related to deconfliction (disruption of friendly SR, C2, delivery systems, payloads, BDA assets, GPS, and so on) • Fallout codes need to be improved • Work is needed on understanding thermal and blast effects as a function of depth of weapon burst • Effects on infrastructure, including electromagnetic pulse (EMP) effects, need to be included in analyses
Integrated nuclear and non-nuclear attack planning tools	Enable consistent and accurate planning	• Damage to targets is typically not evaluated on a common basis for nuclear and conventional weapon types • Integrated planning would *inter alia* improve delivery system routing, enhance our understanding of collateral effects, and in general reduce the uncertainty involved with the possible use of nuclear weapons
Controlling weapons to target (in-flight control)	• Control the delivery system while in flight • Gather information on the system's health and the status of the target	• In-flight control yields several operational advantages, including improved target assessment and better performance against fleeting or relocatable targets • In-flight control would allow a commander to disable or destroy a nuclear warhead if necessary • In-flight updates are more challenging for guided re-entry vehicles

7.2.4 *Communications: Maintain connectivity in all environments.*

Most of the needs of the command and control for strategic strike are not so unique that they will not be met by existing and planned communications architectures. The general characteristics of the GIG and the Transformational Communications Architecture (TCA) allow for the flexible interconnection of diverse network elements with different needs and priorities. That said, the issues summarized in the table below will require special attention.

Topic	*Purpose*	*Notes*
Data links to missiles in flight	Receive feedback from missile and allow for in-flight control	• Such links would greatly expand the strategic options available for command and control • A concern for linking to ballistic missiles in flight is the lack of long-range links; the problem in this scenario is not only one of network characteristics, but also the availability of the physical channel, whether directly through a satellite or through a relay
Quality of service (QoS) for low latency requirements	Ensure rapid communications with missile	• The missile data would need the equivalent of a dedicated switched channel for the duration of the flight • The network has to be engineered for latency control, and priority assignments have to be obtainable on short notice
Bandwidth for video sensors	Ensure transmission of high-bandwidth feeds	• Given all the past experience with networks, bandwidth in the GIG may not accommodate all future demands • The inevitable shortfall implies the need to prioritize traffic and apply intelligent bandwidth management; the traffic needs for strategic strike will have to fit into this framework
Exfiltration of data from sensor networks	Ensure exfiltration of data from embedded sensor networks	• The conservation of power is a critical parameter • Sensors can self-organize in ad-hoc networks and use packet relay and distributed processing to conserve battery power • In the rogue state scenario, sensor nodes can communicate with airborne platforms, while in the peer adversary scenario, nodes may have to talk directly to satellites
Assured communications in potential future nuclear exchanges	Ensure communications in the event of a nuclear exchange with a near-peer adversary	We must ensure the continued performance of our strategic communications systems to support the assurance levels demanded by strategic strike.

7.2.5 *Delivery systems: Get the effect to the target quickly and precisely.*

Desirable attributes of a future strategic strike system include the following:

- Prompt (engage decisively against time-critical targets),
- Assured (high confidence in the desired outcome),
- Precise (focus on the target),
- Tailored (appropriate effect on target—kinetic vs. non-kinetic, etc.), and
- Low risk to U.S. forces (standoff out of harm's way).

A variety of system design choices can be considered to achieve these attributes. This section addresses some ideas (not all inclusive) for future delivery concepts, where we take a liberal view of the term "delivery" to encompass launch and flight transport of warheads, as well as acts such as (1) emplacing robots for Special Operations and (2) enabling computer network attacks. The earlier chapter on delivery systems covers in more detail a number of these ideas, primarily near- and mid-term concepts: submarine- and ship-launched ballistic missiles, air-launched subsonic cruise missiles, and unmanned bombers.

Topic	*Purpose*	*Notes*
Rapid intercontinental emergency response (RAPIER)	Ballistically deliver a powered UCAV into the battle zone over intercontinental ranges	• Launched by a modified heavy-lift ICBM or SLBM • The UCAV would reenter on a shallow flight path angle (glide range up to 3,000 miles) • At near-subsonic speeds it would deploy its wings and transition to powered flight (for perhaps another 1,000 miles) • Several potential operational advantages, including prompt delivery of a wide range of weapons and sensors • An R&D program to develop RAPIER would leverage existing work such as USAF/DARPA FALCON (CAV), the X-38, and the X-45 • A RAPIER ACTD could begin in the 2010 timeframe
Sprint, seek, and strike with forward basing	Deliver an air- or sea-launched payload rapidly from an intermediate range	• Major elements of the system exist already (booster, strike payload, loiter vehicle), although they are not designed and integrated to a launch platform (CSRL, VLS, SSGN, etc.) • A technology development pro-

Topic	*Purpose*	*Notes*
		gram could be initiated with the objective of designing a prototype sprint-seek-strike system with demonstration in 30 to 36 months at a ROM cost of $50 to $100 million
SSGN with mixed loads	Enhance the flexibility of the SSGN platform	• Alternate SSGN loads include the N-TACMS, a larger and longer missile (three per C-4 missile tube), or a mix of offensive and defensive missiles • An engineering study should be conducted to determine (1) the synergy between the SSGN and Virginia Class submarine with mixed loads, and (2) C3 architecture requirements • If the study shows the concept has promise, a Navy ACTD to demonstrate the capability in the offensive mode and then later in the defensive configuration should be initiated
Pre-emplaced disabling/defeat mechanisms	Startle, disorient, or destroy adversaries and their assets	• Would require advanced planning of potential target sets and lead time for emplacement • The mechanisms could be activated by a coded signal from any location in the world
SOF-like robotic operators	Provide automated delivery of sensors and payloads	• Individual robots could assist SOF operators, carry information, be used as sensors, or carry weapons that could be dispensed either independently or on command • Collections of robots could "swarm," share information, and relay this information back to a

Topic	*Purpose*	*Notes*
		"mothership"
Alternatives to GPS	Ensure the accuracy of strategic strike	• Examine affordable alternatives to GPS for providing high accuracy for strategic strike weapons in the end game[19] • Examine how new technology could enable existing concepts (or new ones) • Closely coordinate with NIMA, presumably the source of the reference data that would support the terminal sensor's reference data base (i.e., the alternative to GPS)
Avionics hardening	Ensure the performance of avionics in radiation environments (EMP, nuclear radiation, space)	• DoD should define the environments and scenarios that future strategic strike weapons will be expected to operate in

7.2.6 *Payloads. Create desired effect while minimizing undesirable effects.*

The following section describes payload concepts that specifically address the strategic objectives of *assure*, *dissuade*, *defeat*, and *deter*, including ideas for disabling adversary capabilities.

Topic: Assure/Deter	*Purpose*	*Notes*
HDBT defeat	Defeat hard and deeply buried targets with limited collateral damage	• A Phase 2 feasibility study for a robust nuclear earth penetrator is underway • The design goal is to enhance penetration capability significantly • Two existing warheads are compet-

[19] Cruise missiles have long had a solution appropriate for low-flying weapons which employs radar altimeter-based terrain contour matching (TERCOM) for midcourse updating with terminal sensing provided by optical scene correlation (DSMAC). For higher flying weapons, the all-weather, day/night operation necessitated by strategic strike weapons would dictate a purely radar-based terminal sensing approach for the end game. Terrain or landmark sensing via coherent (beam-sharpened) altimetry, incoherent slant ranging, SAR, and IFSAR are all potential candidates. Use of not only range and Doppler but intensity signatures from the radar return can be exploited to enhance accuracy and maximize scene availability.

Weapons that travel through space (ICBMs and SLBMs) can use optical measurements of stars and LEO space objects (which have well known and predictable ephemeris) to derive attitude and position updates directly via simple triangulation techniques for mid course updates to minimize terminal sensor acquisition size during the end game.

Topic: Assure/Deter	Purpose	Notes
		ing for this role, and nuclear testing is not considered necessary for certifying a production version • Low-yield penetrator designs consistent with high-accuracy delivery and targets of moderate depth should also be feasible without nuclear testing
Low-yield, high-precision weapons	Increase accuracy and reduce collateral damage	• Current warheads could be modified for lower yields with high confidence • An obvious possibility is replacement of a warhead secondary with inert material • Further reductions in yield are also possible without nuclear testing
Enhanced-radiation weapons	Achieve desired effect while reducing heat and blast	• The U.S. has some history with warheads of this design and such warheads could be valuable today in agent defeat or attack of conventional military targets • U.S. design experience should allow such a warhead type to be developed and certified without nuclear testing
Low- to no-fallout weapons	Reduce or eliminate collateral damage from fallout	• Low fission designs have been developed and tested by the U.S., but none is now deployed • Such warheads, if hardened to survive earth penetration loads, could offer dramatic reductions in collateral damage in attacks on HDBT • The nuclear design community has not reached consensus on whether warheads of this design type could enter stockpile without nuclear testing during development.

Topic: Disable	Purpose	Notes
Information operations (IO)	Support strategic strikes	• IO attacks can support future strategic strike in a variety of ways, but they are not by themselves decisive strategic strikes • The information operation that could most plausibly be a decisive,

Topic: Disable	*Purpose*	*Notes*
		low-risk, surgical strike would involve the covert usurpation of a key computer • A reinvented HUMINT service should give priority to understanding (1) the probability of undetected usurpation and (2) the consequences of successful usurpation
Calmatives	Neutralize individuals	• Calmatives might be considered to deal with otherwise difficult situations in which neutralizing individuals could enable ultimate mission success • The principle technical issue is the balance between effectiveness (i.e., the targets are truly "calmed") and margins of safety (i.e., avoiding overexposure and resulting fatalities of neutral bystanders) • The treaty implications are significant
Directed energy	Neutralize individuals	• Lasers or high-power microwaves (HPM) provide an effective less-than-lethal capability against dismounts • The HPM approach termed "active denial" may be used to produce an autonomic burning response in the targeted individual • Laser devices may be used at lower powers to dazzle eyesight or burn the skin or objects • Existing treaties may limit some aspects of the these applications

Topic: Disable	Purpose	Notes
Disabling HDBT	Deny or disrupt the principal use of the facility by disabling a key operational feature	• As adversaries build sanctuaries deeper underground or into harder geological formations, it becomes increasingly difficult for the U.S. to assure destruction of these facilities by direct attack • Examples of potential attack vectors capable of achieving a "functional" defeat include sealing or interrupting air shafts and severing or interrupting communication links, power distribution lines, and logistical supply lines
Massive miniature air vehicle (MAV) attacks for air-defense radar spoofing	Defeat air defenses	• A powerful new option for defeating air defenses is the use of expendable airborne decoys • The recently awarded Air Force Miniature Air-Launched Decoy (MALD) program represents an example of such technology • The MALD electronic payload is capable of stimulating enemy air defenses so that they can be effectively targeted • In the future, programs such as this may be extended to perform a variety of close-in IO and/or ISR missions

Topic: Dissuade	Purpose	Notes
Psychological operations	Influence an adversary's behavior	• In the near term, we have the ability to manipulate speech/audio and still and video images • In the mid term we could pursue such capabilities as directed audio beams • In the far term we could pursue capabilities such as holograms that could remotely project an image in a room
Biological warfare (BW) total immunity	Counter BW attacks	• One possibility is an embedded chip that can sense BW agents and dispense the countermeasure when an agent is detected

Topic: Defense	*Purpose*	*Notes*
Radiation hardening	Protect critical systems against radiation	• Potential use of nuclear-tipped ABM or SAM systems raises the issue of hardening requirements as does the possible use of nuclear weapons and non-nuclear weapons, ISR systems, and communications systems in the same engagement • We need to consider the tradeoff between tactics and the cost of hardening • We need to improve our ability to model the effects of radiation on structural and electronic elements

Topic: Defeat	*Purpose*	*Notes*
X2 to H10 improved high explosives (HE)	Reduce the collateral effects of HE munitions	• New high explosive formulations and munition casing concepts offer the possibility of enhancing lethality near the detonation point, while reducing the range of undesirable collateral effects • A 2-year, ~$20 million program could provide a demonstration unit, leading to possible flight certification
Agent defeat	Defeat chemical or biological weapon systems, infrastructure, while reducing collateral damage to civilian populations and facilities in the vicinity of WMD and associated facilities	• Some promising technologies include smart-fuze weapons and foam-based products • Advanced modeling tools are being developed to understand the effects of these approaches • Low-yield nuclear weapons may be able to provide high-confidence destruction of chemical or biological stores by thermal or prompt radiation effects • Missing are full end-to-end systems concepts
Directed energy	Strike an adversary at the speed of light	• Megawatt-class solid state, space-based lasers offer the capability to strike targets on the ground • In the complementary relay-mirror approach, a relay mirror takes laser energy from another source (an-

Topic: Defeat	*Purpose*	*Notes*
		other SBL or a ground-based laser) and redirects the energy to a ground target • While lasers could be used at long ranges for strategic strike, HPM are effective at much shorter ranges (< 5 km)
Penetration aids (penaids)	Penetrate adversary defenses	• Operational concepts for strategic nuclear or non-nuclear strike should consider penaids as a design element • We should establish an R&D effort that systematically examines strike vulnerabilities against defended targets and proposes appropriate design or operational solutions • A ROM investment of $5 to 10 million/year would be appropriate, with additional funding on the order of $10 to 15 million for flight test demonstrations of concepts

7.2.7 *Battle Damage Assessment (BDA): Assess effects to determine subsequent actions.*

Significant uncertainty often exists after a strike mission as to whether the desired effects were achieved. Often it takes days to retask the ISR systems for BDA. The uncertainty created during the interval between strike and BDA can lead to some targets being unnecessarily retargeted (with resulting lost opportunities, excess collateral damage, and so on) or the failure to eliminate real threats if they are not retargeted. For targets that are relocatable or mobile, the delay between strike and BDA can lead to permanent uncertainty as to the status of the target. Here, we identify potential options for near-real-time BDA.

Topic	*Purpose*	*Notes*
Through-strike remote observation	Improved BDA	• Via a radar or electro-optical/infrared (EO/IR) system • Coordinated SAR imaging immediately before and after a strike might provide some all-weather real-time remote BDA capabilities • High frame-rate multispectral EO/IR systems can provide high-fidelity BDA to include validation of detonation, detection of secondary explosions, and imagery • Key to the successful implementa-

Topic	Purpose	Notes
		tion of any such remote system is the synchronization of observation with the detonation
Deploy small sensors with weapons	Improved BDA	• Such systems are capable of providing video or still imagery or other intelligence during the strike • The Munition Deployed Bomb Damage Assessment (MDBDA) program that was sponsored by the Air Force Research Lab Munitions Directorate successfully demonstrated the feasibility of such an approach • The MDBDA system demonstrated a parachute-deployed camera on a GBU-10 weapon
Other indicators	Improved BDA	• In addition to imagery, other indicators (such as the disruption of radio or radar transmissions) can be used as real time indicators of bomb damage • Tags and UGS that are emplaced prior to strike can also provide BDA through a variety of phenomenologies • Such sensors might directly observe destruction (via imagery, chemical sensing, etc.) or indirectly (via seismic triangulation, etc.)

7.3 CONCLUSIONS

We present here the conclusions of our future systems and technologies assessment. Many (but not all) of these conclusions provided input to the recommendations found in the previous chapters of this report.

7.3.1 *Understanding Adversaries*

As we noted above, understanding adversary culture, values, and behavior characteristics is critical to anticipating their actions and developing strategies and operational concepts to counter their objectives. Only when we effectively penetrate adversary organizations and cultures can we gain the proper insight into their strategic motivation and likely operational tactics. USD(I) should provide leadership within the Intelligence Community and throughout DoD to assure development of the analytical expertise and supporting tools to build the body of knowledge needed for strategic military planning and strike execution.

7.3.2 *Close-In Sensing Capabilities*

Tagging systems. DARPA, SOCOM, and other Agencies should continue their efforts to develop sensors, tagging techniques, and interrogation and employment techniques, but with an emphasis on end-to-end system integration as well as the individual parts. In addition to the development of sensors and tags, ancillary technologies such as energy storage/harvesting, communications protocols, mobility concepts, and plug-and-play sensor and communications standards should continue to be developed.

Networked sensor arrays. SOCOM should begin to develop an integrated architecture and demonstration system for networked tags and UGS. SOCOM should work with other R&D agencies (e.g., DARPA, CECOM) to ensure that both a near-term ACTD-like demonstration system is implemented and that a technology plan exists for inserting new sensors, protocols, communications, and networking technologies as these technologies mature.

BDA. The Air Force should take the lead for the developing through-strike BDA systems. Programs such as MDBDA should serve as a logical starting point for near-term transition. We should also initiate R&D programs aimed at coordinating real-time BDA from airborne or space-based video-frame-rate sources.

7.3.3 *Controlling Weapons to Targets*

USD(AT&L) should fund R&D on systems for communicating with and controlling strategic strike weapons in flight. Communication from vehicles in flight to a human controller can enable reporting of vehicle health and status as the mission proceeds and battle damage indications and assessment unfold in the terminal segment. With this information and a link from controller to vehicles, a controller can redirect vehicles as needed to increase likelihood that intended targets are struck and collateral damage is limited (the controller can also mitigate consequences if the weapon fails to perform as intended). The Tactical Tomahawk cruise missile now under development will employ such a system. We recommend that R&D be conducted to examine use of such systems for controlling air-launched cruise missiles, UCAVs, and ballistic missile re-entry vehicles.

7.3.4 *Richer Set of Effects*

Payload options for future strategic strike systems should provide capabilities not only for destroying a physical target by blast or thermal effects but also capabilities for a range of other possible effects. These include techniques for disabling or impairing the function of adversary systems or personnel (including techniques not "delivered" by missiles or aircraft), and effects that can be applied in a very target-specific way, with limited or no collateral effects. Specifically, the following capabilities are needed:

1. *Agent defeat weapons to provide high confidence of lethality and low-collateral consequences from the weapons themselves or from agent dispersal.* We should consider conventional techniques relying on thermal effects or biocidal materials, along with innovative techniques for applying large radiation doses. Smart-fuze weapons and foam-based products are promising. SOF needs reliable decontamination and damage assessment techniques. For targets posing a time-urgent concern, low-yield,

low-fission nuclear weapons may be the only choice. DTRA should be assigned leadership for developing agent-defeat systems; NNSA should develop a low-yield nuclear option.

2. *Weapons using advanced high explosive and munition-casing designs that provide enhanced overpressure impulse near impact and a dramatically reduced collateral effects radius.* When delivered by a very accurate system, these munitions offer the possibility of precision attack against highly specific targets such as facilities or individuals in urban areas or particular segments of a WMD complex. DTRA should be assigned the development responsibility.

3. *Nuclear weapons for attacking HDBT with improved earth penetration characteristics and reduced collateral damage compared to current capability.* Feasibility of low fission fraction warhead designs for this and other missions should be explored. NNSA should be supported by DoD in developing these weapons.

4. *Information operations capabilities, including both high-power microwave devices for attacking specific electronic targets and network attack approaches for disabling or compromising an adversary's information systems.* STRATCOM, with its strategic IO mission assignment, should align the many separate programs to achieve more robust IO options.

5. *Non-lethal effects directed at the physiological or psychological functions of specific individuals or the populace.* Applications of biological, chemical, or electromagnetic radiation effects on humans should be pursued. R&D into sophisticated psychological operations designed to change the minds of individuals or the populace is needed. Techniques could include projection of sounds and images to specific points in space. The Joint Non-lethal Weapons Program Directorate should broaden its tactical and operational focus to consider the strategic applications and associated treaty issues of non-lethal weapons.

7.3.5 *Prompt Delivery*

The evolving nature of strategic strike operations (with increasing emphasis on attacking fleeting, relocatable, or mobile targets in a prompt and decisive engagement) will put greater demands on advanced strike, ISR/BDA, delivery, and payload systems. Strike systems will require near real-time, high-confidence information on target location and identification and then prompt response capability to seek out and engage targets.

An analysis of alternatives (AoA) should be conducted to assess concepts for future strategic strike weapon delivery systems. The AoA should encompass conventional and/or special nuclear weapon delivery concepts that provide for prompt engagement of targets from stand-off ranges. These concepts should be capable of fast response (high velocity over long ranges), precision tracking (slow speed or loitering in the terminal area with onboard seekers to locate and identify targets), and effective engagement (appropriate weapon payload matched to target objective). Specific delivery system concepts which should be evaluated include:

- ICBM (e.g., PK) and/or SLBM (e.g., D-5) missile systems with UCAV-like payloads for long-range, prompt global strike;
- Shorter range ballistic missile systems compatible with submarine-, surface-, or air-launched platforms with UCAV-like payloads for prompt theater strikes;
- Supersonic and/or hypersonic cruise missile platforms;
- Unmanned ISR/strike, stealthy, subsonic, long-endurance aircraft; and
- Arsenal aircraft capable of long endurance, stand-off, operations.

Summary: Future Systems and Technologies	
Topic	*Conclusion (agent)*
Understanding adversaries	• Invest in HUMINT; strategic motivation and human behavior modeling; systems for network analysis; and tagging, tracking, and identification technologies in order to better understanding adversary culture, values, and behavior characteristics (*DoD*)
Tagging systems	• Continue efforts to develop sensors, tagging techniques, and interrogation and employment techniques, but with an emphasis on end-to-end system integration as well as the individual parts (*DARPA, SOCOM, and other agencies*)
Networked sensors arrays	• Begin to develop an integrated architecture and demonstration system for networked tags and unattended ground sensors (UGS) (*SOCOM*)
BDA	• Develop through-strike battle-damage assessment systems such as the Munition Deployed BDA (MDBDA) sensor (*Air Force lead*)
Controlling weapons to targets	• Fund research and development on systems for communicating with and controlling strategic strike weapons in flight (*USD(AT&L)*)
Agent-defeat weapons	• Develop agent defeat systems (*DTRA lead*) • Develop a low-yield nuclear option (*NNSA*)
Advanced high-explosive weapons	• Develop weapons that use advanced high-explosive and munition-casing designs that provide enhanced overpressure impulse near impact and a dramatically reduced collateral effects radius (*DTRA*)
Nuclear weapons for HDBT	• Develop nuclear weapons with improved earth-penetration characteristics and reduced collateral damage compared to current capability for attacking HDBT (*NNSA supported by DoD*) • Explore the feasibility of low-fission fraction warhead designs for this and other missions (*NNSA supported by DoD*)
Information operations	• Align the many separate programs to achieve more robust IO options, including both high-power microwave devices for attacking specific electronic targets and network attack approaches for disabling or compromising an adversary's information systems (*STRATCOM*)

Summary: Future Systems and Technologies	
Topic	*Conclusion (agent)*
Non-lethal effects	• Broaden the tactical and operational focus of the Joint Non-lethal Weapons Program Directorate to consider the strategic applications and associated treaty issues of non-lethal weapons
Prompt delivery	• Conduct an analysis of alternatives (AoA) to assess concepts for future strategic strike weapon delivery systems that provide for prompt engagement of targets from stand-off ranges; options considered should include - ICBM (e.g., Peacekeeper) and/or SLBM (e.g., D-5) missile systems with uninhabited combat air vehicle (UCAV)-like payloads for long-range, prompt global strike - Shorter range ballistic missile systems compatible with submarine-, surface-, or air-launched platforms with UCAV-like payloads for prompt theater strikes - Supersonic and/or hypersonic cruise missile platforms - Unmanned ISR/strike, stealthy, subsonic, long-endurance aircraft - Arsenal aircraft capable of long endurance, stand-off, operations

8. Capabilities Assessment

In this chapter, we assess the potential impact on U.S. strategic strike capabilities resulting from the study's various recommendations. We begin by describing our purpose and approach. We then describe the individual functional assessments. After discussing the aggregated individual assessments, we close by mapping the assessed capabilities against the adversary's value model and comparing the "before" and "after" situation.

8.1 INTRODUCTION

Our purpose in this section is to determine the impact of the recommendations contained in this report on U.S. global strike capabilities as they might exist in 20 years or so. That, by necessity, requires an assessment of U.S. capabilities with and without the improvements recommended in this report.

In making these assessments, we used a mix of subjective judgments and quantitative analyses to arrive at our results (appendix C contains the full set of results). Because we are focused on comparing capabilities, relative values are more important than absolute ones. This leads us to present our results on a hypothetical "percentage of objective capability" scale, measured between zero and 100, where zero means we have no capability and 100 means we are doing as good as we could ever imagine we would want to be. Thus, the difference between *23 percent* and *28 percent* means very little; what is more meaningful would be an observation that we are, for example, "only a quarter of the way toward where we would like to be."

We describe the assessment process in more detail later; in summary form, however, it looks like the process displayed in figure 8-1.

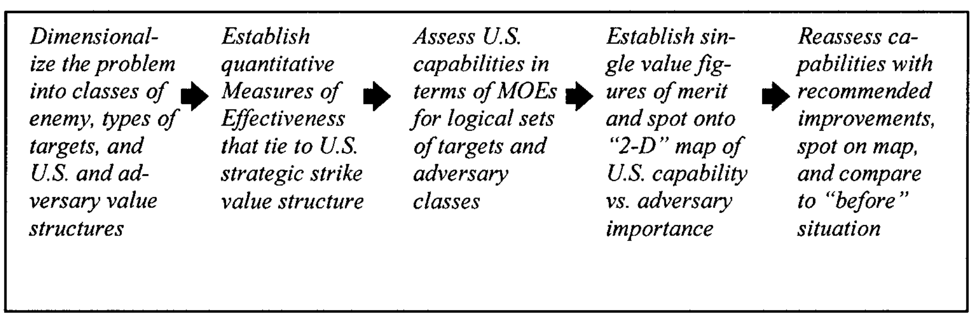

Figure 8-1: The assessment process.

8.2 DIMENSIONALITY

In the context of strategic strike, the word "capability" has many dimensions. Since our definition of "strategic" entails actions that create a fundamental change in an adversary's behavior, "capability" must be measured in terms of what a particular adversary holds dear. This is, of course, a function of what type of adversary we are dealing with and what kind of target we are attacking. The problems that exist when dealing with a "near peer" adversary are quite different than those that emerge when trying to dissuade or compel a non-state terrorist organization. Possessing the ability to destroy the civilian and economic infrastructure of a near peer adversary may be key to deterring its use of WMD. But against a terrorist organization with a few weapons of mass destruction, eliminating them may be much more important than attempting to deter their use.

In addition, some targets are static, others move or relocate, and still others may even be buried and protected in hardened bunkers. Each situation affects both how we attack and how well we do. And lastly, how well we do depends upon what the word "well" means. Is destroying or functionally disabling the target more important than the amount of collateral damage we might create? Do we care how much risk we expose ground forces and other assets to in order to make the strike? Such factors are all "dimensions" of the problem, and they all interact.

To handle all of these interacting issues, we dimensionalized the problem into an adversary "value model" (table 8-1) and a U.S. value model (table 8-2). Both models are built on the following target type definitions:

- *Leadership*: Heads of state or terrorist group, closest advisors, and major government political leaders.
- *WMD*: Chemical, biological, radiological, and nuclear payloads, storage facilities, and manufacturing capabilities.
- *Conventional military*: Critical sea, air, and ground forces such as air bases, air defenses, naval ports, and personnel staging areas.
- *Economic/civilian infrastructure*: Financial markets, centers of commerce, industrial capability, power plants, key bridges, distribution networks, public communication networks, and in some situations, population centers.
- *Command and control (C2)*: Embedded government and paramilitary command authority that manages and controls the society and executes the ability to respond militarily.

Type of Adversary		*Type of Target*				
		LEADERSHIP	WMD	CONVENTIONAL MILITARY	ECON. OR CIV. INFRA-STRUCTURE	COMMAND AND CONTROL
	MAJOR POWER	✓ *fixed*, mobile, *HDB*	✓✓✓ *mobile, HDB*	✓✓ *fixed, mobile*	✓✓✓ *fixed*	✓✓✓ *fixed, HDB*
	ROGUE AND/OR TERRORIST	✓✓✓ fixed, *mobile, HDB*	✓✓✓ fixed, *mobile, HDB*	✓ fixed, *mobile*	✓ *fixed*, mobile	✓✓✓ *fixed, HDB*

✓✓✓ Highest on adversary's value chain. Crucial to long-term viability.
✓✓ High on value chain but of lesser importance than above.
✓ Valued, but not critical to long-term viability.

Dominant modality

Table 8-1: The adversary's strategic value set and modality.

The adversary model estimates the relative importance or "value" to the adversary of the five types of assets listed above as a function of adversary type. For instance, we assume that the near peer is a near peer largely because of its highly developed civilian, industrial, and economic infrastructure, and that because of this, the near peer highly values this infrastructure. Important, but of less value, is the near peer's leadership because it is likely highly hierarchical and not focused around a single figure.

In contrast, a terrorist organization places its weapons of mass destruction at the very top of its value chain, because it is these weapons that in some sense raise its status to that of the near peer. The terrorist leadership is also more likely to be focused around a single leader. Similar logic lies behind the assessments included in the other blocks of the matrix. Also included in the figure is the "modality" of each asset type, i.e., fixed, rapidly relocatable or mobile, or hardened and/or deeply buried.

Type of Adversary		*Type of Target*				
		LEADERSHIP	WMD	CONVEN-TIONAL MILI-TARY	ECON. OR CIV. INFRA-STRUCTURE	COMMAND AND CONTROL
	MAJOR POWER	*Psuccess* Collat. dmg. *Exposure* Timeliness BDA	*Psuccess* Collat. dmg. Exposure *Timeliness* *BDA*	*Psuccess* Collat. dmg. *Exposure* Timeliness BDA	Psuccess Collat. dmg. *Exposure* Timeliness BDA	*Psuccess* Collat. dmg. Exposure *Timeliness* *BDA*
	ROGUE AND/OR TERRORIST	*Psuccess* *Collat. dmg.* Exposure Timeliness *BDA*	*Psuccess* Collat. dmg. Exposure *Timeliness* *BDA*	*Psuccess* *Collat. dmg.* *Exposure* Timeliness BDA	Psuccess *Collat. dmg.* *Exposure* Timeliness BDA	*Psuccess* Collat. dmg. Exposure *Timeliness* *BDA*

Most important MOEs

Table 8-2: Desirable characteristics from U.S. viewpoint.

From a U.S. perspective, five key measures of effectiveness (MOE) are important in establishing how "well" we might do in our ability to attack the important targets of our adversaries. The most obvious measure of effectiveness is our ability to functionally or physically disable the intended target. But what may also be important is the level of collateral damage such an attack would create, the level exposure of ground forces and other assets to enemy hostile action that may be required, how long it might take from decision to delivery of effect, and our ability to assess how well we did and whether or not it is necessary to restrike. Table 8-2 lists these values as a function of target type and adversary. The measures that are italicized and highlighted in red are considered more important than those that are not.

8.3 INDIVIDUAL FUNCTIONAL ASSESSMENTS

What remains to be done is to assess the five MOEs listed in the entries of Table 8-2 for each target type and for each class of adversary. This assessment is intended to be subjective, measuring each attribute on a scale of one to ten—essentially equivalent to "no value at all" to "about as good as we would want." To guide us in these assessments, we attempted to define "bounds" of goodness for each MOE or attribute. We have listed them in table 8-3, below.

Having established some guidelines for the assessment process, we aggregated the individual functions of the kill chain into three major macro functions: ISR, C3, and engagement. Figure 8-2 shows the mapping. All of the mapping should be self explanatory, except perhaps for the BDA function, which we split between the ability to examine the potential observables and adversary behavior (ISR) and the ability to decide and command re-engagement based upon the damage evidence at hand (C3).

Attribute or MOE	*Scoring Criteria* POOR (1 TO 3)	MEDIUM (4 TO 6)	HIGH (7 TO 10)
PROBABILITY OF SUCCESS	Cannot destroy or deny with any reasonable assurance	Ability to destroy or deny but assurance is at mid level	Can destroy or deny with high assurance for at least weeks
COLLATERAL DAMAGE	Long-term damage to environment with mass casualties in and out of area	Limited damage to environment with low to moderate casualties in or out of area	No long term damage out of area and very limited damage and casualties in area
EXPOSURE OF GROUND FORCES AND OTHER ASSETS	Significant numbers of troops in harm's way for many hours	Limited exposure of small numbers of individuals	Very little exposure to enemy action of any kind
TIMELINESS OF RESPONSE	>1.5 x target cycle time or > 8 hours from go ahead	About the same as the target cycle time or between 2 and 8 hours	Well below target cycle time or less than 2 hours from go ahead
BDA	Takes more than 24 hours to assess and low confidence (level 1)	12 hours to assess and medium confidence (level 2)	Near real time and high confidence (level 3)

Table 8-3: Guidelines for scoring capabilities.

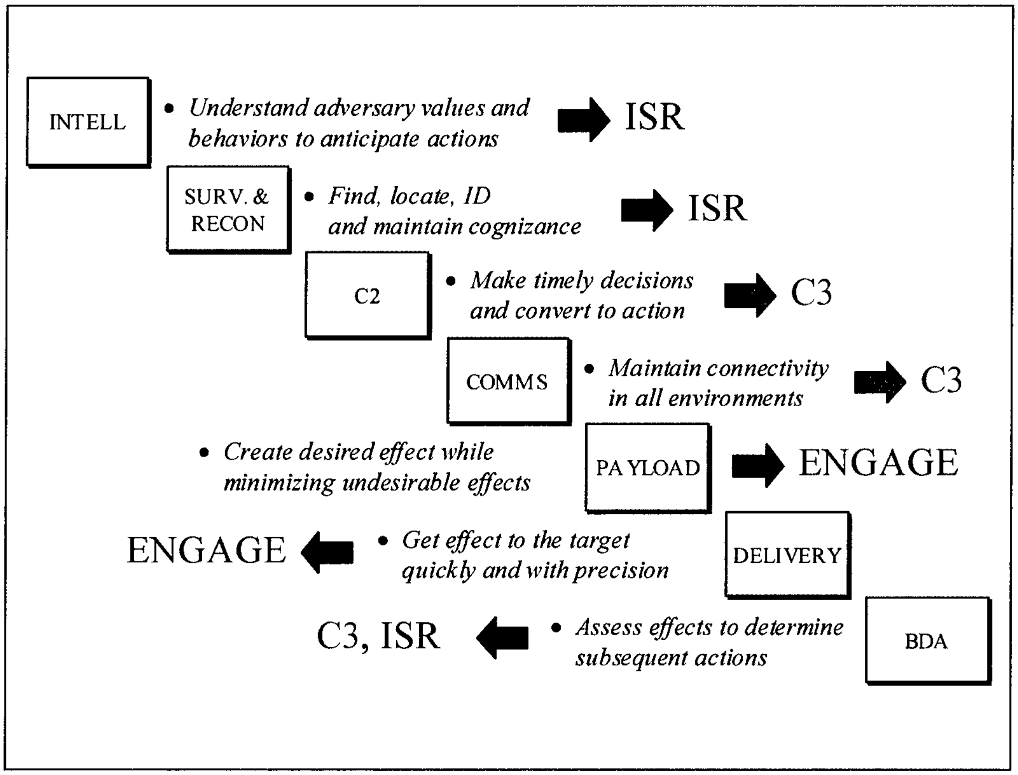

Figure 8-2: Kill chain mapping into three functions.

We then assessed each of the three functions' contribution to the five MOE's of table 8-1 for each of the target/adversary class pairings and dominant modalities identified in the table. The assumption built into these initial assessments was an enemy of the 2025 time period and a U.S. capability that had evolved along the lines of programs currently programmed during the same period. These yielded approximately 150 individual functional assessments of the type exemplified in each bar of figure 8-3 (the product of the three functions, five MOEs, five target types and two classes of adversary).[20]

[20] The actual number of cases examined differs from this number for two reasons: (1) some of the dimensional intersections are not sensible combinations, and (2) we treated the rogue state and the transnational terrorist separately at first, giving rise to three, not two, classes of adversary. We ultimately combined these two adversary classes into one by letting the lower of the two assessments dominate for each target type. All of the data from these analyses are provided in Appendix X.

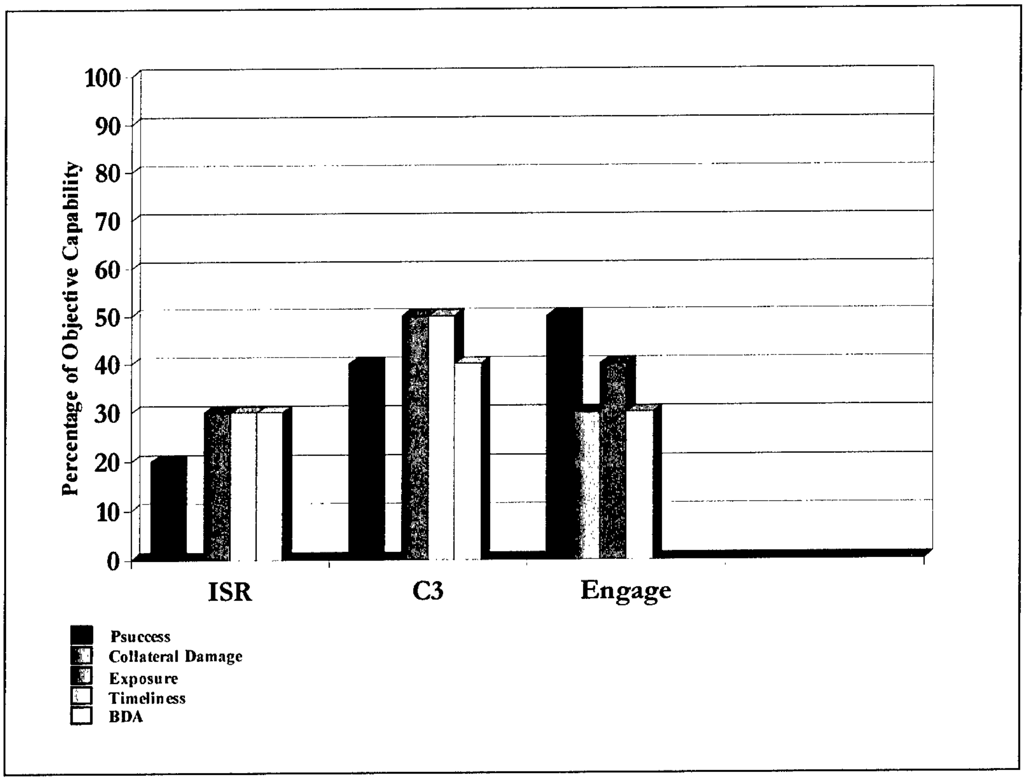

Figure 8-3: Capability against rogue/terrorists: WMD.

In the example above, we are assessing the capability of destroying or otherwise preventing the use of the terrorist or rogue-state WMD. The individual bars within a given function should be viewed, in a sense, as partial derivatives of an overall capability; i.e., the level of success we can assume, even if we don't worry about exposure or collateral damage; the kind of exposure it would take; the level of collateral damage that might result, and so on. In this sense, we assessed that the ISR function is not very good, regardless of which attribute we examine—i.e., it will not yield a high probability of finding, identifying, and tracking hidden or deeply buried WMD components; to do anything will require the presence of large numbers of special operations personnel; the assemblage of the information will take a long time; and our ability to know whether or not we destroyed the target will not be very good. We similarly assessed the C3 and engage functions.

In the latter assessment, a trade existed as to what kind of payload might be used (nuclear or conventional). This revolved around the trade between a higher probability of destruction coupled with the very severe collateral damage associated with today's nuclear payloads vice a much lower level of collateral damage coupled with a much lower probability of WMD nullification associated with the best of programmed conventional devices. The assessment in the figure is based upon the use of conventional weapons, because a sense existed among the study members that the projected level of collateral damage—particularly outside the target area—could self deter the use of a nuclear weapon against this class of adversary and target type.[21]

8.4 AGGREGATION OF INDIVIDUAL ASSESSMENTS

The final task of the assessment process was to aggregate the large number of individual assessments exemplified in the bars of figure 8-4 into a few higher level assessments that are more useful for determining meaningful trends and messages. This aggregation was done in two steps.

Figure 8-5 shows the first level of aggregation for the example portrayed in figure 8-4. The difference between the figures is the "Overall" assessment at the far right of figure 8-5. We arrived at the "Overall" assessment from the products of the three sub-functions for each of the individual MOEs.[22] As can be seen, serious problems exist across the board.

[21] We performed these assessments twice during the course of the study, and each time a different group of five people performed the assessment. The first time, a representative from each topic area (e.g., ISR, delivery, payloads, etc) participated. The second time, five members of the advanced concepts and technology assessment team were involved. It is interesting to note that although the assessments are subjective, the variation in assessed levels among individuals within an assessment group typically varied by 10 percentage points and only occasionally by as much as 20 percentage points. Between the two assessment groups, the variation was typically less than 10 percentage points, particularly at the aggregated level that will be discussed next. This gave us confidence that although one can always argue with the details of the assessments, they are likely to be in the right "ballpark," which was the overall objective of the exercise.

[22] There was considerable discussion over how to combine the functional assessments (e.g., products, sums, normalized RSS, etc.) into the overall ones. It was finally decided that although no process was perfect, the product method of combining had the three most desirable characteristics—a null capability yields a null result, a unity capability in one function has no impact on the combined capabilities of the other two, and the net result is lower than any of the individual contributors.

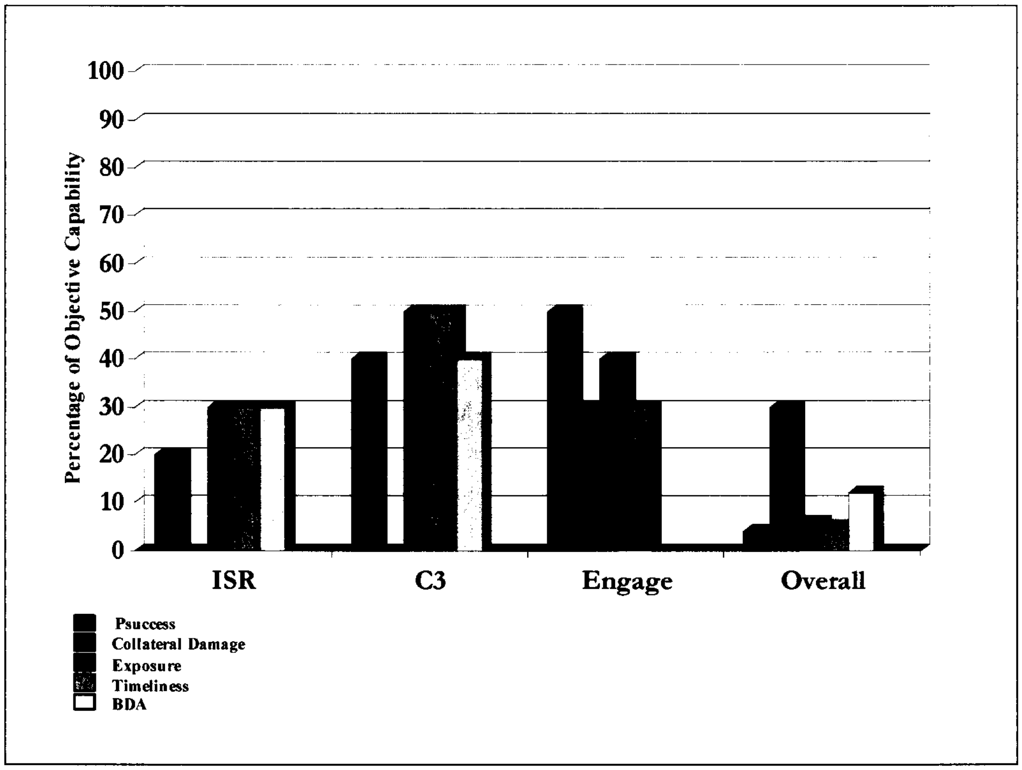

Figure 8-4: Capability against rogue/terrorists: WMD (with "overall" MOEs).

The final step in the aggregation process is indicated in figure 8-5. The individual MOEs in the overall assessments are combined to yield a "weighted average score," indicated by the green background at the bottom of the chart (the weighted average is slightly less than 10 percent in this example). The "weighting" comes from the relative importance of the five MOEs for this type of target and class of adversary contained in the matrix of table 8-2. Numerically this was accomplished by

- Weighting the "red" MOEs of table 8-2 (in this case, probability of success and timeliness) twice as heavily as the other three MOEs,
- Adding the weighted values together, and
- Normalizing by the sum of the weights.

Thus, given that ISR, C3, and weapon procurements evolve along the currently anticipated lines, the overall capability of projected U.S. strategic strike capability against a rogue or terrorist's stash of WMD weapons or storage facilities (defined broadly across a number of desired attributes), is likely to be an order of magnitude less than we would otherwise like it to be.

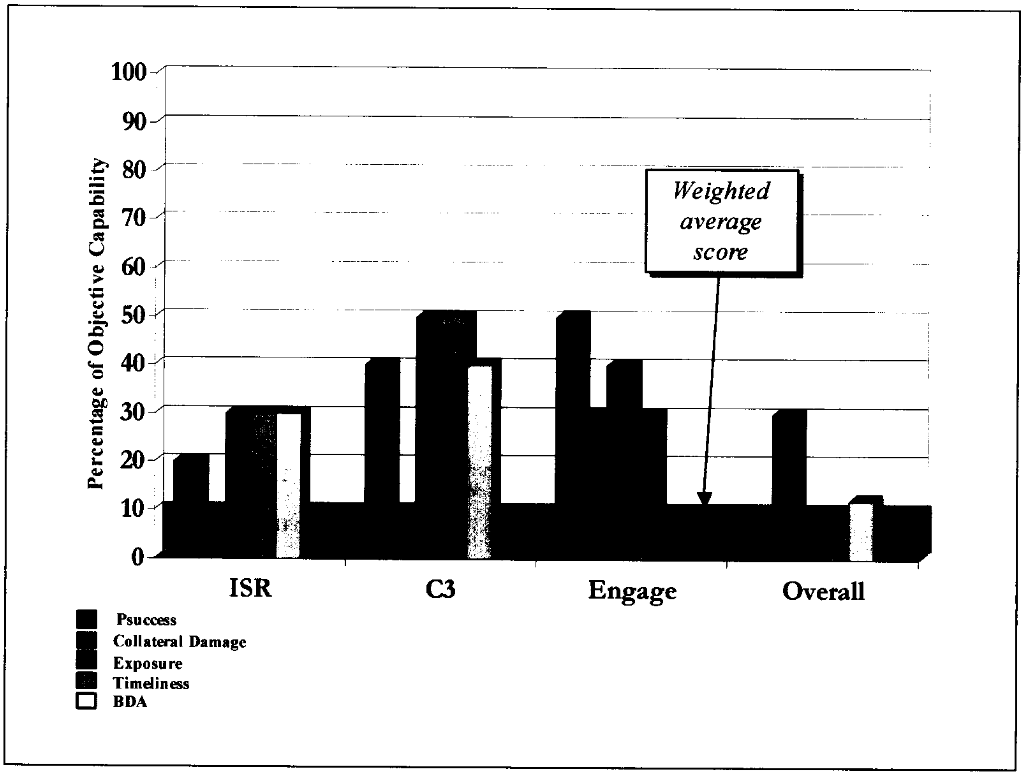

Figure 8-5: Capability against rogue/terrorists: WMD (with weighted average score).

In similar fashion, we assessed all of the other combinations of target/adversary pairings. Both the spreadsheets containing the numerical assessments and the graphs similar to figure 8-5 visually portraying the results are contained in appendix C.

8.5 MAPPING CAPABILITIES AGAINST ADVERSARY VALUE MODELS

What should be most important to us is to have as high a capability as we can to destroy or functionally disable the things that are most highly valued by our adversaries. This clearly plays into deterrence for those against whom deterrence is likely to remain an important element of U.S. policy. However, it also is a key element against those to whom deterrence is more speculative, because it underscores U.S. ability to remove leadership, disconnect their command and control, and significantly hamper their ability to employ their WMD.

To better understand and portray this interplay between our capabilities and our potential adversaries' target spectrum and value model we created the mapping of figure 8-6. It spots each combination of target type and adversary class (1) vertically (based upon the "weighted average" capability we assessed the United States would achieve prior to the implementation of any of the improvements recommended in this study), and (2) horizontally (based upon the relative importance we ascribed to the adversary). Clearly, the lower right of this space—targets that are very important to our adversaries and against which we have poor capability—should be our highest priority to improve. Conversely, the upper left of the space—targets against which we do very well but don't matter much to our adversaries—should be low on our improvement priority list.

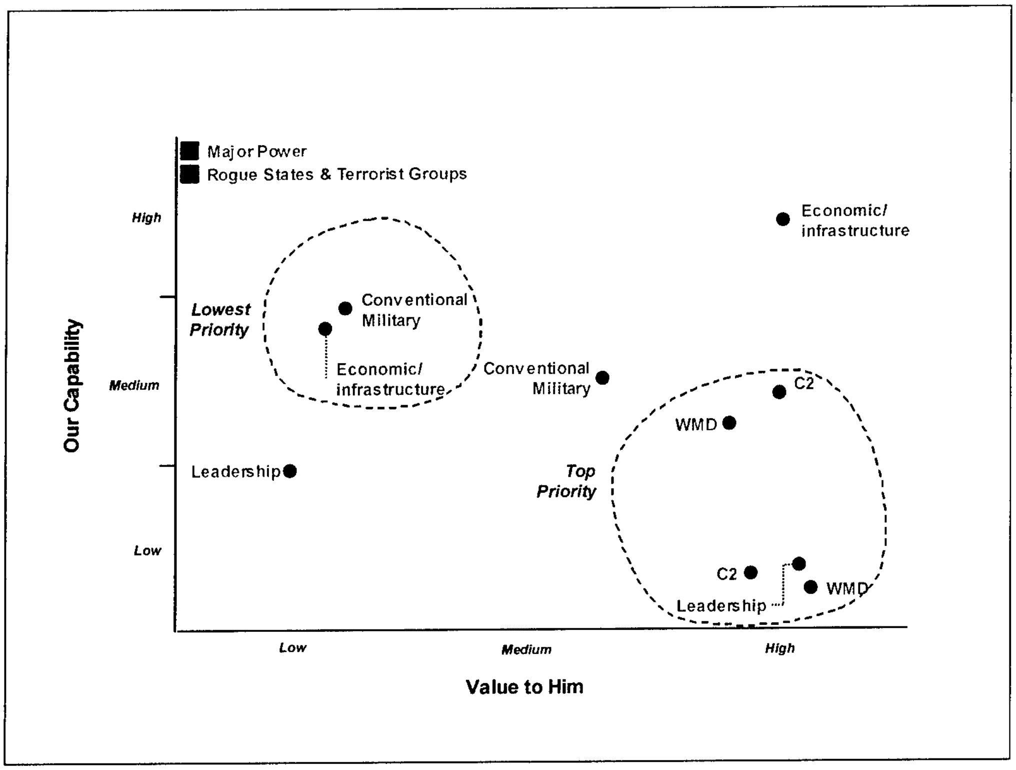

Figure 8-6: U.S. strategic strike capability—baseline.

As mentioned above, the issues of biggest concern should be the poor capability against the targets in the lower right of the figure. A number of deficiencies were noted by the task force during the course of this study. Below, we summarize those that contributed primarily to the poor performance against those targets in the lower right:

- ISR
  - Lack of persistent, global on-demand surveillance.
  - Little ability to assess functional effect of non-catastrophic damage.
  - Timeliness of tasking and deployment.
  - Combination of all-weather and high-resolution imaging.
  - Ability of intelligence to know what and where.
  - Poor capability against concealed, hidden, camouflaged, or buried targets.
  - Poor data fusion, analysis, and correlation of *I*, *S*, and *R* data
  - Survivability of *S* and *R* assets in capable air-defense environment.

- C3
  - Sluggishness of decision making in "messy" or complex situations.
  - Inability to observe and correlate pre-/post-strike behavior with BDA.
- Engagement
  - All-weather precision engagement of mobile or time-critical targets.
  - Rapid, global precision weapon delivery.
  - Inability to defeat chemical or biological agents with high confidence.
  - Low collateral damage/high effectiveness engagement of HDB targets.

The most significant of these deficiencies are those that contribute to three higher level shortfalls:

- Our inability to find, ID, and keep track of individuals and targets (especially WMD) that are highly temporal, concealed, camouflaged, or deceptively hidden;
- The lack of a C3 network that lends itself to timely and effective collaboration between the many players involved in making decisions and executing actions relating to strategic strike; and
- Our inability to deliver weapons rapidly that have the ability to defeat "difficult" targets without creating unacceptable levels of collateral damage. An example of such targets are hardened or deeply buried WMD components or storage facilities.

Many of the study's recommendations focus on alleviating these three primary shortfalls. We reviewed all of the improvements recommended by the study. Assuming that they all come to fruition and there is at least partial payoff from the science and technology (S&T) recommendations as well, we reassessed all of the target/adversary class pairings discussed above. The result is shown in figure 8-7.

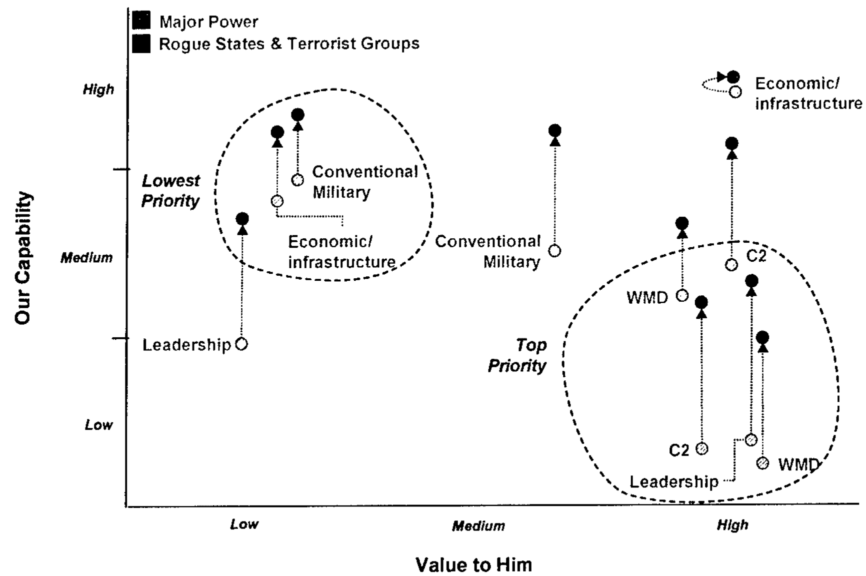

Figure 8-7: U.S. strategic strike capability—with recommendations.

As can be seen in the figure (particularly when compared to the capabilities in figure 8-6), much progress will result from these improvements. In particular, our capabilities against the three most important rogue/terrorist targets are improved by between approximately 200 to 300 percent. Against the major power, the improvements are not so dramatic because the levels were not as low to begin with. However, the improved levels are significant, with deterrent capability against the economic and civilian infrastructure remaining very high and capability against C2 and WMD increasing more than 60 percent.

None of these improvements is a panacea, nor is there a "silver bullet" that solves the entire problem. The problems to be solved—particularly in dealing with non-state terrorist organizations (about whom we lack familiarity and share few values)—are tough. The entire kill chain needs to be treated and the combination of "indistinct" targets, limited access, hardened targets, and the likelihood of a restrictive ROE environment affects every element on the chain. S&T efforts, even beyond those for which we have definitive recommendations in this study, will ultimately be the key for further improvements in capability. They must be nourished in the years ahead.

A. Terms of Reference

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY AND LOGISTICS

07 FEB 2003

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT Terms of Reference -- Defense Science Board 2003 Summer Study Task Force on Future Strategic Strike Forces

You are requested to form a Defense Science Board (DSB) Task Force to assess the future strategic strike force needs of the Department of Defense.

The strategic environment facing the United States is substantially changed from the times when we deployed our current nuclear strike forces and implemented the concepts that guide their use. The Nuclear Posture Review and the President's direction for the Unified Command Plan and the recent budget initiatives restructure our strategic posture. We need to assure that we evolve long-range strike forces and concepts by application of technology for non-nuclear weapons systems, communications, planning systems, and intelligence, as well as the integration of strategic strike with active defenses as part of a new triad.

You are requested to:

1 Assess the estimated systems life, including the nuclear stockpile, of the current long-range nuclear strike forces. Assess the future need for nuclear strike forces and recommend a strategy for the evolution of the current nuclear force capability

2) Identify promising non–nuclear, long-range strike systems capable of such dominating effects and consequences that they should be planned and directed in the same manner as strategic nuclear forces

3) Identify new concepts and approaches for the application of strategic nuclear and non-nuclear forces to our overall security strategy

The study will be co-sponsored by me as the Under Secretary of Defense (Acquisition, Technology and Logistics), and the Director, Defense Systems. General Michael P C Carns, USAF (Ret), and Admiral Dennis Blair, USN (Ret) will serve as the Task Force Co-Chairmen. Mr. Michael Novak will serve as the Executive Secretary, and LtCol Roger W. Basl will serve as the Defense Science Board Secretariat Representative.

The Task Force will be operated in accordance with the provisions of Public Law 92-463, the "Federal Advisory Committee Act", and DoD Directive 5104.5, "DoD Federal Advisory Committee Management Program". It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code, nor will it cause any member to be placed in a position of acting as a procurement official.

E.C. Aldridge, Jr.

B. Task Force Members and Advisors

Co-Chairs	*Organization*
ADM Dennis Blair, USN (Ret)	Institute for Defense Analyses
Gen Michael Carns, USAF (Ret)	Private Consultant
Mr. Vincent Vitto	C.S. Draper Laboratory

Executive Secretary	*Organization*
Mr. Michael Novak	DASD/Defense Systems

DSB Secretariat	*Organization*
LtCol Roger Basl	Defense Science Board

Payload Panel	*Organization*
Dr. John Foster*	Northrop Grumman
Dr. Harold Agnew	Private Consultant
Dr. Sydell Gold	Science Applications International Corp. (SAIC)
Dr. Anne Hillegas	DynCorp
Mr. John Nuckolls	Lawrence Livermore National Laboratory
Dr. George Ullrich	SAIC
Dr. Starnes Walker	Argonne National Laboratory
MajGen Jasper Welch, USAF (Ret)	Private Consultant
Gen Larry Welch, USAF (Ret)	Institute for Defense Analyses
Dr. Michael Wheeler	SAIC

C3/ISR Panel	*Organization*
Dr. Robert Strickler*	Private Consultant
Dr. Sydell Gold	SAIC
Dr. Charles Henkin	LMC Advanced Concepts
Dr. Jerry Krill	JHU/APL
MajGen Tom Neary, USAF (Ret)	SAIC
Dr. Paul Robinson	Sandia National Laboratories
Dr. Nils Sandell	ALPHATECH, Inc.
Dr. Bruce Wald	Private Consultant
Dr. Owen Wormser	Principal Director for Spectrum, Space, Sensors & C3, OASD(NII)

CONOPS Panel	*Organization*
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Dr. Victor Utgoff*	Institute for Defense Analyses
Ms. M. Elaine Bunn	National Defense University
Dr. Lewis Dunn	SAIC
RADM Charles Griffiths, USN (Ret)	Raytheon
MajGen Ron Henderson, USAF (Ret)	SAIC
Hon. Fred Ikle	Center for Strategic and International Studies
Dr. Robert Jervis	Columbia University
Hon. Ronald Lehman II	Lawrence Livermore National Laboratory
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Dr. Charles Henkin	Lockheed-Martin
Dr. Don Hicks	Hicks & Associates, Inc.
Mr. John Stillwell	Draper Laboratory
Dr. Robert Strickler	Private Consultant
Mr. John B. Walsh	Private Consultant
RADM Robert Wertheim, USN (Ret)	SAIC

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Dr. Delores Etter	U.S. Naval Academy
Dr. Matthew Ganz	C.S. Draper Laboratory
Dr. Kent Johnson	Lawrence Livermore National Laboratory
Dr. David Kalbaugh	Johns Hopkins University
Dr. Ronald Kerber	Private Consultant
Dr. Jerry McDowell	Lawrence Livermore National Laboratory
Dr. Tom Meyer	Los Alamos National Laboratory
Dr. Nils Sandell	ALPHATECH, Inc.
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Mr. Robert Stein	Private Consultant

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CDR Calvin Craig	OPNAV
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Mr. Dennis Evans	OSD
Mr. Greg Hulcher	OSD
Dr. Ted Hardebeck	STRATCOM
LtCol Kirk Hunigan	OSD(NII)
Mr. Jay Kistler	OSD(AT&L)
Dr. Don Linger	DTRA
Mr. Steve Maaranen	OSD
Mr. James Miller	USAF
Col Don Minner	DTRA
CAPT Mark Patton	STRACOM
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Mr. Tom Troyano	OSD
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RADM Charles Young	Navy SSP

Support	*Organization*
Ms. Allison Balzano	SAIC
Mr. Richard Balzano	SAIC
Ms. Allison Burrey	SAIC
Ms. Nicole Coene	SAIC
Mr. Mark Mateski	SAIC
Ms. Martha Ann Richardson	SAIC
Ms. Cara Sievers	SAIC

* Panel chairs.

Note that some individuals served on more than one panel.

C. Supporting Data for Capabilities Assessment

In this appendix, we further explain the assessment methodology we applied and discussed in chapter 8.

The following two spreadsheets contain all of the data used to perform the capabilities assessment discussed in the body of this report. Table 1 contains the individual capabilities assessments for the five target types by the three functions (*ISR*, *C3* and *Engage*) for each of the relevant desired U.S. attributes. Each figure is scored on a *0* through *10* basis, with *10* representing "perfection." The fourth column under each target type (*All*) is the combined assessment, arrived at by the product of the preceding three figures and normalized from 0 to 1. We initially considered three classes of adversary: (1) near peer or major power, (2) rogue, and (3) non-national or terrorist. We arrived at the combination of the rogue and terrorist (used in the body of this assessment and in the main report) by using the lesser figure from the two individual assessments. The bold figure at the bottom of each target type and adversary class is the overall assessment, arrived at by creating a weighted average of the individual attribute assessments where the weighting is the relative importance of each attribute (the *1* or *2* in the shaded column) for the particular target and adversary class. These figures are the "capabilities" portrayed in the "bubble charts" of the final outbrief and summer study report (see figurers 1-1 and 1-2 in chapter 1).

		Leadership ISR	Leadership C3	Leadership Engage	Leadership all	Command and Control ISR	Command and Control C3	Command and Control Engage	Command and Control all
Peer	Psuccess	4	5	7	0.14	7	7	8	0.392
	Coll. Dmg			2	0.2			2	0.2
	Exposure	6	9	9	0.486	8	8	9	0.576
	Timeliness	7	7	9	0.441	7	7	9	0.441
	BDA	5	6		0.3	6	7		0.42
					0.313286				**0.440286**
Rogue	Psuccess	3	4	5	0.06	7	7	7	0.343
	Coll. Dmg			5	0.5			6	0.6
	Exposure	4	6	6	0.144	6	7	7	0.294
	Timeliness	4	5	4	0.08	6	7	7	0.294
	BDA	3	5		0.15	6	7		0.42
					0.2066				**0.376**
Terrorist	Psuccess	2	3	3	0.018	2	4	3	0.024
	Coll. Dmg			4	0.4			5	0.5
	Exposure	4	6	6	0.144	5	5	7	0.175
	Timeliness	3	3	3	0.027	3	5	4	0.06
	BDA	2	4		0.08	3	4		0.12
					0.145876				**0.146143**

		WMD ISR	WMD C3	WMD Engage	WMD All	Economic/Infrastructure ISR	Economic/Infrastructure C3	Economic/Infrastructure Engage	Economic/Infrastructure All	Conventional Military ISR	Conventional Military C3	Conventional Military Engage	Conventional Military All
Peer	Psuccess	4	7	8	0.224	9	9	10	0.81	8	8	8	0.512
	Coll. Dmg			2	0.2			2	0.2			4	0.4
	Exposure	7	9	9	0.567	9	10	9	0.81	7	9	9	0.567
	Timeliness	7	8	9	0.504	9	9	9	0.729	7	8	8	0.448
	BDA	5	6		0.3	8	8		0.64	8	8		0.64
					0.322286				**0.7598**				**0.620857**
Rogue	Psuccess	3	5	6	0.09	8	8	9	0.576	9	9	9	0.729
	Coll. Dmg			4	0.4			7	0.7			8	0.8
	Exposure	4	6	4	0.096	9	8	9	0.648	7	9	7	0.441
	Timeliness	3	5	3	0.045	7	8	8	0.448	7	8	8	0.448
	BDA	4	6		0.24	7	7		0.49	8	8		0.64
					0.164286				**0.601429**				**0.6285**
Terrorist	Psuccess	2	4	5	0.04								
	Coll. Dmg			3	0.3								
	Exposure	3	5	4	0.06								
	Timeliness	3	5	3	0.045								
	BDA	3	4		0.12								
					0.101429								

Table C-1. Assessment before recommended improvements

Table 2 contains the assessment data under the assumption that the recommendations contained in the main body of the report are implemented successfully.

		Leadership ISR	Leadership C3	Leadership Engage	Leadership all	Command and Control ISR	Command and Control C3	Command and Control Engage	Command and Control all	WMD ISR	WMD C3	WMD Engage	WMD All
Peer	Psuccess	7	9	8	0.504	8	10	8	0.64	5	9	8	0.36
	Coll Dmg			2	0.2			5	0.5			5	0.5
	Exposure	8	10	9	0.72	9	10	9	0.81	9	10	9	0.81
	Timeliness	9	9	10	0.81	9	10	10	0.9	9	9	10	0.81
	BDA	8	9		0.72	7	9		0.63	5	9		0.45
					0.696857				0.735714				0.64
Rogue	Psuccess	6	8	8	0.384	7	9	8	0.504	5	10	8	0.4
	Coll Dmg			6	0.6			6	0.6			5	0.5
	Exposure	6	10	9	0.54	8	10	9	0.72	6	9	7	0.378
	Timeliness	9	8	9	0.648	9	9	10	0.81	7	8	9	0.504
	BDA	8	9		0.72	7	9		0.63	5	8		0.4
					0.6745				0.651				0.444
Terrorist	Psuccess	5	7	8	0.28	5	8	8	0.32	3	10	8	0.24
	Coll Dmg			8	0.8			7	0.7			6	0.6
	Exposure	4	9	7	0.252	6	9	9	0.486	4.5	9	5	0.2025
	Timeliness	7	6	9	0.378	6	9	8	0.432	6	7	8	0.336
	BDA	7	8		0.56	5	9		0.45	5	8		0.4
					0.48876				0.461143				0.364671

		Economic/Infrastructure ISR	Economic/Infrastructure C3	Economic/Infrastructure Engage	Economic/Infrastructure All	Conventional Military ISR	Conventional Military C3	Conventional Military Engage	Conventional Military All
Peer	Psuccess	9	9	10	0.81	9	9	9	0.729
	Coll Dmg			2	0.2			6	0.6
	Exposure	9	10	9	0.81	9	10	8	0.72
	Timeliness	10	9	10	0.9	9	9	9	0.729
	BDA	9	9		0.81	9	10		0.9
					0.828				0.732429
Rogue	Psuccess	8	9	9	0.648	9	10	9	0.81
	Coll Dmg			8	0.8			8	0.8
	Exposure	8	10	9	0.72	9	10	8	0.72
	Timeliness	9	9	9	0.729	9	9	9	0.729
	BDA	8	9		0.72	9	10		0.9
					0.733857				0.786125

Table C-2. Assessment after implementation of recommended improvement

The complete set of capabilities bar charts for each of the target types and adversary classes are contained in the remaining pages of this appendix.

Figure 1 - Near Peer: Leadership

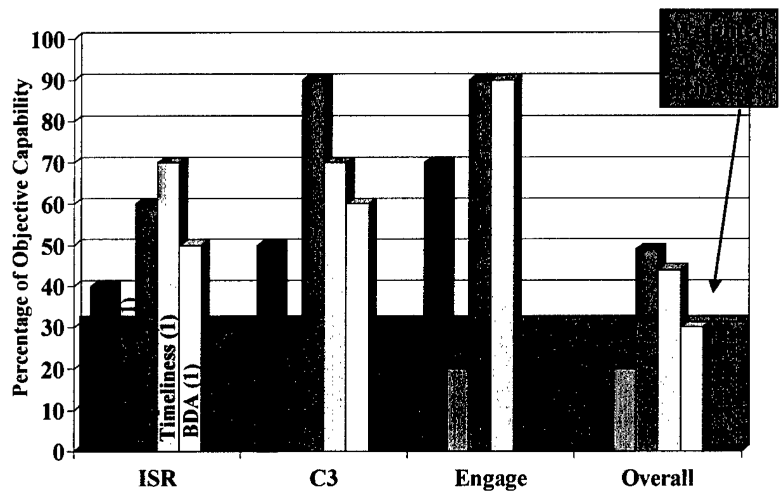


Figure 2 - Near Peer: Leadership w/ Recommendations

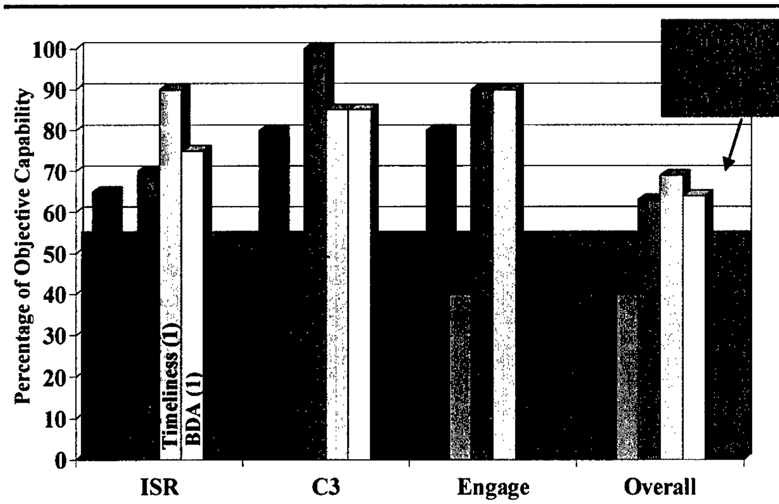


Fig. 3 - Rogue: Leadership

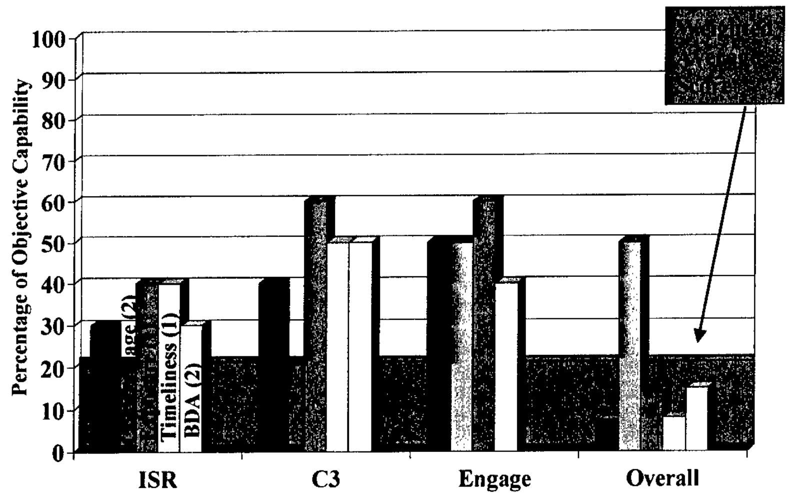


Fig. 4 - Rogue: Leadership w/ Recommendations

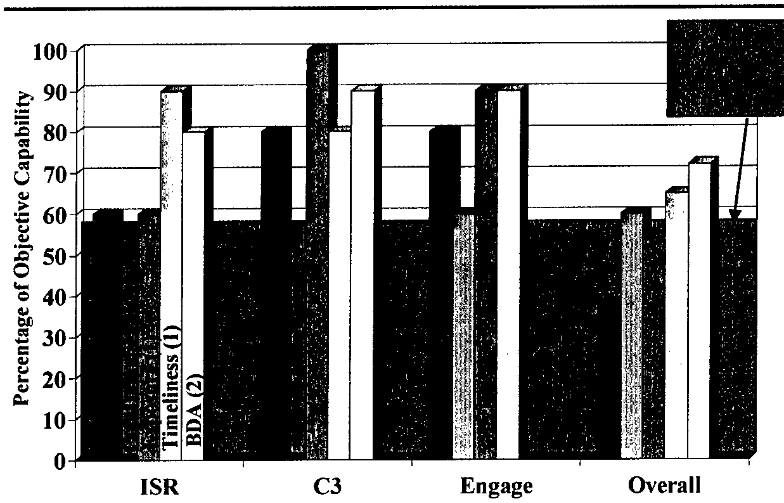


Fig. 5 - Terrorist: Leadership

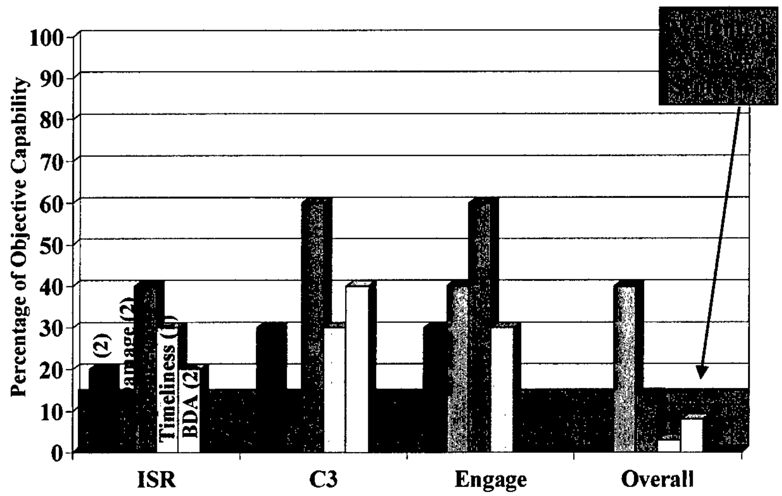


Fig. 6 - Terrorist: Leadership w/ Recommendations

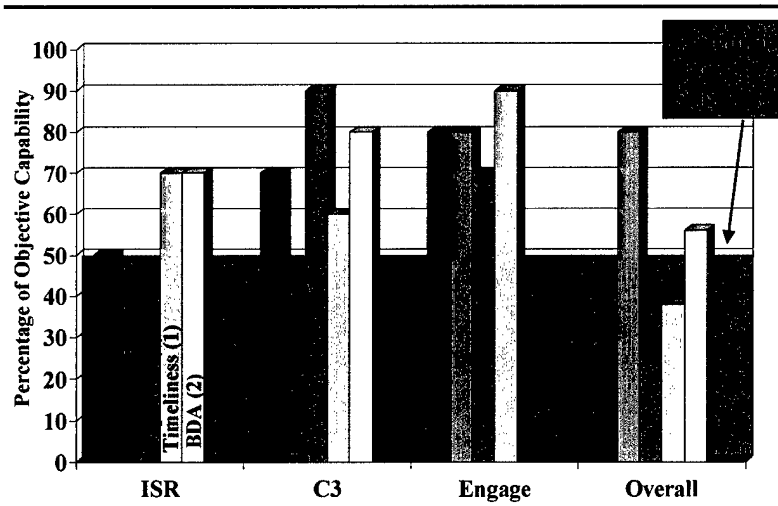


Fig. 7 - Near Peer: Command and Control

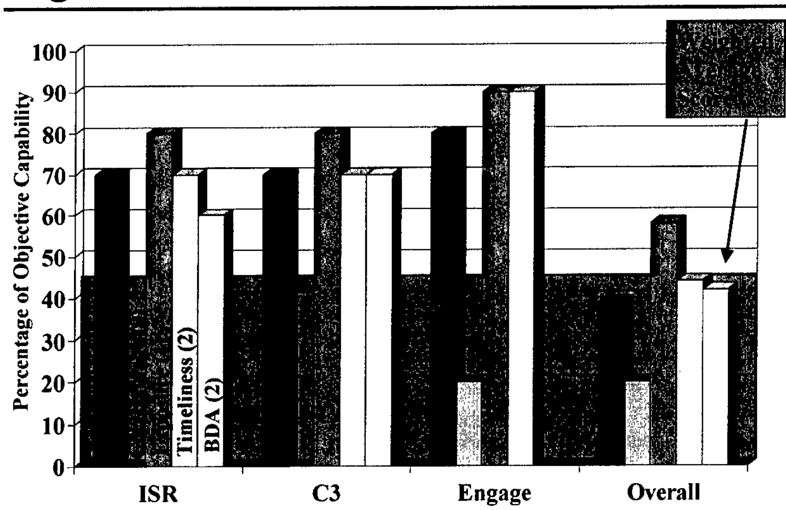


Fig. 8 - Near Peer: Command and Control w/ Rec's

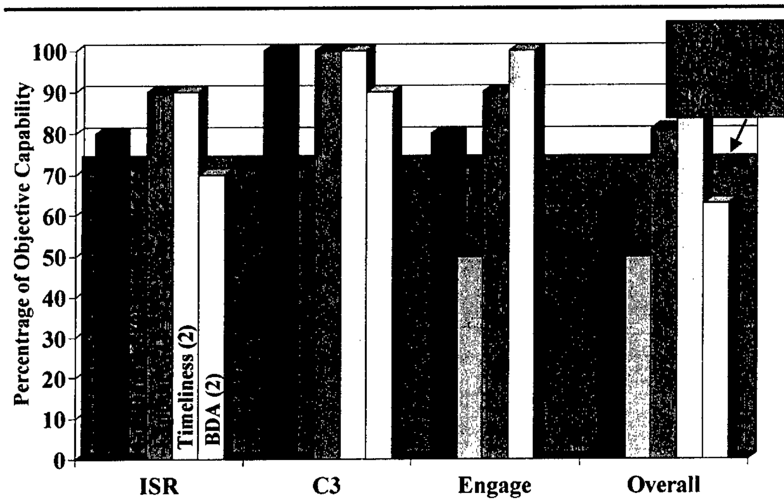


Fig. 9 - Rogue: Command and Control

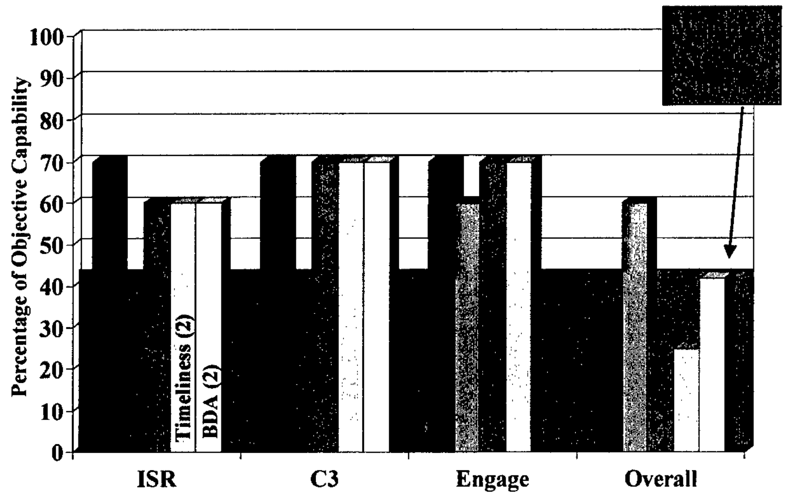


Fig. 10 - Rogue: Command and Control w/ Rec's

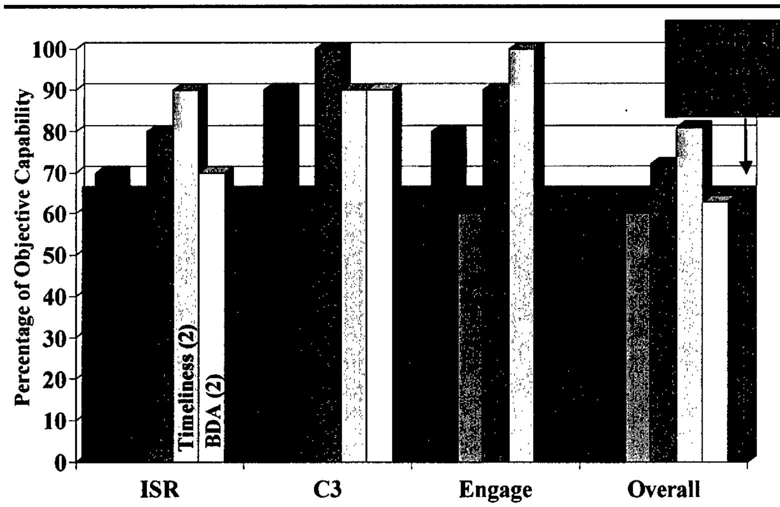


Fig. 11 - Terrorist: Command and Control

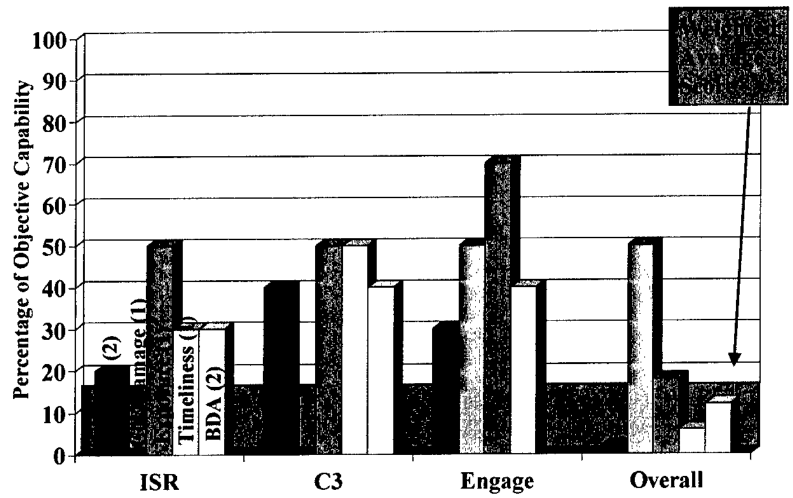


Fig. 12 - Terrorist: Command and Control w/ Rec's

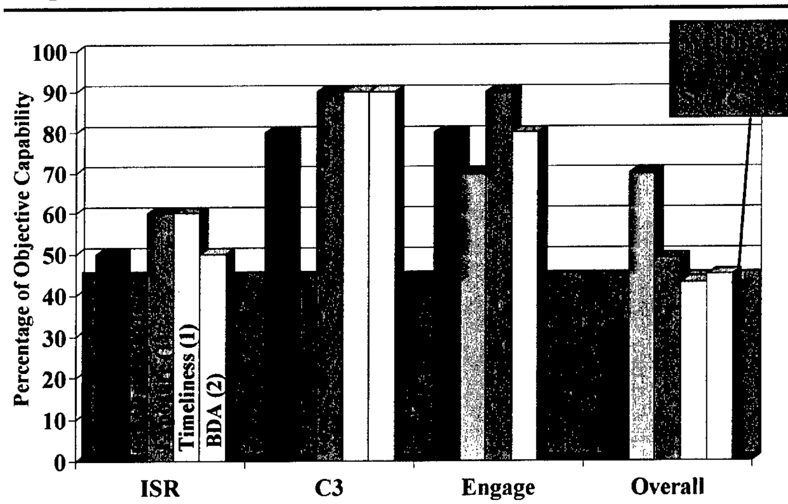


Fig. 13 - Near Peer: WMD

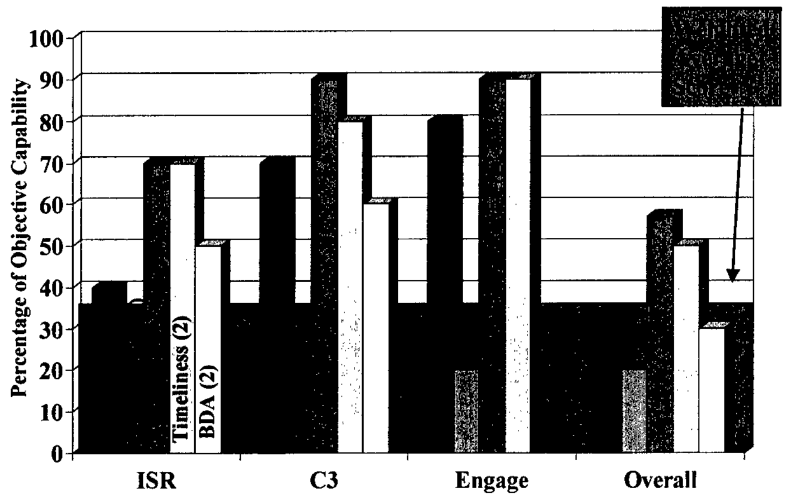


Fig. 14 - Near Peer: WMD w/ Recommendations

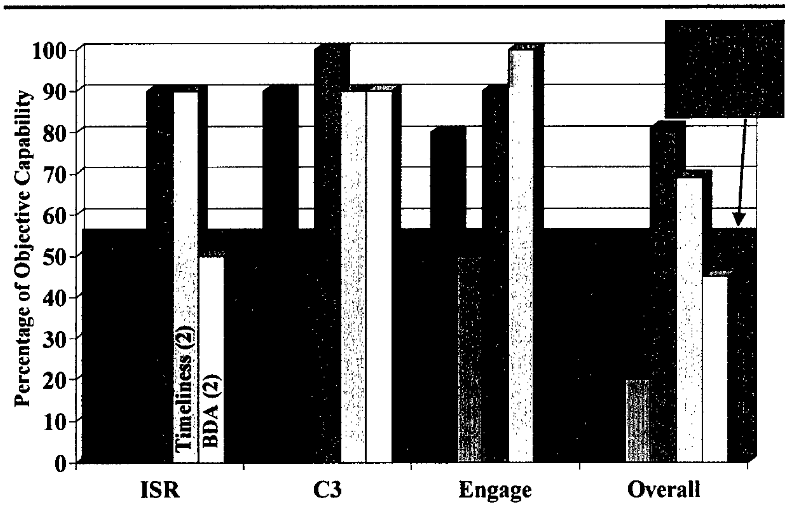


Fig. 15 - Rogue: WMD

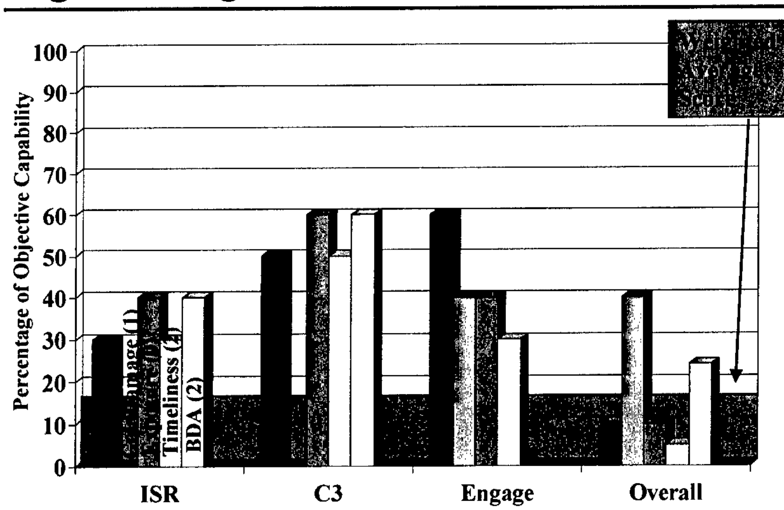


Fig. 16 - Rogue: WMD w/ Recommendations

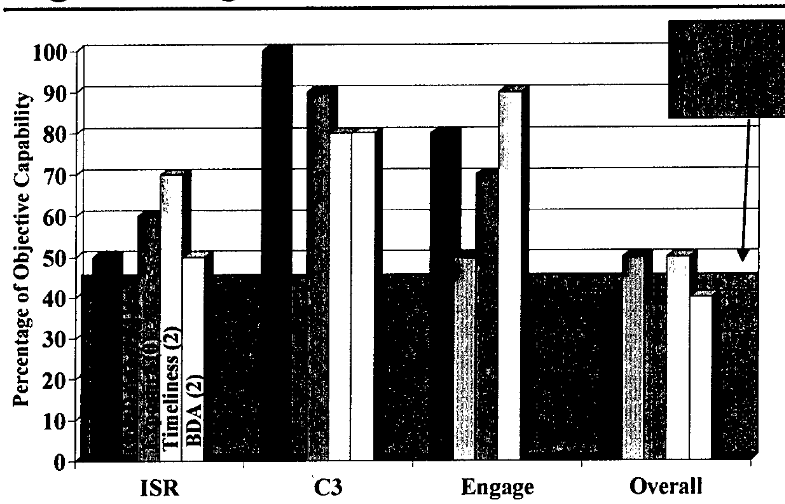


Fig. 17 - Terrorist: WMD

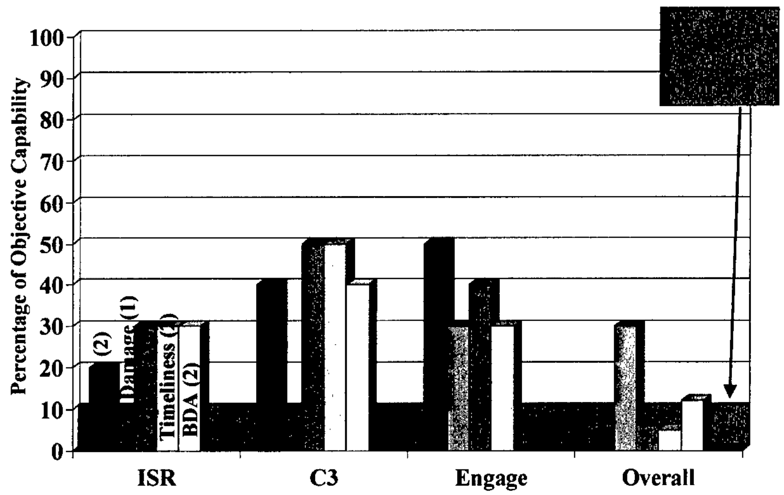


Fig. 18 - Terrorist: WMD after Recommendations

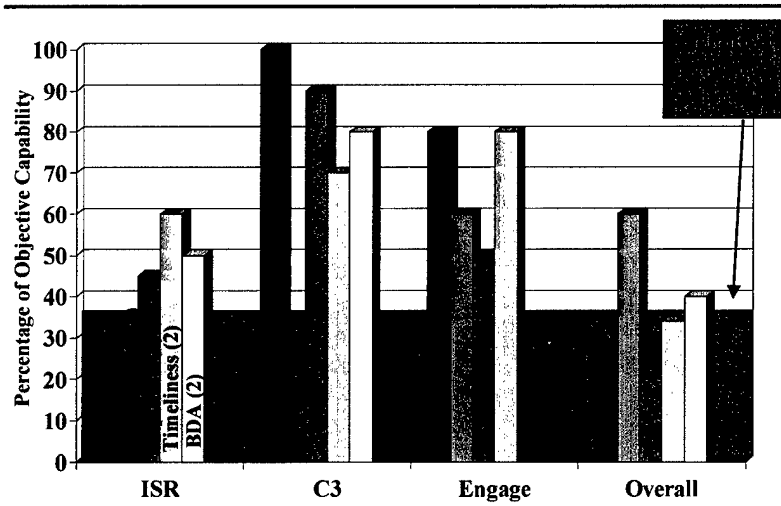


Fig. 19 - Near Peer: Economic/Civilian Infrastructure

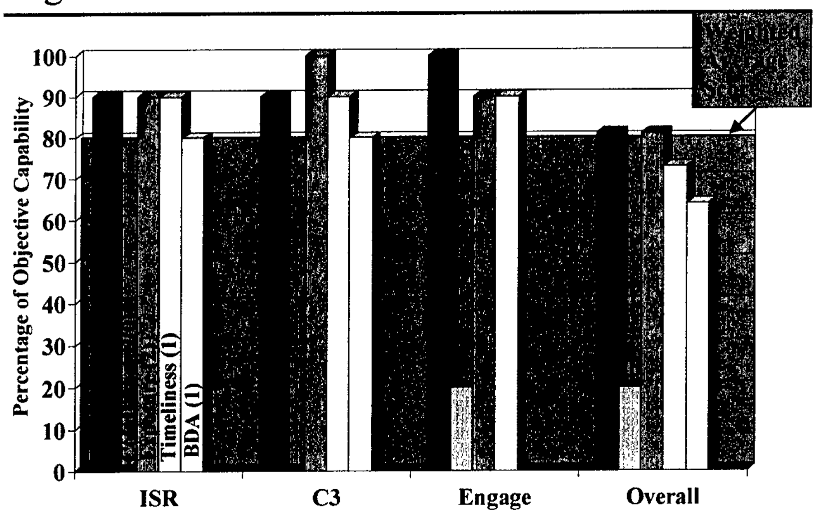


Fig. 20 - Near Peer: Econ/Civ Infrastructure w/ Rec's

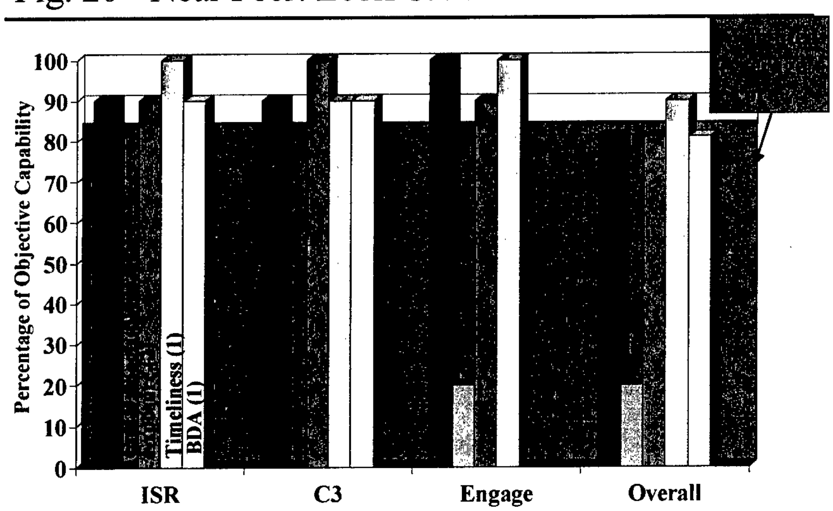


Fig. 21 - Rogue: Economic/Infrastructure

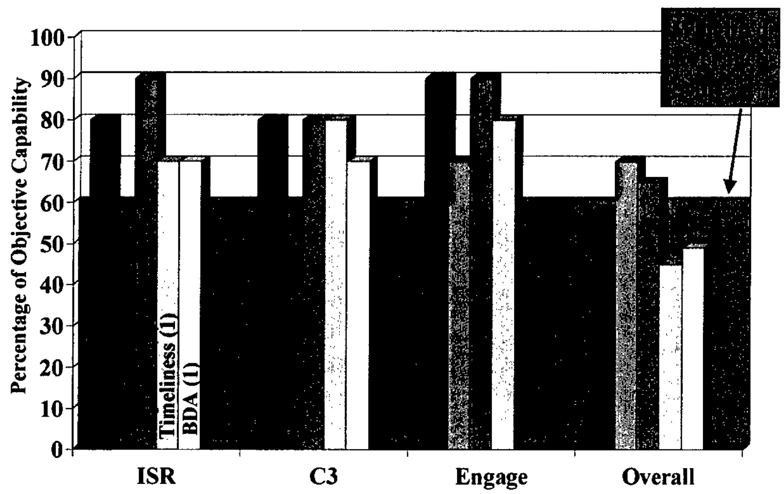


Fig. 22 - Rogue: Economic/Infrastructure w/ Rec's

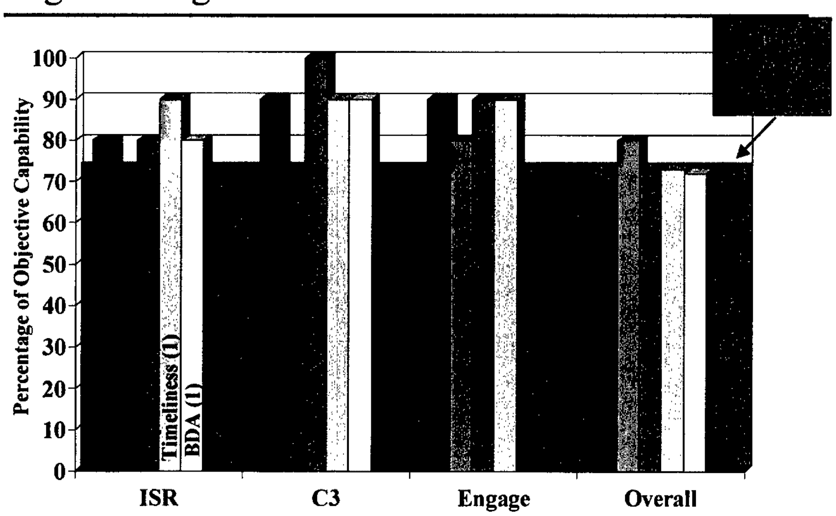


Fig. 23 - Near Peer: Conventional Military

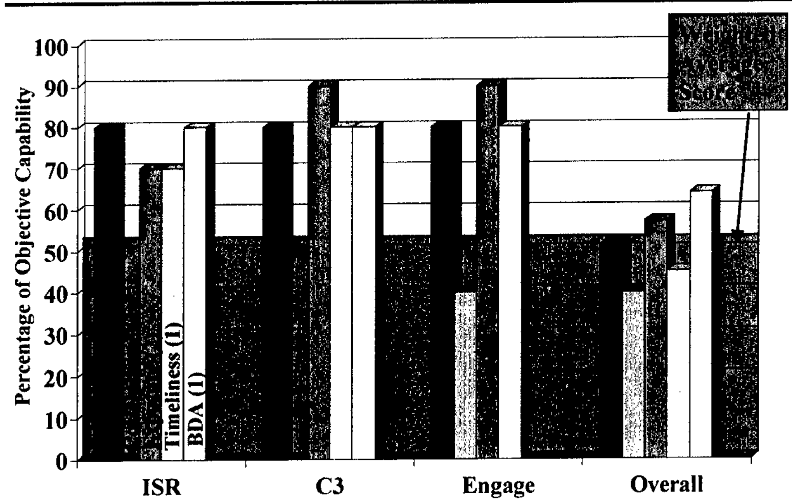


Fig. 24 - Near Peer: Conventional Military w/ Rec's

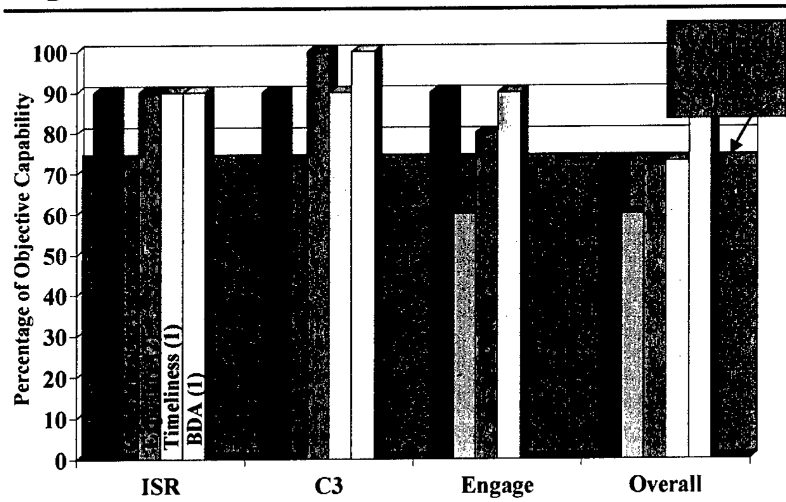


Fig. 25 - Rogue: Conventional Military

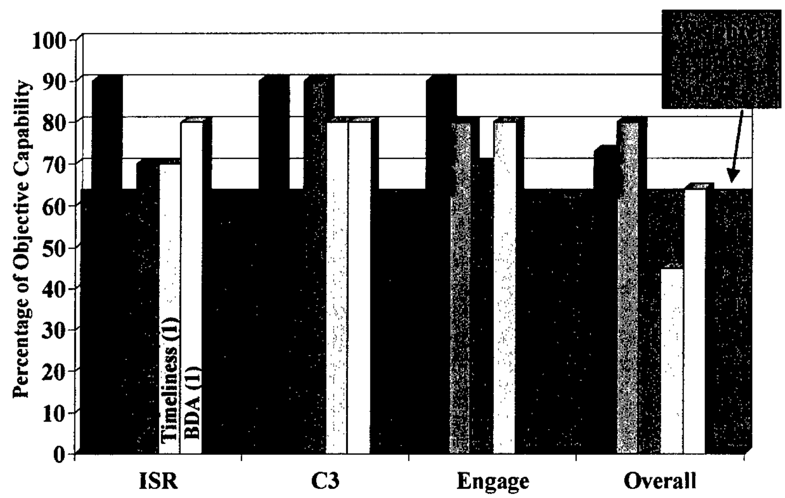
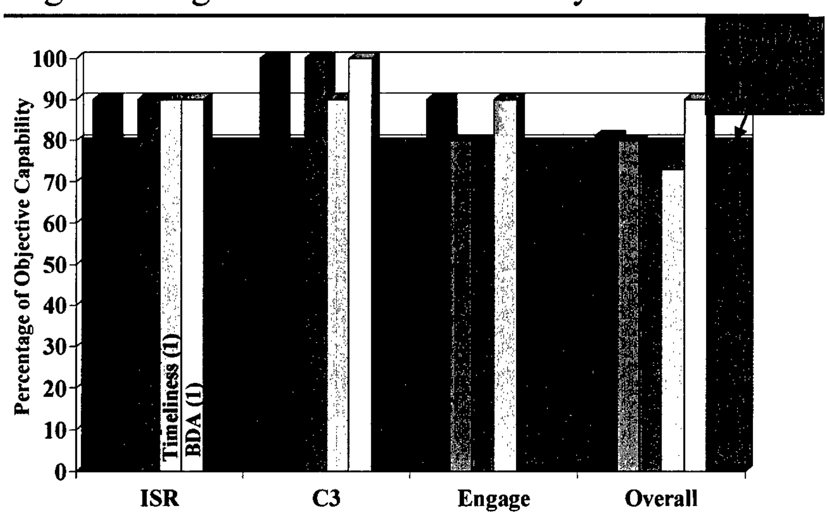


Fig. 26 - Rogue: Conventional Military w/ Rec's



D. Acronyms

Acronym	*Definition*
ABM	anti-ballistic missile
ACM	Advanced Cruise Missile
ACTD	Advanced Concept Technology Demonstration
AIM	Advanced ISR Management Program
ALCM	Air-Launched Cruise Missile
AoA	analysis of alternatives
ASD(NII)	Assistant Secretary of Defense for Networks and Information Integration
BDA	battle damage assessment
BMDS	ballistic missile defense systems
BW	biological weapons
C2	command and control
C2BMC	command and control battle management/fire control system
C2ISR	command, control, intelligence, surveillance, and reconnaissance
C3	command, control, and communications
C3I	command, control, communications, intelligence
C3ISR	command, control, communications, intelligence, surveillance, and reconnaissance
C4ISR	command, control, communications, and computers, intelligence, surveillance, and reconnaissance
CALCM	Conventional Air-Launched Cruise Missile
CCD	camouflage, concealment, and deception
CCS	Combat Control System
CEP	circular error probable
CIA	Central Intelligence Agency
CND	computer network defense
COA	course of action
CONOPS	concept of operations
CONUS	continental United States
CRD	Capstone Requirements Document
CROP	common, relevant operational picture
CSRL	Common Strategic Rotary Launcher
DARPA	Defense Advanced Research Projects Agency
DCI	Director, Central Intelligence
DIA	Defense Intelligence Agency
DO	Directorate of Operations (CIA)

Acronym	*Definition*
DoD	Department of Defense
DOE	Department of Energy
DRR&E	Director of Defense Research and Engineering
D-SIDE	Defensive Strategic Integrated Decision Environment
DTED	digital terrain elevation data
DTRA	Defense Threat Reduction Agency
E2	Enhanced Effectiveness
ECCM	electronic counter-countermeasures
EMP	electromagnetic pulse
EO	electro-optical
ESM	electronic support measures
FIA	Future Imagery Architecture
GAP	Guidance Applications Program
GIG	Global Information Grid
GIG-BE	Global Information Grid Bandwidth Expansion
GMTI	ground moving target indicator
GNCST	Global Strike Force Network-Centric Surveillance and Targeting
GPS	Global Positioning System
HDBT	hard and deeply buried target
HE	high explosive
HFI	Horizontal Fusion Initiative
HPM	high-power microwaves
HSI	hyper-spectral imagery
HUMINT	human intelligence
IC	Intelligence Community
ICBM	intercontinental ballistic missile
IMU	inertial measurement unit
INF	Intermediate-Range Nuclear Forces
INS	inertial navigation system
IO	information operations
IOC	initial operational capability
IR	infrared
ISR	intelligence, surveillance, and reconnaissance
JASSM	Joint Air-to-Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JFCOM	Joint Forces Command
J-STARS	Joint Surveillance and Target Attack Radar System
JTRS	Joint Tactical Radio System
J-UCAS	Joint Unmanned Combat Air System

Acronym	*Definition*
KPP	key performance parameters
LEO	low-earth orbit
LOCAAS	Low-Cost Autonomous Attack System
MASINT	measurement and signatures intelligence
MALD	Miniature Air-Launched Decoy
MAV	miniature air vehicle
MDA	Missile Defense Agency
MDBDA	Munition Deployed Battle Damage Assessment
MEO	mid-earth orbit
MIRV	multiple, independently targeted reentry vehicles
MMIII	Minuteman III
MOE	measures of effectiveness
NBC	nuclear, biological, and chemical
NCES	Network-Centric Enterprise Services
NFIP	National Foreign Intelligence Program
NIMA	National Imagery and Mapping Agency
NNSA	National Nuclear Security Administration
NPR	Nuclear Posture Review
N-TACMS	naval variant of the Army Tactical Missile System
OAS	Offensive Aviation System
OIF	Operation Iraqi Freedom
OSD	Office of the Secretary of Defense
OSD(P)	Office of the Secretary of Defense for Policy
PK	Peacekeeper (missile)
PSYOP	psychological operations
QDR	Quadrennial Defense Review
QoS	quality of service
RAPIER	Rapid Intercontinental Emergency Response
RCC	regional combatant commander
R&D	research and development
RDT&E	research, development, test, and engineering
RHAP	Radiation Hardened Applications Program
RNEP	Robust Nuclear Energy Penetrator
ROE	rules of engagement
ROM	rough order of magnitude
RSAP	Reentry System Applications Program
RV	reentry vehicle
SAM	surface-to-air missile
SAR	synthetic aperture radar
SATCOM	satellite communications

Acronym	*Definition*
SBR	space-based radar
SEAL	sea and land
SECDEF	Secretary of Defense
SIGINT	signals intelligence
SIOP	single integrated operational plan
SLBM	submarine/sea-launched ballistic missile
SLBN	submarine launched ballistic missile
SLEP	service life extension program
SOCOM	Special Operations Command
SOF	special operations forces
SPAP	Strategic Propulsion Applications Program
SR	surveillance and reconnaissance
SSBN	nuclear powered ballistic missile submarine
SSGN	nuclear powered cruise missile submarine
SSP	Stockpile Stewardship Program
S&T	science and technology
START	Strategic Arms Reduction Talks
STRATCOM	Strategic Command
TC	Transformational Communications
TCA	Transformational Communications Architecture
TCT-F	Time Critical Targeting - Functionality
TEL	transporter/erector/launcher
TLAM-N	Tomahawk Land Attack Missile - Nuclear
TPED	task, process, exploit, and disseminate
TPG	Transformation Planning Guidance
TPPU	task, post, process, use
TSAP	Transformational Space and Air Program
TSAT	Transformational Satellites
TST	time sensitive targets
UAV	unmanned aerial vehicles
UCAV	uninhabited combat air vehicle
UCP	Unified Command Plan
UCS	Unified Command Structure
UGS	unattended ground sensors
UGSSS	unmanned, global, surveillance/strike system
UHF	ultra-high frequency
USD(AT&L)	Under Secretary of Defense for Acquisition Technology, and Logistics
USD(I)	Under Secretary of Defense for Intelligence
USD(P)	Under Secretary of Defense for Policy

Acronym	*Definition*
VLS	vertical launch system
WMD	weapons of mass destruction