THE BALANCED TECHNOLOGY INITIATIVE:

ITS RELEVANCE TO CONVENTIONAL FORCES

Even though it is a technology development program, its focus is squarely on operational needs in the context of existing U.S. warfighting guides.

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THE PRE-EMINENT military position of the United States today can be attributed in large part to its longstanding and significant technological capabilities. Our ability to end World War II, for example, was greatly influenced by rapid technological achievements by highly competent scientists and engineers that led to the development of nuclear weapons. Furthermore, the relative stability that followed in the period known as the "Cold War" was made possible by the existence of our strategic nuclear force, which served as a check against possible Soviet and Warsaw Pact aggression in Europe.

As the Soviets developed somewhat comparable capabilities, the United States responded with further advances in nuclear weapons technology and began to deploy a variety of tactical nuclear weapons in Europe to offset a recognized imbalance in conventional forces. This process began in the late 1950s during

the Eisenhower administration, extended through the 1950s and 1970s and continues even today.

Over the last decade, however, rough parity between U.S./NATO and Soviet/Warsaw Pact nations has been established in this area, but amidst growing awareness and acceptance of the overall futility of nuclear conflict at any level. This global concern most recently culminated in an aggreement to eliminate intermediate-range missiles (ranges from 500 to 5,500 kilometers) armed with nuclear warheads -- giving rise to a corresponding need to fill the eventual attendant gap in our European defense posture. This can only be accomplished by rapid development of improved capabilities for conventional forces. But Europe is not our only area of concern. Improvements in U.S. conventional force capabilities can be expected to have a positive impact on our effectiveness in possible future conflicts in other parts of the world as well.

The United States has a longstanding commitment to the needs of conventional forces — reflected by the fact that more than 70 percent of the current DoD science and technology program is concerned with the development of technologies important to conventional defense. Ongoing science and technology program activities involve extensive work in the area of military systems technology — including significant efforts in the fields of aeronautics, propulsion, structures, materials and weapons design; electronics and electronic devices — including sensors and seekers, fire control, surveillance and target-acquisition systems. Directed-energy battle-management communications, command and control systems; in the areas of chemical warfare and chemical/biological defense, environmental sciences, medical and life sciences and training and personnel technology; and in the area of computer science. Supporting these efforts is a DoD basic research program that involves work in diverse technical fields — including physics, chemistry and materials science, electronics, biology, energy conversion, oceanography, mathematics and computer science, terrestrial and atmospheric sciences and behavioral sciences.

Significant technological developments important to conventional defense are also derived from other defense programs. For example, many of the realized results and expected accomplishments of the Strategic Defense Initiative and the Air Defense Initiative programs have significant applications in the conventional arena.

Recent Congressional Actions

A number of recent and significant actions by the Congress have emphasized the growing concern over current U.S. and allied tactical, non-nuclear warfighting capabilities. In 1986, the NATO Cooperative Research and Development Program (frequently called the Nunn Amendment Program) was established to support cooperative "research and development on defense equipment and munitions" and to promote related joint efforts involving material production. This latter activity was to include "coproduction of conventional defense equipment" by the United States and other members of NATO and the "production by United States contractors of conventional defense equipment designed and developed by other member nations of NATO." Congress noted that "for more than a decade the member nations of NATO have provided in the aggregate significantly larger resources for defense purposes than have the member nations of the Warsaw Treaty Organization."

Congress also noted, however, that "despite this fact, the Warsaw Treaty Organization member nations have produced and deployed many more major combat items such as tanks, armored personnel carriers, artillery pieces and rocket launchers, armed helicopters and tactical combat aircraft than have the member nations of NATO." The major reason cited for this problem was "inadequate cooperation among NATO nations in research, development and production of military end-items of equipment and munitions." The NATO Cooperative Research and Development Program was established to help address this deficiency.

Two new initiatives to focus increased attention on the enhancement of U.S. and allied conventional defense capabilities were established by the Congress in 1987. The Conventional Defense Initiative was created "to provide an emphasis on improving the conventional weapons of the armed forces (and the testing of such weapons) and to enhance cooperation with the other member nations of the North Atlantic Treaty Organization." This latter objective is also being promoted by the NATO Cooperative Research and Development Program just described.

The Balanced Technology Initiative was created to provide additional support for the development of "promising new technologies that could substantially advance our conventional defense capabilities." The two initiatives are intended to be complementary efforts that provide both near-term and long-term contributions to the effectiveness of conventional forces — But I will focus on the Balanced Technology Initiative, the larger of the two.

Responsibility for the development of program details for the Balanced Technology Initiative was assigned to the defense research and engineering organization. Appropriated funds — $200 million for fiscal 1987 — were directed to be used to "expand research on innovative concepts and methods of enhancing conventional defense capabilities" and for related research to facilitate

"restoration of the conventional defense technology base." A detailed and substantive Balanced Technology Initiative Program Plan was developed under the direction of the deputy under secretary of defense for research and advanced technology, consistent with those directives. I will briefly address the Balanced Technology Initiative program planning process, describe the program in some detail and attempt to relate the comprehensive technology development efforts included in the program to existing warfighting doctrines, in particular the air-land battle doctrine of the Army and the Air Force and the Navy maritime strategy.

Program Planning Process

Candidate projects for the Balanced Technology Initiative Program suggested by technical experts from a number of Office of the Secretary of Defense organizations and the military services covered a broad range of advanced weapons concepts and important technology-base work. Candidate project areas suggested by the Strategic Defense Initiative Organization were presented as technology spinoff opportunities with clear relevance for conventional defense problems. These suggestions involved work in the areas of hypervelocity guns and projectiles, high-power microwaves, and advanced seekers and sensors, for example.

Overall, approximately 250 candidate projects were considered in a review process that followed a "bottoms-up" approach that emphasized operational need and potential payoff. Guidelines were developed to aid in the evaluation and selection process. Projects were required to be consistent with the stated intent of Congress in establishing the initiative.

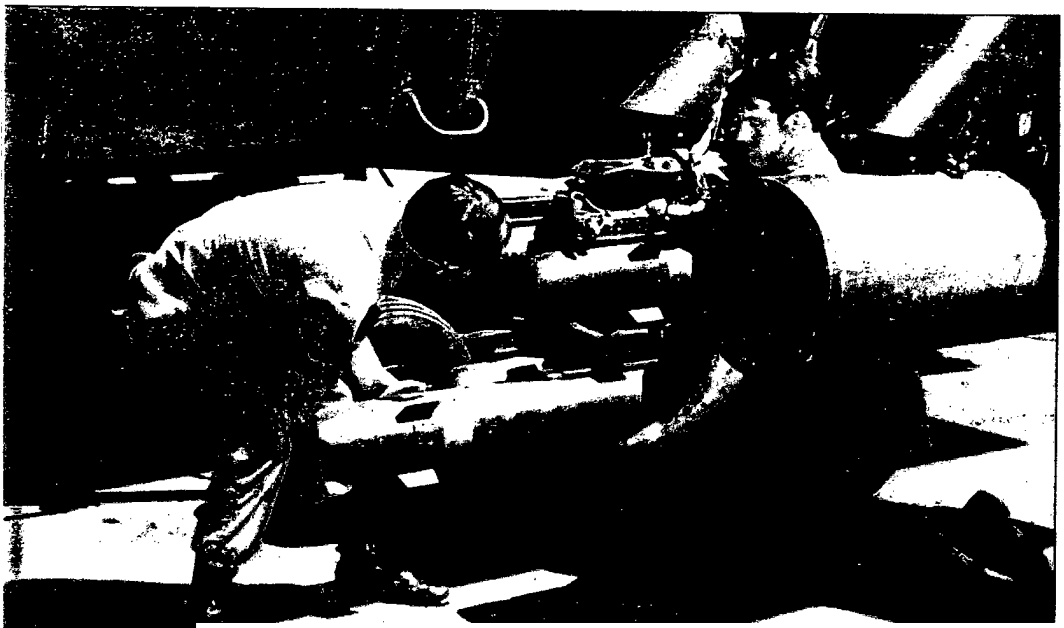
Emphasis was given to technology areas that addressed recognized critical conventional-force needs: Chemical, biological defense and nuclear programs were generally excluded. Projects offering both near-term and longer-term potential for enhancing conventional-force capabilities were also emphasized. Preferred candidates were projects complementary to ongoing work that offered the possibility of high payoff in military effectiveness through additional funding. Joint programs (e.g., Defense Advanced Research Projects Agency/Services, multiservice or involving international cooperation) were encouraged. Finally, emphasis was given to projects supporting a limited number of thrust areas for the overall program. The intent of this guideline was to assure that the Balanced Technology Initiative Program could "make a difference" in a few technology areas critical to conventional-defense missions.

The comprehensive program plan developed following this approach embraces five thrust areas, which include smart-weapons technology; reconnaissance, surveillance and target acquisition/battle-management communications, command and control technology; armor/anti-armor technology; high-power microwaves; and a fifth program category called special technology opportunities.

Smart-Weapons Technology

The overall objective of work included in this area is to accelerate the growth of technologies critical to the development of next- and future-generation fire-and-forget, autonomous weapons required for a broad range of ground, sea and air engagements by conventional forces. The development of improved target-acquisition, identification and hit capabilities, together with enhanced target-prioritization schemes, represents a giant step toward overcoming the troublesome quantitative superiority of Soviet and Warsaw Pact forces in Europe.

These enhancements in conventional-defense capabilities also provide significant and credible force-multiplier potential for both short-and longer-range engagements. The projects included in this category address problems related to the development of advanced sensors and seekers, autonomous guidance and automatic target recognition and the producibility of smart-weapons components.



The Hellfire missile, shown here being strapped to an AH-64 Apache helicopter, is being developed as a ground-launched system, part of the effort to make U.S. conventional forces more effective. This effort complements that of the longer-term efforts of the Balanced Technology Initiative, which is designed to create support for more promising technologies for those same forces.

Advanced sensor and seeker work includes projects involving millimeter-wave, infrared and laser technologies. Millimeter-wave seeker technology is important in developing affordable standoff weapons having autonomous guidance and precision accuracy useful (under all weather conditions) in attacking mobile and fixed air-defense units, as well as battlefield and second-echelon massed armor. Development of high-performance infrared seekers will provide an improved capability to intercept attacking missiles and aircraft at extended ranges by hypersonic missiles.

Balanced Technology Initiative work to develop a dual-mode infrared/laser seeker will improve targeting capabilities for a variety of advanced munitions and existing weapon systems that could be improved using such a seeker include Maverick, Hellfire and Copperhead.

BTI projects related to autonomous guidance and automatic target recognition are also directed toward precision targeting. Work by the Air Force will focus on standoff delivery of advanced munitions to high-value fixed targets and will include further development and testing of a simple preprogrammed target system for initial target acquisition and terminal guidance. Development of a number of critical aspects of air technology will be vigorously pursued by the Defense Advanced Research Projects Agency to establish the full potential and possible limitations of air systems required for virtually all second-generation smart weapons.

This work is also part of a project to develop an advanced sensor-fuzed weapon thought to offer significant potential in attacking high-value, deep-battle targets that are mobile or relocatable. Such targets, which include tactical surface-to-surface missile launchers and air-defense batteries, are difficult to engage with conventional weapons because of the difficulty in establishing their precise location. The effective use of reconnaissance and surveillance data, together with increased target search area capabilities compared to present-day sensor-fuzed weapons, can overcome this problem. Significant cost advantages may also be realized because sensor-fuzed munitions are inherently simpler than the precision-guided, lock-on-after-launch submunitions currently in development. Other work to develop guided tactical hypervelocity projectiles and fire-control technology will also enhance our ability to strike and destroy military targets at extended ranges, a significant advantage in conventional warfare. Targets of principal interest include tanks, aircraft and other air targets — tactical ballistic missiles and cruise missiles.

Other projects in the smart-weapons-technology category address issues related to the producibility of critical systems components. One Defense Advanced Research Projects Agency project will investigate new methods for producing infrared detectors and detector arrays and seek to alleviate the current signal-processing-component complexity of infrared focal plane arrays. These advanced sensors can provide for greatly enhanced target acquisition and recognition capabilities in a variety of smart weapons, reconnaissance and surveillance systems. Another project of the agency will investigate the application of expert systems technology to the cost-effective manufacture of reliable smart-weapons components. To enhance U.S. conventional defense capabilities, smart weapons must be deployed in sufficient quantities to assure preparedness, promote deterrence and provide for an effective and sustained response as required to meet critical mission objectives. This can happen only if the costs of smart weapons are reduced to levels significantly below those incurred in manufacturing today's coimplex weapons.

RSTA/BMC³ Technology

The overall objective of the reconnaissance surveillance and target acquisition/battle-management communications, command and control technology thrust area is to advance the state-of-the-art in information and communications technologies important to the successful implementation of current and future concepts for effective conventional-force engagements, including the Army and Air Force air-land battle doctrine, the Army 21 concept — a future version of air-land battle doctrine and the Navy maritime strategy. Detailed information on enemy force deployment and movement, timely and reliable communication of that information to field commanders, thorough coordination of responsive operations for maximum economy of force and precise targeting of enemy assets are required. Associated technological demands cover a broad spectrum of sensor performance, signal processing and communications systems requirements. The projects included in this category address a wide range of technical issues related to surveillance, targeting and information management.

The principal surveillance activity is an undersea surveillance project that involves expansion of important Navy work in this area. The work will supplement and accelerate ongoing submarine-surveillance investigations included in a recently initiated advanced anti-submarine warfare development program. Significant improvements in U.S. submarine-detection capabilities are needed to maintain an anti-submarine warfare advantage based on large-area surveillance rather than on the use of expensive, short-range tactical sensors.

Two other surveillance projects are important to ground forces. One involves surveillance of enemy tactical ballistic-missile units to

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An A-10 Thunderbolt II aircraft is checked out by technicians following a flight from Villabranca Air Base near Verona, Italy. Some 70 percent of the current DoD science and technology program is concerned with technologies important to conventional defense, including the fields of aeronautics, propulsion, structures, materials and weapons design.

provide information pertaining to readiness and possible intent. This work is of critical importance because of the serious threat tactical missiles pose to U.S. and allied forces in Europe. The second such project accelerates Army development of the Digital Topographic Support System. This system is intended to expedite the availability of accurate, up-to-date, meaningful terrain data to field commanders, who must rely on such information to conduct effective battlefield operations. This information provides for the identification of possible air and ground avenues of approach for both friendly and enemy forces, mobility corridors for different types of ground combat vehicles, river-crossing sites, air-drop zones and likely locations for command and control centers — high-value targets.

Several projects in this category address targeting problems. Work by the Navy will involve assessment of an advanced sensor system to detect postulated future threat anti-ship missiles. An aided target-recognition project will be conducted by the Army to develop an improved understanding of target-recognition phenomenology and technical issues critical to the development of militarily useful aided target recognition systems.

This effort is related to the development of man-in-the-loop target recognition systems for weapons-delivery platforms. Navy work to develop a fiber-optic data link for air-launched weapons will seek to improve air-to-surface delivery of advanced munitions by eliminating a number of problems characteristic of current radio-frequency weapon data links: high cost, susceptibility to jamming, platform location broadcasting and pod drag.

In the area of information management, one project in this category involves Army work to develop an integrated, synchronized, data-linked information system to automate many important command and control functions for ground combat vehicles. This work is intended to improve force coordination and overall warfighting effectiveness at battalion, company and platoon levels. Yet another project supports Defense Advanced Research Projects Agency/Navy development of optical signal processing technology, which may help us develop greatly improved capabilities for handling the extremely high data rates required for operation of complex battle-management communications, command and control and weapon systems of the future. Throughput rates for optical processors may be 1,000 to 10,000 times faster than those of their electronic counterparts.

Armor/Anti-Armor Technology

The overall objectives in the armor/anti-armor technology thrust area are to increase the survivability of U.S. ground combat forces through the continuing development of advanced armor systems and to develop improved weapons to engage and defeat enemy land combat vehicles and other important targets. Soviet and Warsaw Pact forces possess a potentially overwhelming numerical superiority that to date has been offset to some extent by a U.S./NATO technological advantage. Maintaining this advantage is becoming increasingly difficult in the face of continuing improvements in Soviet

capabilities. Extensive ongoing armor/anti-armor work seeks to counter these Soviet advances, but much additional work is needed to address this serious threat.

Balanced Technology Initiative activities include both system-specific projects and important technology-base activities. There are four principal project areas: advanced guns and projectiles, advanced weapons, mine/countermine technology and materials/phenomenology/modeling.

Advanced guns and projectiles work includes enhanced kinetic-energy weapons, liquid-propellant gun, advanced-composite gun and coilgun technology development projects. All of these projects offer significant potential to improve U.S. and allied anti-armor firepower. The objective of the kinetic-energy weapons work is to develop new, high-performance, kinetic-energy projectiles compatible with present tank guns that can defeat advanced threat armors at extended ranges. Development of liquid propellant and coilgun technologies may also accelerate the achievement of this capability. BTI support for liquid-propellant gun work leverages ongoing Army efforts to develop a 155mm liquid-propellant artillery demonstrator, as well as related work on a 30mm (subscale) anti-armor gun.

In addition to higher projectile velocity, liquid-propellant tank guns may provide other important advantages: Automated firing may be facilitated, vehicle vulnerability might be reduced by remote propellent storage, and battlefield logistics problems may be reduced.

The coilgun technology project involves Army-directed work to evaluate an alternative approach to railguns for more efficient use of electromagnetic energy to achieve very high projectile velocities. The development of coilgun technology to date has been limited.

Possible important future applications for electromagnetic guns include both anti-armor and air-defense missions. The purpose of the advanced-composite gun project is to develop high-performance guns that use advanced ceramic and composite materials in the barrel and breech assembly. Possible benefits, particularly for small- and medium-caliber weapons, include reduced barrel erosion, higher muzzle velocity (achieved through the use of more efficient propellants), greater accuracy, increased rate-of-fire, longer sustained fire and improved longer-range lethality.

In the area of advanced weapons, several projects address the defeat of various hard targets by different means and under different conditions. One effort involves the development of a lightweight, short-range, self-defense, anti-tank weapon that could provide dismounted infantry the capability to fire upon and defeat heavy armor when required for survival in close combat.

Another project supports the development of a ground-launched Hellfire capability that could provide a major boost to the capabilities of Army and Marine Corps light divisions to engage and defeat threat armor and other hard targets.

Work in this area also considers the defeat of certain hard targets at sea. Further development of an advanced torpedo warhead by the Navy is intended to provide significant improvements in lethality against newer classes of Soviet double-hulled submarines.

The timely and effective use of mine and barrier warfare is of critical importance in attriting, delaying and disrupting enemy offensive maneuvers. Since mine warfare is expected to be of increasing importance in future conventional conflicts, two BTI projects address mine and countermine technology development.

The objective of Defense Advanced Research Projects Agency/Army work is to significantly improve the effectiveness and ease of use of future mines and to develop mine-detection technology to allow safe avoidance or neutralization of individual mines or large area minefields. One focus of this effort is on the development of command-and-control links for wide-area, anti-armor, smart mines. Countermine work by the Marine Corps accelerates the ongoing development of the catapault-launched fuel-air explosives amphibious-assault countermine system, which uses fuel-air explosives to detonate mines in the surf zone. Such a system is urgently needed for the conduct of successful, fast-paced, amphibious assaults from Navy surface ships. The catapault-launched fuel-air explosives system is expected to have land mine-clearing utility as well.

Armor/anti-armor work in the materials/phenomenology/modeling area involves three projects. The principal objective of one of these projects (armor materials) is to develop low-cost materials-processing technologies applicable to the manufacture of high-performance ceramics for use in advanced armor systems. A second major objective is to develop an improved understanding of ceramic armor material properties and dynamic fracture associated with ballistic impact.

This latter objective should be enhanced by work in the third area, which involves developing enhanced computation capabilities pertinent to the design and evaluation of advanced weapons.

High-Power Microwaves

The fourth thrust area in the Balanced Technology Initiative Program involves work in the area of high-power microwaves, recognition that complex advanced weapons and other important military assets with sophisticated sensors and electronic components may be extremely sensitive to this type of radiation. High-power microwaves can be produced from a variety of sources adaptable to ground-based or airborne weapon

State-of-the-art information and communications technologies are critical for systems that will help successfully implement current and future concepts for conventional-force engagements (battle-management technology). Ultra-thin sandwich structures known as superlattices — formed here by a process known as molecular beam epitaxy — will be found in those systems.

systems, and weapons based on this technology may become increasingly important in future conventional engagements. However, while limited laboratory studies of high-power-microwave effects on certain weapons systems and components have been conducted, the range and nature of these effects are not well understood. Detailed knowledge of these effects is critical to the development of appropriate hardening techniques, for maintaining proper functionality of advanced weapons and other military equipment and in evaluating potential high-power-microwave weapon concepts.

High-power-microwave work supported by the BTI involves five general areas. In the area of high-power-microwave effects, a systematic and comprehensive investigation will be conducted to develop a detailed effects data base with respect to frequency, intensity and pulse characteristics. High-power-microwave hardening work will explore the development of techniques that are both cost-effective and compatible with system operational characteristics and requirements.

The principal objective of high-power-microwave components development work will be to support simulation and effects-testing activities. These propagation/phenomenology studies are intended to develop an improved quantitative understanding of high-power-microwave propagation, energy transport and failure mechanisms. Finally, a standardized assessment methodology will be established to guide all ongoing U.S. high-power-microwave testing and evaluation activities.

Special Technology Opportunities

A number of additional projects not identifiable with the four major thrust areas described above are also included in the Balanced Technology Initiative Program in a fifth category called special technology opportunities. All have significant potential to enhance conventional-defense capabilities. Representative projects include advanced short take-off/vertical landing technology to provide additional required support for an ongoing NATO cooperative program concerned with the advancement of key technologies pertinent to the development of highly maneuverable and survivable aircraft; enhanced blast munitions to re-evaluate the weapons potential of improved fuel-air explosives for use in certain special-purpose missions such as close air support, mine clearing and destruction of impulse-sensitive targets (e.g., fuel depots, buildings and bunkers); high-temperature superconducting materials to fabricate such materials into thin films and composite forms needed for a broad range of advanced weapons system applications; and tactical missile interceptor technology to develop a surface-to-air, command-guided, highly maneuverable, hit-to-kill interceptor.

One additional example of work in this category is a project called Cruise Missile Advanced Guidance. The objective of this project is to develop precision delivery capabilities for long-range, conventionally armed cruise missiles that might be used to attack a variety of high-value fixed or relocatable targets. Achieving this capability takes on added importance in view of the forthcoming intermediate-range nuclear force reductions in Europe.

Military Utility

The Balanced Technology Initiative is a technology development program; however, the program plan maintains a sharp focus on operational need and potential utility to the armed forces. Technology development alone does not improve the peacekeeping or warfighting capabilities of our military forces. It is the timely, effective implementation of promising new technologies that produces real battlefield benefits. It is thus useful to view the activities of the program in the context of existing U.S. warfighting guides, in particular the air-land battle doctrine of the Army and the Air Force and Navy maritime strategy.

Air-land battle doctrine embodies battle tactics developed primarily for conventional conflict in Europe. It recognizes that in any major future European conflict, U.S. and allied forces must be prepared —

and able — to fight outnumbered and win. Basic elements of air-land battle include initiative, agility, depth and synchronization. These elements are, of necessity, interrelated. In a clearer sense, what is required is the development of a fluid defense at the forward line of troops; highly mobile forces over the range of the larger battlefield; an emphasis on counterattack capabilities, including the ability to maneuver in depth; the use of accurately delivered, concentrated firepower (e.g., from artillery, aircraft and deep-battle weapons) to split the tactical and operational levels of war; and correlated/coordinated air and ground actions.

The BTI Program can impact all of these areas. Efforts involving Digital Topographic Support System development, aided and automatic target recognition, an advanced data link, combat vehicle command and control and advanced close-air-support technology may all contribute to improved force agility and more effective control of the flow of battle. Force mobility over greater distances will be enhanced by improvements in communications and surveillance systems and by the accelerated development of new methods for mine-clearing.

BTI efforts related to improving counterattack capabilities for United States conventional forces include much of the work in the smart-weapons program category: advanced sensors and seeker projects, projects involving autonomous guidance and aided target recognition technology, the long-range sensor-fuzed weapon project and work to develop guided tactical hypervelocity projectiles. Counterattack capabilities will be enhanced through developments in the areas of advanced guns and kinetic-energy weapons, as well as through work on advanced on- and off-route mines that can greatly restrict enemy freedom of action. Many of the just-mentioned smart-weapons-technology development activities apply equally well in facilitating effective delivery of both short- and long-range ordnance. Effective firepower is critical to seizing the initiative by frustrating enemy commitment to a planned course of action.

Principles of naval warfare represented in the Navy maritime strategy cover three phases. Phase I addresses deterrence and the transition to war and is characterized by forward deployment of naval forces worldwide, with aggressive positioning of anti-submarine warfare elements. Phase II involves seizing the initiative. Dominance is sought through forceful engagement of enemy submarine, surface and air assets, together with amphibious action, mining and mine-clearing as needed. Phase III continues the destruction of enemy vessels and other military targets, employs amphibious assault forces to regain territory and provides available carrier air strength to support the land war.

The principal contribution of the BTI Program to Phase I of the maritime strategy is through support for expanded work in the area of undersea surveillance. Knowledge of the locations and movements of enemy submarines improves our overall defense posture, thereby reducing the risk of war, but also promotes an effective, rapid response to open hostilities. Successful implementation of Phases II and III requires effective anti-submarine warfare actions, surface-ship and submarine self-protection capabilities, lethal and accurate weapons to strike at enemy targets and materiel to support amphibious operations. Relevant BTI Program work includes efforts to develop improved torpedo warheads, a submarine anti-torpedo weapon, high-energy lasers for ship defense against cruise missiles and tactical ballistic missiles, advanced target-acquisition capabilities for ship defense, the catapault-launched fuel-air explosives surf zone mine-clearing system and many smart-weapons projects.

The Balanced Technology Initiative is an important new element of the DoD science and technology program, which already includes much work pertinent to the future needs of conventional forces. However, the program affords an unparalleled opportunity to expand technology development work in areas critical to the successful conduct of conventional defense missions.

It only remains for us to expand and exploit those opportunities we have already seized.

William E. Snowden

Prior to assuming his present position in June 1986, Dr. Snowden served for seven years (1979–1986) at the Lawrence Livermore National Laboratory, Calif. His service there was interrupted by a stint as program manager, armor anti-armor, at the Defense Advanced Research Projects Agency (April 1984 to June 1985). His recent service at Livermore was as program manager, advanced strategic systems; earlier he had been a staff scientist at the laboratory. He holds a BS degree in ceramic engineering from Alfred University (1969) and MS and PhD degrees in engineering science from the University of California at Berkley.

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