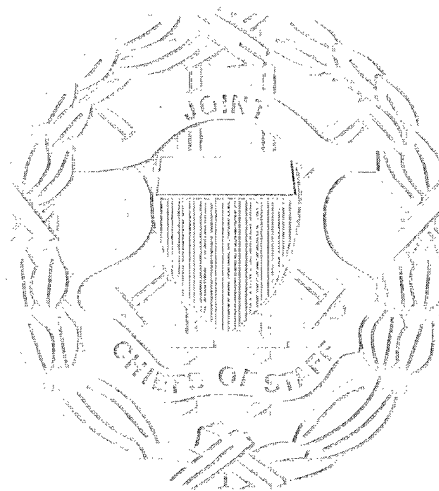
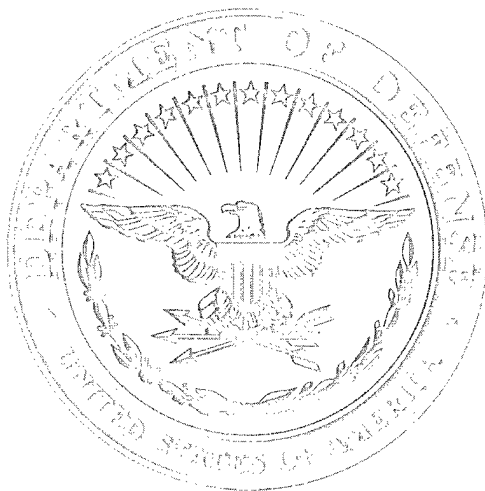




19970401 123

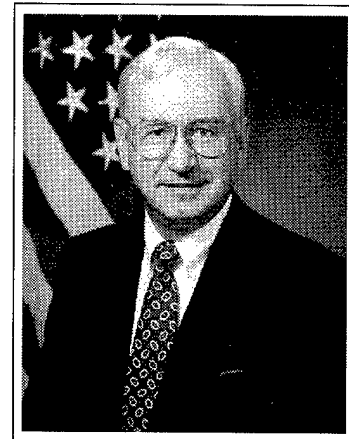
RESTRICTED, CONFIDENTIAL

Approved for public release;
Distribution Unlimited



OFFICE OF THE SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301



Today's national security environment requires that the Armed Forces of the United States fight as a joint force. This requires advanced technology and concepts to capitalize on joint warfare principles and fight effectively as a true joint force; not as a combination of air, land, and naval forces. It is the responsibility of the defense acquisition community to ensure that our future forces have the combat edge provided by technologically superior weapons. With the current emphasis on joint warfare, it is essential that we pursue a focused, high quality, aggressive science and technology program to maintain this edge for the joint warfighter.

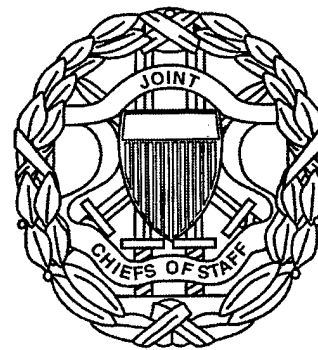
This second edition of the *Joint Warfighting Science and Technology Plan* embodies many of the refinements we have made to our science and technology strategic planning process to ensure that we are responsive to our customers. It has identified ten joint warfighting capability objectives critical to our future forces. This plan takes a horizontal perspective across the technology development and advanced concept technology demonstrations, of the Military Services and Defense Agencies. It presents an integrated approach to the development of technology required to achieve the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010*.

This Plan is the joint product of the Office of the Secretary of Defense, the Joint Staff, the Military Services and the Defense Agencies. The Joint Requirements Oversight Council has reviewed and endorsed the Joint Warfighting Capability Objectives upon which this plan is based. It is responsive to Section 270 of the National Defense Authorization Act for Fiscal Year 1997 which requires the annual submission of a plan for ensuring that the DoD S&T program supports joint warfighting requirements.

JOSEPH W. RALSTON
General, USAF
Vice Chairman
Joint Chiefs of Staff

PAUL G. KAMINSKI
Under Secretary of Defense
(Acquisition and Technology)

Joint Warfighting Science and Technology Plan



January 1997

**DEPARTMENT OF DEFENSE
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING**

CONTENTS

I.	INTRODUCTION	I-1
II.	VISION AND STRATEGY	II-1
	A. Joint Vision 2010	II-1
	B. Joint Warfighting Capability Objective	II-1
	C. Joint Warfighting Capability Assessments	II-4
	D. S&T Strategic Planning Process	II-4
III.	TRANSITION OF TECHNOLOGY TO THE JOINT WARFIGHTER ..	III-1
	A. Advanced Technology Demonstrations	III-1
	B. Advanced Concept Technology Demonstrations	III-1
	C. Joint Warfighting Experiments	III-7
IV.	ACHIEVING JOINT WARFIGHTING CAPABILITY OBJECTIVES ..	IV-1
	A. Information Superiority	IV-A-1
	1. Definition	IV-A-1
	2. Operational Capability Elements	IV-A-1
	3. Functional Capabilities	IV-A-5
	4. Current Capabilities, Deficiencies, and Barriers	IV-A-9
	5. Technology Plan	IV-A-10
	6. Summary	IV-A-25
	B. Precision Force	IV-B-1
	1. Definition	IV-B-1
	2. Operational Capability Elements	IV-B-2
	3. Functional Capabilities	IV-B-3
	4. Current Capabilities, Deficiencies, and Barriers	IV-B-3
	5. Technology Plan	IV-B-7
	6. Summary	IV-B-15
	C. Combat Identification	IV-C-1
	1. Definition	IV-C-1
	2. Operational Capability Elements	IV-C-1
	3. Functional Capabilities	IV-C-4
	4. Current Capabilities, Deficiencies, and Barriers	IV-C-5
	5. Technology Plan	IV-C-10
	6. Summary	IV-C-14
	D. Joint Theater Missile Defense	IV-D-1
	1. Definition	IV-D-1
	2. Operational Capability Elements	IV-D-2
	3. Functional Capabilities	IV-D-2
	4. Current Capabilities, Deficiencies, and Barriers	IV-D-4

5. Technology Plan	IV-D-8
6. Summary	IV-D-12
E. Military Operations in Urban Terrain (MOUT)	IV-E-1
1. Definition	IV-E-1
2. Operational Capability Elements	IV-E-1
3. Functional Capabilities	IV-E-3
4. Current Capabilities, Deficiencies, and Barriers	IV-E-5
5. Technology Plan	IV-E-10
6. Summary	IV-E-15
F. Joint Readiness and Logistics	IV-F-1
1. Definition	IV-F-1
2. Operational Capability Elements	IV-F-3
3. Functional Capabilities	IV-F-4
4. Current Capabilities, Deficiencies, and Barriers	IV-F-7
5. Technology Plan	IV-F-13
6. Summary	IV-F-22
G. Joint Countermine	IV-G-1
1. Definition	IV-G-1
2. Operational Capability Elements	IV-G-1
3. Functional Capabilities	IV-G-3
4. Current Capabilities, Deficiencies, and Barriers	IV-G-3
5. Technology Plan	IV-G-8
6. Summary	IV-G-15
H. Electronic Combat	IV-H-1
1. Definition	IV-H-1
2. Operational Capability Elements	IV-H-1
3. Functional Capabilities	IV-H-3
4. Current Capabilities, Deficiencies, and Barriers	IV-H-4
5. Technology Plan	IV-H-10
6. Summary	IV-H-13
I. Chemical/Biological Warfare Defense and Protection	IV-I-1
1. Definition	IV-I-1
2. Operational Capability Elements	IV-I-1
3. Functional Capabilities	IV-I-6
4. Current Capabilities, Deficiencies, and Barriers	IV-I-6
5. Technology Plan	IV-I-11
6. Summary	IV-I-14
J. Counter Weapons of Mass Destruction	IV-J-1
1. Definition	IV-J-1
2. Operational Capability Elements	IV-J-2
3. Functional Capabilities	IV-J-3
4. Current Capabilities, Deficiencies, and Barriers	IV-J-4
5. Technology Plan	IV-J-5
6. Summary	IV-J-9

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

REFERENCES

FIGURES

I-1	Science and Technology Strategic Planning	I-2
II-1	The Concept of <i>Joint Vision 2010</i>	II-2
II-2	Joint Warfighting Capability Objectives Funding, Fiscal Year 1998	II-7
II-3	DTO Share of Defense 6.2 and 6.3 Investment	II-7
II-4	Technology Area Review and Assessment Process	II-9
IV.A-1	Concept—Information Superiority	IV-A-2
IV.A-2	Concept—Information Warfare	IV-A-3
IV.A-3	Technology to Capability—Information Superiority	IV-A-22
IV.A-4	Roadmap—Information Superiority, Battlespace Awareness Capability Area	IV-A-23
IV.A-5	Roadmap—Information Superiority, Effectiveness Employment of Forces and The Grid Capability Areas	IV-A-24
IV.A-6	Progress—Information Superiority	IV-A-26
IV.B-1	Concept—Precision Force	IV-B-1
IV.B-2	Technology to Capability—Precision Force	IV-B-8
IV.B-3	Roadmap—Precision Force	IV-B-11
IV.B-4	Progress—Precision Force	IV-B-15
IV.C-1	Concept—Combat Identification	IV-C-1
IV.C-2	Technology to Capability—Combat Identification	IV-C-11
IV.C-3	Roadmap—Combat Identification	IV-C-13
IV.C-4	DTO Progress—Combat Identification	IV-C-15
IV.D-1	Concept—Joint Theater Missile Defense	IV-D-1
IV.D-2	Technology to Capability—Joint Theater Missile Defense	IV-D-9
IV.D-3	Roadmap—Joint Theater Missile Defense	IV-D-13
IV.D-4	Progress—Joint Theater Missile Defense	IV-D-14
IV.E-1	Concept—Military Operations in Urban Terrain	IV-E-3
IV.E-2	Technology to Capability—Military Operations in Urban Terrain	IV-E-11
IV.E-3	Roadmap—Military Operations in Urban Terrain	IV-E-14
IV.E-4	Progress—Military Operations in Urban Terrain	IV-E-16
IV.F-1	Concept—Joint Readiness and Logistics	IV-F-2
IV.F-2	Logistics Pipeline	IV-F-12
IV.F-3	Technology to Capability—Joint Readiness	IV-F-15
IV.F-4	Roadmap—Joint Readiness	IV-F-17
IV.F-5	Technology to Capability—Real-Time Focused Logistics	IV-F-20
IV.F-6	Roadmap—Real-Time Focused Logistics	IV-F-23
IV.F-7	Progress—Joint Readiness	IV-F-24
IV.F-8	Progress—Real-Time Focused Logistics	IV-F-25
IV.G-1	Concept—Joint Countermine	IV-G-2
IV.G-2	Technology to Capability—Joint Countermine	IV-G-9
IV.G-3	Roadmap—Joint Countermine	IV-G-13

IV.G-4	Progress—Joint Countermine	IV-G-17
IV.H-1	Concept—Electronic Combat	IV-H-2
IV.H-2	Technology to Capability—Electronic Combat	IV-H-11
IV.H-3	Roadmap—Electronic Combat	IV-H-14
IV.H-4	Progress—Electronic Combat	IV-H-15
IV.I-1	Concept—Chemical/Biological Warfare Defense and Protection	IV-I-1
IV.I-2	Technology to Capability—Chemical/Biological Warfare Defense and Protection	IV-I-3
IV.I-3	Roadmap—Chemical/Biological Warfare Defense and Protection	IV-I-13
IV.I-4	Progress—Chemical/Biological Warfare Defense and Protection	IV-I-14
IV.J-1	Concept—Counter Weapons of Mass Destruction	IV-J-2
IV.J-2	Technology to Capability—Counter Weapons of Mass Destruction	IV-J-6
IV.J-3	Roadmap—Counter Weapons of Mass Destruction	IV-J-8

TABLES

II-1	Joint Warfighting Support of <i>Joint Vision 2010</i>	II-2
II-2	Relationship Between Joint Warfighting Capability Assessment Areas and Joint Warfighting Capability Objectives	II-5
IV.A-1	Functional Capabilities Needed—Information Superiority	IV-A-6
IV.A-2	Goals, Limitations, and Technologies—Information Superiority	IV-A-11
IV.A-3	Defense Technology Objectives—Information Superiority	IV-A-18
IV.A-4	Demonstration Support—Information Superiority	IV-A-19
IV.B-1	Functional Capabilities Needed—Precision Force	IV-B-4
IV.B-2	Goals, Limitations, and Technologies—Precision Force	IV-B-5
IV.B-3	Defense Technology Objectives—Precision Force	IV-B-9
IV.B-4	Demonstration Support—Precision Force	IV-B-10
IV.C-1	Functional Capabilities Needed—Combat Identification	IV-C-4
IV.C-2	Goals, Limitations, and Technologies—Combat Identification	IV-C-9
IV.C-3	Defense Technology Objectives—Combat Identification	IV-C-12
IV.C-4	Demonstration Support—Combat Identification	IV-C-12
IV.D-1	Functional Capabilities Needed—Joint Theater Missile Defense	IV-D-3
IV.D-2	Goals, Limitations, and Technologies—Joint Theater Missile Defense ...	IV-D-6
IV.D-3	Defense Technology Objectives—Joint Theater Missile Defense	IV-D-9
IV.D-4	Demonstration Support—Joint Theater Missile Defense	IV-D-10
IV.E-1	Functional Capabilities Needed—Military Operations in Urban Terrain ..	IV-E-4
IV.E-2	Goals, Limitations, and Technologies—Military Operations in Urban Terrain	IV-E-6
IV.E-3	Defense Technology Objectives—Military Operations in Urban Terrain ..	IV-E-12
IV.E-4	Demonstration Support—Military Operations in Urban Terrain	IV-E-12
IV.F-1	Functional Capabilities Needed—Joint Readiness	IV-F-5
IV.F-2	Functional Capabilities Needed—Real-Time Focused Logistics	IV-F-5
IV.F-3	Goals, Limitations, and Technologies—Joint Readiness	IV-F-8
IV.F-4	Goals, Limitations, and Technologies—Real-Time Focused Logistics ...	IV-F-10
IV.F-5	Defense Technology Objectives—Joint Readiness	IV-F-13
IV.F-6	Demonstration Support—Joint Readiness	IV-F-14
IV.F-7	Defense Technology Objectives—Real-Time Focused Logistics	IV-F-18
IV.F-8	Demonstration Support—Real-Time Focused Logistics	IV-F-19
IV.G-1	Functional Capabilities Needed—Joint Countermine	IV-G-4
IV.G-2	Goals, Limitations, and Technologies—Joint Countermine	IV-G-5
IV.G-3	Defense Technology Objectives—Joint Countermine	IV-G-10
IV.G-4	Demonstration Support—Joint Countermine	IV-G-11
IV.H-1	Functional Capabilities Needed—Electronic Combat	IV-H-3
IV.H-2	Goals, Limitations, and Technologies—Electronic Combat	IV-H-5
IV.H-3	Defense Technology Objectives—Electronic Combat	IV-H-12
IV.H-4	Demonstration Support—Electronic Combat	IV-H-13

IV.I-1	Functional Capabilities Needed—Chemical/Biological Warfare Defense and Protection	IV-I-7
IV.I-2	Goals, Limitations, and Technologies—Chemical/Biological Warfare Defense and Protection	IV-I-8
IV.I-3	Defense Technology Objectives—Chemical/Biological Warfare Defense and Protection	IV-I-11
IV.I-4	Demonstration Support—Chemical/Biological Warfare Defense and Protection	IV-I-12
IV.J-1	Functional Capabilities Needed—Counter Weapons of Mass Destruction	IV-J-3
IV.J-2	Goals, Limitations, and Technologies—Counter Weapons of Mass Destruction	IV-J-4
IV.J-3	Defense Technology Objectives—Counter Weapons of Mass Destruction	IV-J-7
IV.J-4	Demonstration Support—Counter Weapons of Mass Destruction	IV-J-7
IV.J-5	Counter-WMD Counterforce Program Enhancements	IV-J-9

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Technological superiority has been, and continues to be, a cornerstone of our national military strategy. Technologies such as radar, jet engines, nuclear weapons, night vision, smart weapons, stealth, the Global Positioning System, and vastly more capable information management systems have changed warfare dramatically. Today's technological edge allows us to prevail across the broad spectrum of conflict decisively and with relatively low casualties. Maintaining this technological edge has become even more important as the size of U.S. forces decreases and high-technology weapons are now readily available on the world market. In this new environment, it is imperative that U.S. forces possess technological superiority to achieve and maintain the dominance displayed in Operation Desert Storm. The technological advantage we enjoy today is a legacy of decades of investment in science and technology (S&T). Likewise, our future warfighting capabilities will be substantially determined by today's investment in S&T.

The Director, Defense Research and Engineering (DDR&E), has strengthened the S&T strategic planning process to improve the S&T community's responsiveness to their warfighting and acquisition customers. Critical to this process is the *Defense Science and Technology Strategy* (Reference 1) with its supporting *Basic Research Plan* (BRP) (Reference 2), *Defense Technology Area Plan* (DTAP) (Reference 3), and this *Joint Warfighting Science and Technology Plan* (JWSTP). These documents present the DoD S&T vision, strategy, plan, and objectives for the planners, programmers, and performers of defense S&T. These documents are a collaborative product of the Office of the Secretary of Defense (OSD), Joint Staff, military services, and defense agencies. The strategy and plans are fully responsive to the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* (JV 2010) (Reference 4) and the National Security Science and Technology Council's (NSTC's) *National Security Science and Technology Strategy* (Reference 5), as shown in Figure I-1. These documents and the supporting individual S&T master plans of the military services and defense agencies guide the annual preparation of the DoD budget and program objective memorandums (POMs). The strategy and plans are made available to the U.S. Government, defense contractors, and our allies with the goal of better focusing our collective efforts on superior joint warfare capabilities and improving interoperability between the United States and our allies.

Defense Science and Technology Strategy (Reference 1). The *Defense Science and Technology Strategy* is responsive to the Secretary of Defense's vision to "develop and transition superior technology to enable affordable, decisive military capability." The overall S&T strategy is to "address the joint warfighters' stated needs, maintain a broad-based program spanning all defense-relevant sciences and technologies to anticipate future needs, support the unique needs of the military Departments, preserve long-range research, and do it within limited budgets." The strategy focuses on four generic considerations that have high priority in making strategic decisions about which technologies are pursued:

- *Affordability.* Where appropriate, S&T projects must focus on increasing the effectiveness of a capability and decreasing cost, increasing operational life, and incrementally improving material through planned upgrades.

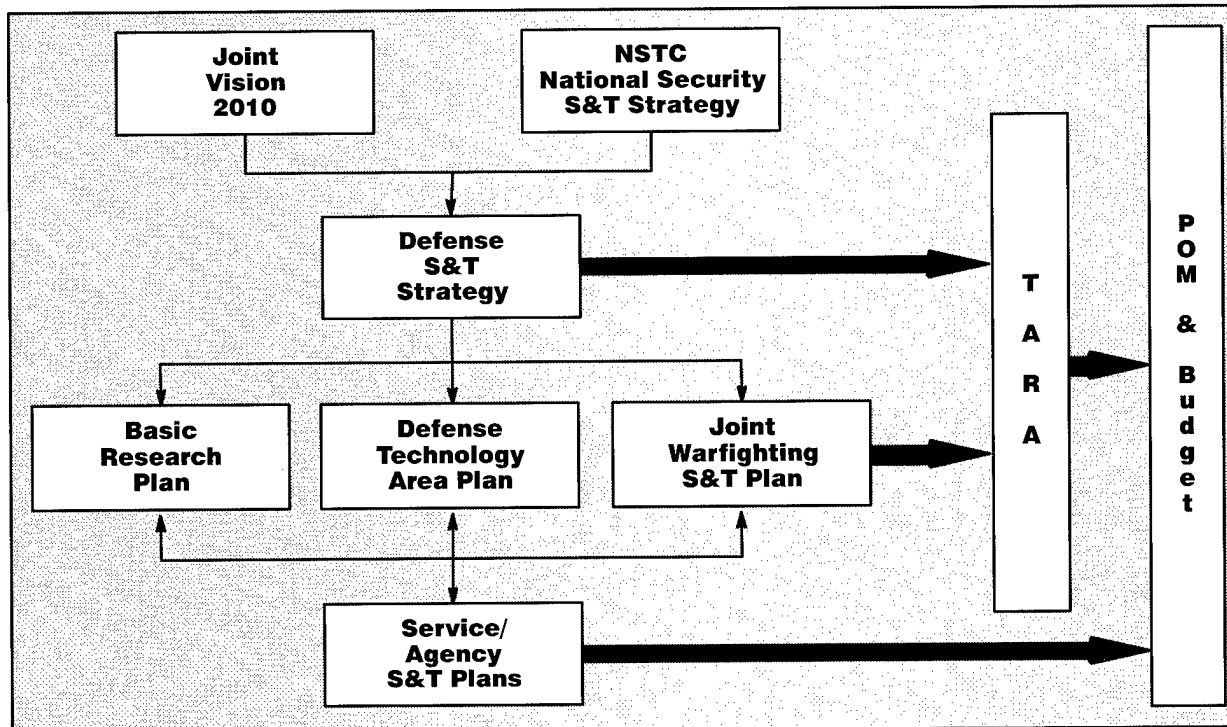


Figure I-1. Science and Technology Strategic Planning

- *Dual Use.* The S&T program must contribute to building a common industrial base by using commercial practices, processes, and products, and by developing, where possible, technology that can be the base for both military and commercial products and applications.
- *Accelerated Transition.* Advanced Concept Technology Demonstrations (ACTDs) are a key element in the S&T program to focus science and technology on supporting military needs and problems, expediting transitions, and providing a sound basis for acquisition decisions.
- *Strong Technology Base.* Basic and applied research generate DoD's legacy to tomorrow's warfighter. Accordingly, it is imperative to maintain a stable technology base investment to develop options for the truly long term—beyond the threats, situations, and budgets that we can predict.

Basic Research Plan (Reference 2). The BRP presents the DoD objectives and investment strategy for DoD-sponsored basic research (6.1) performed by universities, industry, and service laboratories. In addition to presenting the planned investment in each of 12 Basic Research Areas (BRAs) across several technical disciplines composing the basic research program, the plan highlights six strategic research objectives holding great promise for the development of breakthrough technologies for revolutionary 21st century military capabilities:

- Biomimetics
- Mobile wireless communications
- Nanoscience
- Intelligent systems
- Smart structures
- Compact power sources

The coupling of the BRP with the DTAP and the JWSTP is carried out in several ways. First, the planning stage of the 12 individual research areas has the active participation of both the service laboratories and the warfighters (through the operating commands, such as the Army's Training and Doctrine Command (TRADOC)). This activity takes place by providing requirements and, often-times, serving on planning committees that focus on or include basic research. Second, representatives of the service laboratories and operating commands also take part in the program evaluation process through attendance and participation in service S&T program reviews and the ODDR&E Technology Area Reviews and Assessments (TARAs).

Defense Technology Area Plan (Reference 3). The DTAP presents the DoD objectives and the applied research (6.2) and advanced technology development (6.3) investment strategy for technologies critical to DoD acquisition plans, service warfighter capabilities, and the JWSTP. It takes a horizontal perspective across the service and defense agency efforts, thereby charting the total DoD investment for a given technology. The DTAP documents the focus, content, and principal objectives of the overall DoD S&T efforts. This year the DTAP includes a separate annex that provides an assessment of the potential technology capabilities of other countries vis-à-vis the United States.

Joint Warfighting Science and Technology Plan. This JWSTP also takes a joint perspective horizontally across the applied research (6.2) and advanced technology development (6.3) plans of the services and defense agencies, but for a different purpose. Its objective is to ensure that the S&T program supports priority future joint warfighting capabilities. The Joint Requirements Oversight Council (JROC) has endorsed the JWSTP planning process and methodology and the Joint Warfighting Capability Objectives (JWCs) used in the development of the JWSTP. The 10 JWCs are not all inclusive—there are other important joint and service-unique warfighting and operations other than war capabilities that need strong S&T support. Nevertheless the JWCs provide an important focus for the S&T program.

This is the second edition of the *Joint Warfighting Science and Technology Plan*. It will be issued annually as defense guidance. Advanced concepts and technologies identified as enhancing high-priority joint warfighting capabilities, along with prerequisite research, will receive funding priority in the President's Budget and accompanying Future Years Defense Plan (FYDP).

Together, the JWSTP, DTAP, and BRP ensure that the near-, mid-, and far-term needs of the joint warfighter are properly balanced and supported in the S&T planning, programming, budgeting, and assessment activities of DoD.

Defense Technology Objectives (Reference 6). The S&T investment is focused and guided through Defense Technology Objectives (DTOs). Each DTO identifies a specific technology advancement that will be developed or demonstrated, the anticipated date of technology availability, the specific benefits resulting from the technology advance, and the funding required to achieve the new capability. These benefits not only include increased military operational capabilities but also address other important areas, including affordability and dual-use applications, that have received special emphasis in the *Defense Science and Technology Strategy*. JWSTP DTOs are limited to Advanced Technology Demonstrations (ATDs) and Advanced Concept Technology Demonstrations (ACTDs).

CHAPTER II

VISION AND STRATEGY

CHAPTER II

VISION AND STRATEGY

A. JOINT VISION 2010

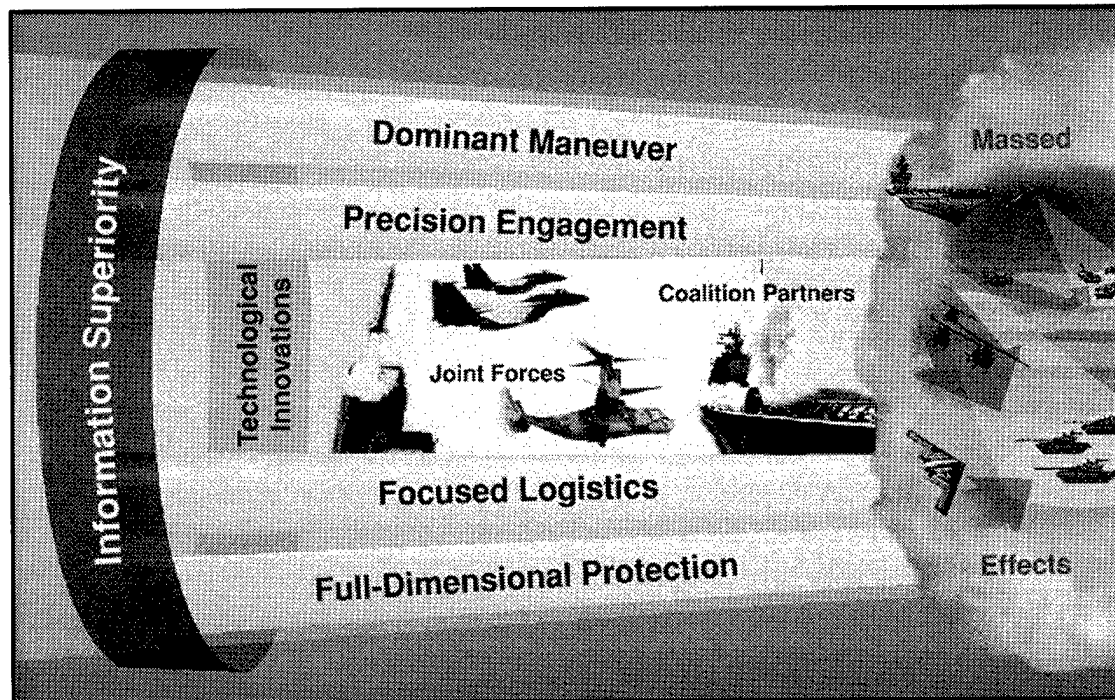
The Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* (JV 2010) (Reference 4) is the conceptual template that provides a common direction to help the military services develop their unique capabilities within a joint framework of doctrine and programs. JV 2010 builds on the enduring foundation of high-quality people and innovative leadership. The traditional concepts of maneuver, strike, protection, and logistics are leveraged with *technological advances* and *information superiority* to produce improvements that are potentially so powerful that they become, in effect, new operational concepts. As shown in Figure II-1, these operational concepts emerge as:

- *Dominant maneuver*—the multidimensional application of information and maneuver capabilities to provide coherent operations of air, land, sea, and space forces throughout the breadth, depth, and height of the battlespace to seize the initiative and control the tempo of the operation to a decisive conclusion.
- *Precision engagement*—the capability to accurately locate the enemy, command and control friendly forces, precisely attack key enemy forces or capabilities, and accurately assess the level of success.
- *Full-dimensional protection*—the capability to protect our forces at all levels and obtain freedom of action while they deploy, maneuver, and engage an adversary.
- *Focused logistics*—the capability to respond rapidly to crises, shift warfighting assets between geographic regions, monitor critical resources en route, and directly deliver tailored logistics at the required level of operations.

These new operational concepts interact to create the powerful, synergistic effect of *full-spectrum dominance*—the capability to dominate an adversary across the full range of military operations. Full-spectrum dominance emerges as a key characteristic of U.S. armed forces for the 21st century.

B. JOINT WARFIGHTING CAPABILITY OBJECTIVE

Achieving *Joint Vision 2010* will, in large measure, depend on the ability to achieve and exploit the 10 Joint Warfighting Capability Objectives (JWCs) described below and discussed in detail in Chapter IV. These objectives, developed by the Joint Staff in collaboration with the Office of the Secretary of Defense (OSD) and the service science and technology executives, represent some of the most critical capabilities for maintaining the warfighting advantage of U.S. forces. The JWCs support the four leveraged operational concepts of full-spectrum dominance, as shown in Table II-1.

Figure II-1. The Concept of *Joint Vision 2010*Table II-1. Joint Warfighting Support of *Joint Vision 2010*

Joint Warfighting Capability Objectives	Joint Vision 2010 Operational Concepts			
	Dominant Maneuver	Precision Engagement	Full-Dimensional Protection	Focused Logistics
A. Information Superiority	●	●	●	●
B. Precision Force	○	●	○	
C. Combat Identification	○	●	●	
D. Joint Theater Missile Defense		●	●	
E. Military Operations in Urban Terrain (MOUT)	●	○	●	
F. Joint Readiness and Logistics	●	○	○	●
G. Joint Countermine	●		●	○
H. Electronic Combat	●	●	○	
I. Chemical/Biological Warfare Defense and Protection	●	○	●	○
J. Counter Weapons of Mass Destruction		●	●	

● Strong Support ○ Moderate Support

Information Superiority combines the capabilities of intelligence, surveillance, and reconnaissance (ISR) and command, control, communications, computers, and intelligence (C⁴I) to acquire and assimilate information needed to dominate and neutralize adversary forces and effectively employ friendly forces. It includes the capability for near-real-time awareness of the location and activity of friendly, adversary, and neutral forces throughout the battlefield area. It also includes a seamless, robust C⁴ network linking all friendly forces to provide common awareness of the current situation throughout the battlefield area. Information superiority encompasses information warfare—that is, the capability to affect an adversary's information, information-based processes, information systems, and computer-based networks while defending one's own information, information-based processes, information systems, and computer-based networks.

Precision Force is the capability to destroy selected targets with precision while limiting collateral damage. It includes precision guided munitions, surveillance, targeting capabilities, and the "sensor-to-shooter" C⁴I capabilities necessary for responsive, timely force application.

Combat Identification is the capability to differentiate potential targets as friend, foe, or neutral in sufficient time, with high confidence, and at the requisite range to support weapon release and engagement decisions.

Joint Theater Missile Defense is the capability to use the assets of multiple services and agencies to detect, track, acquire, and destroy enemy theater ballistic missiles and cruise missiles. It includes the seamless flow of information on missile launches by specialized surveillance capabilities, through tracking by sensors from multiple services and agencies, to missile negation or destruction.

Military Operations in Urban Terrain (MOUT) is the capability to operate and conduct military operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. It includes precise weapons, surveillance, navigation, and communications effective in urban areas.

Joint Readiness and Logistics is the capability to enhance readiness and logistics for joint and combined operations. It includes capabilities for enhanced simulation for training; improved and affordable operations and maintenance (O&M) and life-cycle costs; mobility and sustainability (i.e., transportation support technologies, speed of delivery); and near-real-time visibility of people, units, equipment, and supplies that are in storage, in process, in transit, or in theater, linked with the ability to act on this information.

Joint Countermine is the capability for assured, rapid surveillance, reconnaissance, detection, and neutralization of mines to enable forced entry by expeditionary forces. It includes the capability to control the sea and to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, littoral, and land mines. For land forces, dominance means the ability to conduct in-stride tempo operations in the face of severe land mine threats.

Electronic Combat is the capability to disrupt or degrade an enemy's defenses throughout the area and time required to permit the deployment and employment of U.S. and allied combat systems. It includes the capabilities for deceiving, disrupting, and destroying the surveillance and command and control systems as well as the weapons of an enemy's integrated air defense network; and the capabilities for recognizing attempts by hostile systems to track or engage.

Chemical/Biological Warfare Defense and Protection is the capability for standoff detection of biological agents—our single most pressing need. Capabilities in both point and standoff detection of chemical and biological agents, combined with the ability to assess and disseminate threat information in a timely manner, are critical to protecting fielded forces.

Counter Weapons of Mass Destruction (WMD) is the capability to detect and evaluate the existence of a manufacturing capability for WMD, and to identify and assess the weapon capability of alert and launched WMDs on the battlefield to permit the appropriate level of counterforce to be exerted promptly. It includes counterforce against hardened WMD storage and production facilities.

C. JOINT WARFIGHTING CAPABILITY ASSESSMENTS

The Joint Warfighting Capabilities Assessment (JWCA) process—supported by the unified commanders-in-chief, services, and defense agencies—identifies opportunities for improving warfighting effectiveness. The JWCA must also take into consideration finding affordable S&T solutions to joint warfighting needs. This continuous process provides insights into issues involving joint warfighting requirements, readiness, plans for recapitalization, and support for joint requirements and resource recommendations. The Joint Requirements Oversight Council (JROC), composed of the Vice Chiefs of Staff of the four services and chaired by the Vice Chairman of the Joint Chiefs of Staff, oversees the JWCA process.

The relationship between the 10 JWCA areas and the 10 JWCOs is shown in Table II-2.

D. S&T STRATEGIC PLANNING PROCESS

Oversight. The Director, Defense Research and Engineering (DDR&E), is responsible for the overall direction, quality, and content of the DoD S&T Program. The DDR&E has established an integrated S&T strategic planning process to effectively discharge these responsibilities. This process is accomplished and coordinated through Defense Science and Technology Reliance. Development of the BRP, DTAP, JWSTP, and supporting DTOs is the responsibility of the Defense S&T Reliance Executive Committee (EXCOM). Membership of the EXCOM is shown below:

EXECUTIVE COMMITTEE
Deputy DDR&E, Chairman
Deputy Assistant Secretary of the Army (Research and Technology)
Chief of Naval Research
Deputy Assistant Secretary of the Air Force (Science, Technology, and Engineering)
Deputy Director, Defense Advanced Research Projects Agency
Assistant Deputy Director for Technology, Ballistic Missile Defense Organization
Deputy Director, Defense Special Weapons Agency

Table II-2. Relationship Between Joint Warfighting Capability Assessment Areas and Joint Warfighting Capability Objectives

Joint Warfighting Capability Objectives	JWCA Areas									
	Strike	Land and Littoral Warfare	Strategic Mobility and Sustainability	Sea, Air, and Space Superiority	Deterrence/Counter Proliferation of Weapons of Mass Destruction	Command and Control	Information Warfare	Intelligence, Surveillance, and Reconnaissance	Joint Readiness	Regional Engagement Presence
A. Information Superiority	●	○	○	○	●	●	●	●	○	○
B. Precision Force	●	●		●	●	○		●		
C. Combat Identification	●	●		●		○		○		
D. Joint Theater Missile Defense	○			●	●	●		●		
E. Military Operations in Urban Terrain (MOUT)		●				○		○		
F. Joint Readiness and Logistics			●		○	○	○		●	○
G. Joint Countermine	○	●	●	○		○		○		○
H. Electronic Combat	●			●		●		●		
I. Chemical/Biological Warfare Defense and Protection					●			●		
J. Counter Weapons of Mass Destruction	●				●	○	○	●		

● Strong Support

○ Moderate Support

When significant actions are undertaken, an Expanded EXCOM is convened to ensure the widest possible coordination within the DoD research and development community. The membership of the Expanded EXCOM is shown below:

EXPANDED EXECUTIVE COMMITTEE

EXCOM Chair and Members

Deputy for Chemical/Biological Matters, Office of the Assistant to the Secretary of Defense (Nuclear, Chemical, and Biological Defense Programs)

Deputy Assistant Secretary of Defense for Health Affairs (Clinical Services)

Deputy Under Secretary of Defense for Advanced Technology

Deputy Under Secretary of Defense for Space

Deputy Chief of Staff for Research, Development and Acquisition, Army Materiel Command

Director of Navy Test and Evaluation and Technology Requirements, Office of the Chief of Naval Operations

Deputy for Science and Technology, Air Force Materiel Command

Chairperson, Joint Engineers

Chairperson, Training and Personnel Systems Science and Technology Evaluation Management Committee (TAPSTEM)

The preparation of the JWSTP is also guided by the Joint Warfighting Panel (JWP). The JWP consists of the following members:

JOINT WARFIGHTING PANEL

EXCOM Chair and Members

Deputy Under Secretary of Defense (Advanced Technology)

Director, Force Structure, Resources and Assessment (J-8), Joint Chiefs of Staff

The EXCOM oversees the work of the Defense Committee on Research (DCOR), which is responsible for preparation of the BRP; the 10 technology area panels responsible for preparation of the DTAP; and the 10 JWCO panels responsible for preparation of the JWSTP. These plans build on—but do not duplicate—the service/agency S&T plans. They also consider recent technology forecasts such as OSD's *Revolution in Military Affairs*, the Air Force's *New World Vistas*, the Army's *Force XXI* and *Army After Next*, the Navy's *Navy After Next*, and the Marine Corps' *Sea Dragon* efforts.

To ensure that the integrated S&T planning is responsive to the strategy, the Defense S&T Reliance network has developed the following goals to guide the effort:

- Enhance the quality of Defense S&T activities and develop world-class products.
- Ensure the existence of critical masses of resources
- Reduce redundant S&T capabilities and eliminate unwarranted duplication.
- Gain productivity and efficiency through collocation and consolidation of in-house S&T work.
- Preserve the vital mission-essential capabilities of the services throughout the process.

Defense Technology Objectives. The focus of the S&T investment is enhanced and guided through Defense Technology Objectives (DTOs). Each DTO identifies a specific technology advancement that will be developed or demonstrated, the anticipated date of technology availability, the specific benefits resulting from the technology advance, and the funding planned to achieve the new capability. These benefits not only include increased military operational capabilities but also address other important areas, including affordability and dual-use applications, that have received special emphasis in the *Defense Science and Technology Strategy*. JWSTP DTOs are limited to Advanced Technology Demonstrations (ATDs) and Advanced Concept Technology Demonstrations (ACTDs). A key responsibility of the EXCOM is to review and approve DTOs. The total of approximately 300 DTOs represents 65 percent of the total 6.2 and 6.3 FY98 funding.

The DTOs that support achievement of specific functional and operational capabilities within each JWCO are listed in Chapter IV for each of the 10 JWCOs. Collectively, the JWCOs and the supporting DTOs from the DTAP will receive 28 percent of the 6.2 and 6.3 budgets in FY98. Figures II-2 and II-3 show the funding allocation to the DTOs cited in this JWSTP, those cited in the DTAP, and the remainder of the 6.2- and 6.3-funded program. Not every needed technology program is captured in a DTO. If the entire DoD S&T program were to be defined by DTOs in the

ERRATA SHEET

1997 Joint Warfighting Science and Technology Plan

Page II-6, last line of next-to-last paragraph: *Change 65 percent to 50 percent.*

Page II-7, Figure II-3: *Replace chart with the following revised chart:*

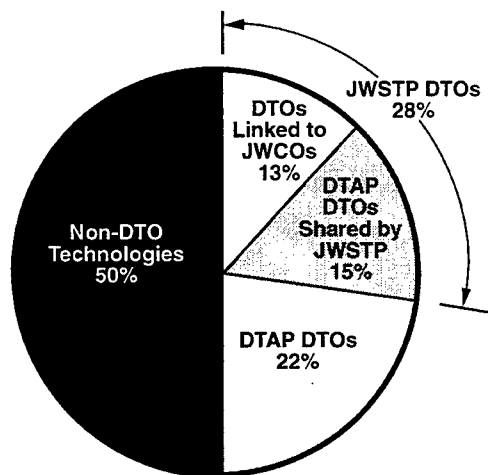


Figure II-3. DTO Share of Defense 6.2 and 6.3 Investment

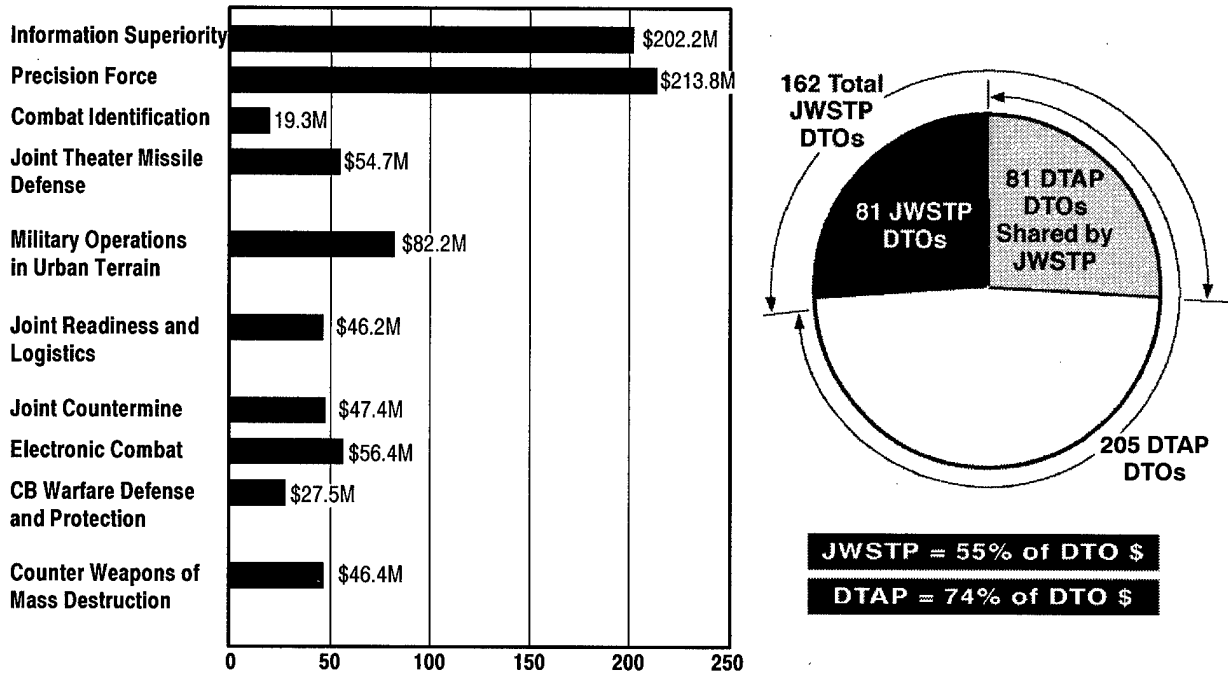


Figure II-2. Joint Warfighting Capability Objectives Funding, Fiscal Year 1998

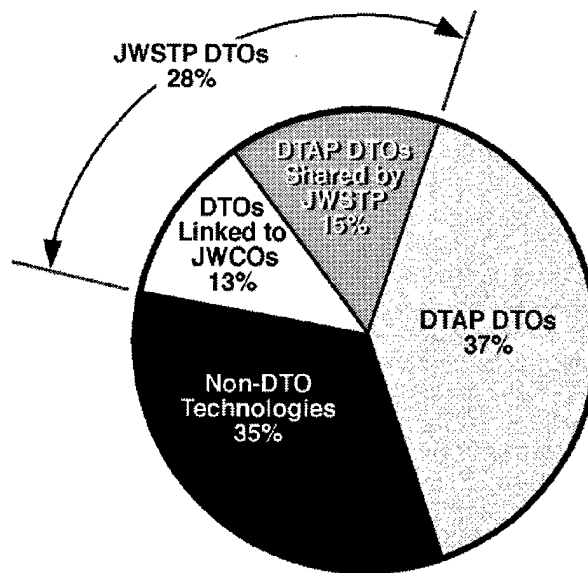


Figure II-3. DTO Share of Defense 6.2 and 6.3 Investment

Defense Science and Technology Strategy and its supporting plans, the services and agencies would lack the flexibility to seize local opportunities. A balanced, innovative program requires that flexibility be retained at the service, agency, and local laboratory levels.

The full texts of the DTAP and JWSTP DTOs are contained in a separate volume of these plans. The DTOs are presented in two parts—one for the DTAP and one for this JWSTP. The DTAP DTO number consists of a two-letter prefix corresponding to the names of the 10 technology areas addressed in that document, a two-digit number that represents the DTO sequence, and a second two-digit number that is an undefined field. The letter prefix for the JWSTP DTO number corresponds to the 10 sections (A through J) of Chapter IV of this document, followed by a two-digit sequence number. Thus, DTO numbers easily distinguish JWSTP from DTAP DTOs. The DTO sequence numbers do not connote priorities.

JWSTP Development. The 10 JWCO panel chairpersons are responsible for preparing their respective JWSTP sections. JWCO panel membership consists of service representatives, appropriate defense agency technical specialists, and representatives from the Joint Chiefs of Staff. Most panels are chaired by a senior OSD or defense agency S&T manager. The 10 JWCO panel chairs are shown below:

JWCO PANEL CHAIRS	
Information Superiority Panel	Mr. Edward Brady, ODDR&E
Precision Force Panel	Mr. Harold Bertrand, IDA
	Mr. Bernard Paiewonsky, IDA
Combat Identification Panel	Mr. John Buchheister, OASD(C ³ I)
Joint Theater Missile Defense Panel	Col John O'Pray, ODDR&E
Military Operations in Urban Terrain Panel	Col James Wojtasek, ODDR&E
Joint Readiness and Logistics Panel	Mr. Brian Sharkey, DARPA
	Mr. Gary Yerace, DMSO
Joint Countermine Panel	Dr. David Heberlein, Army
Electronic Combat Panel	Mr. Anthony Grieco, OUSD(A&T)/S&TS/EW
Chemical/Biological Warfare Defense and Protection Panel	Dr. Anna Johnson-Winegar, ODDR&E/ELS
	Dr. Salvatore Bosco, OATSD(CBM)
Counter Weapons of Mass Destruction Panel	Dr. George Ullrich, DSWA

Review and Assessment. After publication of the planning documents, Technology Area Reviews and Assessments (TARAs) are held for each of the 10 DTAP technology areas, the basic research program, and the manufacturing technology program. These reviews are conducted by TARA teams, with at least two-thirds of their membership from outside DoD. Most TARA team members are recognized experts from the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, the Defense Science Board, the scientific advisory boards of the military departments, industry, and academia. The TARA team is chaired by a senior executive appointed by the DDR&E. The appropriate representatives from the Defense S&T Reliance Techni-

cal Panel brief the DoD program as compared to the planning guidance. Special S&T issues identified by the DDR&E and applicable JWSTP ACTDs are also reviewed.

Following the review, the TARA chair briefs the findings and recommendations to the DDR&E-chaired Defense Science and Technology Advisory Group (DSTAG). Included in this briefing are the TARA chair's program recommendations for termination, adjustment, and enhancement to better align the S&T program to comply with the guidance. Based on recommendations and decisions of the DSTAG, the DDR&E briefs the issues to the Program Review Group (PRG), and program decision memorandums (PDMs) are issued as needed. The TARA process is shown in Figure II-4.

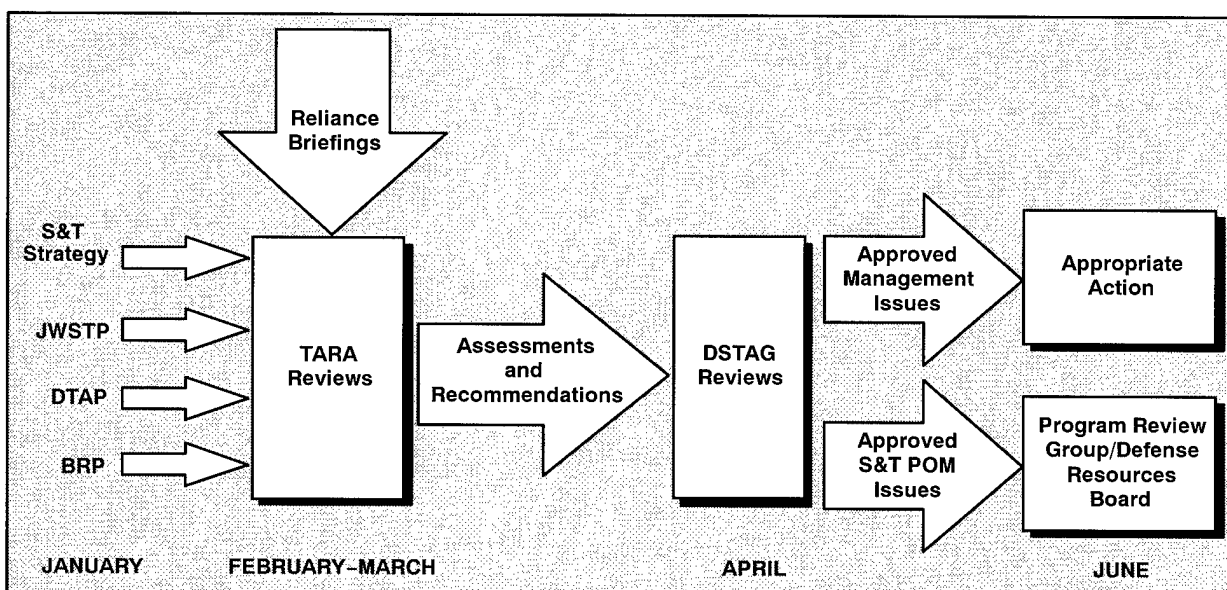


Figure II-4. Technology Area Review and Assessment Process

CHAPTER III

TRANSITION OF TECHNOLOGY TO THE JOINT WARFIGHTER

CHAPTER III

TRANSITION OF TECHNOLOGY TO THE JOINT WARFIGHTER

The cold war acquisition process produced some of the world's best military equipment. That process, however, is too expensive, and the time from concept to fielding is too long for the post-cold war budgetary and geopolitical environment. Three important mechanisms—Advanced Technology Demonstrations (ATDs), Advanced Concept Technology Demonstrations (ACTDs), and Joint Warfighting Experiments (JWEs)—are used to ensure the transition of innovative concepts and superior technology to the warfighter and acquisition customer both faster and less expensively than the traditional means. Each of these mechanisms is described below.

A. ADVANCED TECHNOLOGY DEMONSTRATIONS

Service and agency ATDs seek to demonstrate the maturity and potential of advanced technologies for enhanced military operational capability or cost effectiveness. The DTO volume for the JWSTP and the DTAP presents summary descriptions of the ATDs cited in this plan. ATDs are characterized by four parameters:

- Large scale, both in resources and complexity
- Operator/user involvement from planning to final documentation
- Specific cost, schedule, and performance metrics
- A clearly defined transition target.

B. ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

The ACTD process was initiated in 1994 to permit the early and inexpensive evaluation of mature advanced technologies. The evaluation is accomplished by the warfighter to determine military utility and to develop the concept of operations that will optimize effectiveness. ACTDs are structured and executed so that, when successful, we are able to proceed rapidly into formal acquisition.

By introducing new technologies in the field prior to the initiation of formal acquisition, we allow our operators, who have experience in combat, to evaluate and assess the military utility and develop the tactics to ensure that we can realize the full potential of the substantial technology base that is available to us—both defense and commercial. ACTDs are not a means by which to circumvent the formal acquisition process, but rather a means to enter that process based on a user assessment of the value of the new capability that reduces the user acceptance risk. This process will help us make more informed acquisition decisions and improve our acquisition cycle time.

ACTDs are designed to transfer technology rapidly from the developers to the users. They are user oriented and represent an integrated effort to assemble and demonstrate a significant, new or improved military capability that is based on mature advanced technologies. They also are on a scale large enough to demonstrate operational utility and end-to-end system integrity. A demonstration is jointly developed and implemented by the operational user and materiel development communities as key participants. ACTDs allow the warfighter to:

- Evaluate a technology's military utility before committing to a major acquisition effort.
- Develop concepts of operation for employing the new technology.
- Retain a low-cost residual operational capability if the commander desires.

Upon the conclusion of an ACTD, one of the following three choices will be made based on the results of the exercises:

- Execute the transition of the demonstrated technology directly to the warfighter. In this case, only minor, or perhaps no modifications, to the existing equipment will be required. This transition approach is particularly appropriate where only small quantities of the new equipment are required.
- Based on lessons learned during the ACTD, enter the formal acquisition process at some advanced milestone.
- Terminate the efforts or restructure them based on the evolved concept of operations and lessons learned during the ACTD.

Over the past 3 years, ACTD proposals have been forwarded from the Joint Staff, unified commanders, and the military services. Suggestions have been received from industry and many DoD research and development agencies.

ACTDs come in all shapes and sizes. Some are just a few months in length and evaluate a very specific technology or address a particular mission area. Others are several years long and include coordination of multiple developing technology programs into a series of specific demonstrations. Although no two ACTDs are alike, and proposals are accepted at any time of year, there are some key points to consider before proposal submission:

- *Ensure the proposal addresses current or emerging military needs.* Some ACTDs deal with immediate military needs, such as the Counter-Sniper ACTD. Others explore emerging capabilities, such as the Information Warfare Planning Tool ACTD.
- *ACTDs evaluate relatively mature technologies.* That is, their technical feasibility and technical risk are understood and have been demonstrated. The ACTD evaluates the operational application and military utility of the technologies.
- *User participation.* A key objective of each ACTD is to determine potential military utility of the technologies and to recommend whether further procurement is warranted. Each ACTD is a balance between operational needs and technological opportunity and requires close coordination and teaming between operators and developers.

ACTDs that examine the potential of specific technologies to address immediate or urgent needs can be submitted at any time. All ACTD proposals, including recommendations on potential participants, are coordinated between the Deputy Under Secretary of Defense (Advanced Technology) (DUSD(AT)) and the Joint Chiefs of Staff, J-8 Directorate. Generally, the submission process has developed into the following annual schedule:

- By the first week in December, all ACTD proposals should have been submitted to OSD/DUSD(AT). The AT staff coordinates with potential operational users and technology organizations to identify technologies, objectives, funding, and schedules. The staff then reviews each proposal for technical content and maturity.

- Near the second week in January, OSD/DUSD(AT) provides the Joint Staff, unified commanders, and services with all ACTD proposals that have been submitted and reviewed. They are asked to provide input on the military need addressed, military potential, and merit of each ACTD.
- Based on inputs received from the Joint Staff, unified commanders, and services, ACTD proposals are presented to the Joint Requirements Oversight Council for final review and prioritization. This input is then provided to the Under Secretary of Defense (Acquisition and Technology) for final review.

In fiscal year 1995, the Department of Defense initiated the first 10 ACTDs. Eleven ACTDs were initiated at the beginning of fiscal year 1996 and three were added later in the fiscal year. These ACTDs leverage approximately \$1 billion in military service and DoD agency technology programs. The Joint Requirements Oversight Council (JROC) has recently reviewed the FY 1997 ACTD candidates and prioritized 18 for initiation in FY 1997. Congressional funding reductions will preclude initiation of all but a few of these ACTDs. The JROC has also formulated a list of prospective user sponsors and lead services for these candidates.

The following tabulation is a brief summary of the ACTDs that were initiated in fiscal years 1995 and 1996; six have been completed, as indicated in the table.

ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

Advanced Joint Planning (User sponsor: U.S. Atlantic Command)

Purpose: To enhance joint operational planning capabilities by leveraging, refining, and integrating emerging technologies. To date, two technologies from this ACTD have been introduced and are operationally employed by U.S. Atlantic Command. The Joint Readiness Automated Management System (JRAMS) allows planners to rapidly assess force readiness from a variety of databases and employ these data in viewing potential courses of action. The Time-Phased Force Deployment Data Editor (TPEDIT) is a planning tool developed in the ACTD that allows planners to view, create, and edit the contents of the Time-Phase Force Deployment Database. Both tools were developed and used operationally in less than a year and have been used to assess readiness and courses of action in a wide range of contingencies. These two planning tools have cut the time for contingency planning at U.S. Atlantic Command from in excess of 7 days in 1994 to approximately 2 hours today. The tools are undergoing transition into the Global Command and Control System common operating environment.

KE Boost-Phase Intercept (Phase I) (User sponsors: Air Combat Command, and Naval Air Warfare Center (N-88), Deputy Chief of Naval Operations for Resources & Warfare Requirements)

Purpose: To assess the operational utility, mission effectiveness, and affordability of air-launched kinetic-energy, boost-phase intercept (BPI) systems. This ACTD was terminated after the completion of Phase I. A concept of operations (CONOPS) review indicated that the kinetic kill BPI concept was technically feasible but too asset intensive. Based on the results of Phase I, the decision was made not to proceed with the KE BPI Phase II ACTD, which would have fabricated and demonstrated the capability. *(Completed)*

Cruise Missile Defense—Phase I (User sponsor: U.S. Pacific Command)

Purpose: To detect, track, and successfully engage cruise missiles at ranges beyond the radar horizon of ship- and land-based air defense units, and to assess joint doctrine and concepts of air defense operations. Radars on a mountaintop site (simulating airborne radars) were used to detect and track missiles that would have been beyond line of sight for surface-based sensors. Engagement data were transmitted to interceptor missiles, and successful live-fire engagements with SM-2s and over 100 simulated intercepts with Patriot PAC-3 seekers were demonstrated. This ACTD validated the Air-Directed Surface-to-Air Missile (ADSAM) concept—the key to engaging cruise missiles at over-the-horizon ranges from surface-based air defense units. *(Completed)*

High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) (User sponsor: U.S. Atlantic Command)

Purpose: To address the military utility of an HAE UAV reconnaissance and surveillance capability at an air vehicle flyaway price of \$10 million. Two classes of air vehicles are being developed: a conventional design (Global Hawk) and a low-observable (DarkStar) design. Global Hawk has completed successful wing load, environmental control system, landing gear, and navigation system testing and is on track for first flight (mid 1997). DarkStar's first flight was successful, but the second flight ended in a crash during takeoff. In response to the accident investigation board-identified deficiencies, hardware modifications to Air Vehicle No. 2 are being implemented, and software changes are being investigated.

Joint Countermine (User sponsor: U.S. Atlantic Command)

Purpose: To demonstrate the capability to conduct effective, seamless amphibious mine countermeasure operations from sea to land; to provide simulation tools for Joint Countermine operations; and to define a Joint Countermine command, control, communications, and intelligence (C³I) architecture. Planning is on track for an initial demonstration in summer 1997 under U.S. Atlantic Command sponsorship. The British formally petitioned to participate in the ACTD in early January 1997.

Medium-Altitude Endurance Unmanned Aerial Vehicle (MAE) (Predator) (User sponsor: U.S. Atlantic Command)

Purpose: To provide a rapidly deployable, medium-altitude reconnaissance and surveillance capability. Predator progressed from a concept to a three-system operational capability in less than 30 months. The Predator ACTD was initiated in 1993, and the first flight occurred in 1994. Predator first deployed to Gjader Field, Albania, from June to October 1995 in support of Operation Provide Promise, flying 77 operational missions and logging 753 hours. Since March 1996, it has flown 166 operational flights totaling 1,349 hours from Taszar, Hungary, in support of IFOR/SFOR tasking. Overall, Predator has logged 1,050 flights totaling 4,605 hours. This ACTD is complete; operational lead and program acquisition have undergone transition to the Air Force. (Completed)

Precision-Rapid Counter Multiple Rocket Launcher (User sponsor: U.S. Forces Korea)

Purpose: To develop and demonstrate an adverse-weather, day/night, end-to-end, sensor-to-shooter, precision deep-strike capability against North Korean long-range artillery. Two demonstrations were conducted—one based at Fort Hood, Texas, and the other at Camp Red Cloud in Korea—involving both live and simulated forces. Command and control (C²) links in Korea were upgraded. The Navy and Air Force participated in the Joint Fire Support Interoperability demonstration. The major demonstration in Korea was the successful culmination of the development and installation phase of the ACTD. The leave-behind equipment installed in Korea will be supported by the ACTD team for the 2-year leave-behind period. The ACTD has greatly increased the ability of the 2nd Infantry Division to deal with the threat of long-range artillery from the north. (Completed)

Precision SIGINT Targeting System (PSTS) (User sponsor: U.S. Forces Korea)

Purpose: To develop and demonstrate a near-real-time, precision targeting, sensor-to-shooter capability using existing national and tactical assets. PSTS is developing advanced cooperative precision targeting algorithms, processing enhancements, site interface necessary for cooperative operation, and a concept of operations for asset cooperative utilization and minimal operational impact. This ACTD is being executed as a series of demonstrations that incrementally improve the overall capability in terms of complexity of emitters that can be targeted, degree of engineer versus operator involvement, and tactical utility. A demonstration in Korea and Hawaii was completed in October 1996. This was the fourth of six planned demonstrations. The SIGINT data were collected by assets in Korea and by national means, processed in Hawaii, and transmitted to warfighters in Korea over existing SIGINT dissemination communication links.

Rapid Force Projection Initiative (User sponsor: XVIII Airborne Corps, Dismounted Battlespace Battle Laboratory)

Purpose: To demonstrate sensor-to-standoff killer capability for light early-entry forces. The lethality and survivability of light Army entry forces will be enhanced by the capability to engage high-value targets, including heavy armor, beyond direct-fire ranges. A series of partial demonstrations is planned leading up to a full-scale free-play demonstration in the fourth quarter of FY 1998. This final demonstration will occur at Fort Benning, Georgia, and will include both live and virtual forces.

Synthetic Theater of War (STOW-97) (User sponsor: U.S. Atlantic Command)

Purpose: To provide an operational demonstration of advanced distributed simulation technologies that will directly support joint training and mission rehearsal. An additional goal to effect the transition of the STOW technologies to the next generation of DoD simulations such as the Joint Simulation System (JSIMS), Joint Warfare Simulation (JWARS), and service simulations. In October 1997, STOW will participate in Atlantic Command's Unified Endeavor exercise and demonstrate high-resolution (platform-level) simulation technologies required to implement a Joint Task Force (JTF)-level exercise; interfaces to operational command, control, communications, computers, and intelligence (C⁴I) systems, instrumented ranges, and virtual simulations; and environmental effects across a variety of operation types (e.g., antimine, theater missile defense, battlefield resupply). The exercise scenario includes combined operations with the U.K. participating in STOW.

Airbase/Port Biological Detections (User sponsors: U.S. Central Command, U.S. Pacific Command (U.S. Forces Korea))

Purpose: To demonstrate an interim capability to automatically detect and identify in near-real time a biological attack to an airbase or port facility. This capability can potentially prevent mass casualties and maintain operational effectiveness at the facility. A modified Interim Biological Agent Detector (IBAD)—which includes an integrated, automated agent identification capability—has been developed and has successfully met ACTD objectives for timeliness and sensitivity during testing at Dugway Proving Ground against four biological agent simulants. This device represents a significant enhancement in capability, detection sensitivity, and time from detection to warning. An array of internettted detectors with complete C⁴I connectivity will be deployed to Osan Airbase, South Korea, early this fiscal year.

Battlefield Awareness and Data Dissemination (BADD) (User sponsor: U.S. Atlantic Command)

Purpose: To develop, install, and evaluate a prototype operational system that allows commanders to design their own information system; delivers to warfighters an accurate, timely, and consistent picture of the battlefield; and provides access to any transmission mechanisms and worldwide data repositories. Pre-BADD ACTD efforts were briefed to the Defense Science Board as a possible option to enhance intelligence dissemination in support of Operation Joint Endeavor. This resulted in the creation of the Bosnia Command and Control Augmentation (BC²A) currently operating in theater. This represents a significant enhancement in data dissemination capabilities using the Joint Broadcast System. Phase I of BADD is being developed by DARPA, with CECOM as executive agent, and is focused on demonstration of key capabilities to disseminate data to battalion Tactical Operations Centers during the Task Force XXI Advanced Warfighting Experiment. Phase II will enhance and mature these systems to develop a pilot information management service in support of the Global Broadcast Service on UHF Follow-On (UFO) satellites 8, 9, and 10.

Combat Identification (User sponsor: U.S. Atlantic Command)

Purpose: To demonstrate system alternatives that can enhance the capability of our combat forces to positively identify friendly and hostile platforms during air-to-ground and ground-to-ground operations in order to preclude fratricide due to misidentification and to maximize combat effectiveness. The Battlefield Combat Identification System (BCIS) has been installed on the vehicles of the 4th Infantry division to provide training in anticipation for the Task Force XXI exercise. The Situation Awareness Beacon with Reply (SABER) prototype units that were demonstrated at ASCIET 95 are currently deployed with the 22 MEU. Three major field events will be conducted in FY 1997: Task Force XXI at Fort Irwin, California; All-Service Combat Identification Evaluation Team at Camp Shelby, Mississippi; and an international demonstration in Germany.

Combat Vehicle Survivability (User sponsor: U.S. Army Training and Doctrine Command/III Corps)

Purpose: To demonstrate a modest cost enhancement suite that significantly increases the survivability of combat vehicles on the battlefield. The Management Plan was signed on 30 September 1996.

Counterproliferation I (User sponsors: U.S. European Command, U.S. Southern Command, U.S. Strategic Command)

Purpose: To develop, integrate, demonstrate, and effect the transition to the warfighter of an integrated, militarily ready capability to neutralize facilities for weapons of mass destruction (WMD) and other counterforce targets. This effort encompasses the complete set of military capabilities needed for planning and conduct of such missions, to include target location and characterization, appraisal of munitions' effectiveness, battle damage assessment, and collateral hazard forecasting and mitigation. It includes work to redress shortfalls in hard target smart fuze performance identified in preliminary testing. A successful end-to-end integrated demonstration of fuzes, sensors, targeting, and hazard prediction tools occurred in December 1996, with live ordnance dropped from an F-15E against a simulated biological weapon facility. The Munitions Effectiveness Assessment version 1.0 planning tool was delivered to U.S. European Command for test and evaluation in December 1996.

Joint Logistics (User sponsors: U.S. Pacific Command, U.S. European Command, U.S. Central Command)

Purpose: To provide the users (CINCs and commanders, Joint Task Force) with the capability to rapidly plan and execute more responsive and efficient logistics support to military operations. A prototype network of workstations and commercial technologies has been developed and deployed to provide state-of-the-art planning tools, coupled with asset visibility, for Operation Joint Endeavor. This prototype system is the foundation for advanced capabilities being developed by the Defense Advanced Research Projects Agency (DARPA), the services, and other logistics agencies.

Joint Readiness Extension to the Advanced Joint Planning ACTD (User sponsor: Joint Staff)

Purpose: To provide tools to the Joint Staff and unified commands to assist in automation of the Joint Monthly Readiness Report (JMRR). The first demonstration of automated tools to assist in preparation of the JMRR was completed in August 1996. An additional prototype was delivered in November 1996, and one is planned for delivery in March 1997. This effort will build on technologies employed and lessons learned in the Advanced Joint Planning ACTD.

Low-Life-Cycle Cost, Medium-Lift Helicopter (User sponsors: Navy, Military Sealift Command)

Purpose: To evaluate the military utility of employing a commercial-off-the-shelf helicopter to perform the Military Sealift Command fleet vertical lift support mission. This ACTD, originally planned for FY96, was executed during August–October 1995 with a very successful demonstration of leased commercial helicopters and crews on Military Sealift Command ships. As a result of the demonstration, the Navy has concluded that leasing helicopters may be a viable alternative for vertical replenishment. The Navy completed a 6-month follow-on demonstration in the Indian Ocean in December 1996 and is considering privatization options for the rest of the Military Sealift Command fleet. *(Completed)*

Miniature Air-Launched Decoy (User sponsor: Air Combat Command)

Purpose: To develop and demonstrate a small, very inexpensive air-launched decoy system for the suppression of enemy air defense (SEAD) mission. MALD will greatly enhance the survivability of friendly aircraft and aid in establishing air superiority by stimulating, diluting, and confusing enemy integrated air defense systems. The MALD ACTD is a follow-on to the DARPA Small Engine Advanced Program (SENGAP), which successfully developed an extremely small turbojet engine. The 30-month ACTD contract was awarded to Teledyne Ryan Aeronautical Corporation on 5 November 1996.

Navigation Warfare (User sponsor: U.S. Atlantic Command)

Purpose: To validate the technologies and concept of operations for implementing protection of our use of satellite navigation systems and prevention of an adversary's use of satellite navigation systems. This capability will mitigate hostile use of satellite navigation by unfriendly forces on the battlefield while ensuring unimpeded use of the Global Positioning System for U.S. and allied forces.

Semiautomated Imagery Processing (User sponsor: U.S. Atlantic Command)

Purpose: To significantly improve an image analyst's ability to provide accurate, timely situation awareness to the warfighter. This system will allow analysts to exploit the output of an increasing quantity of image collection assets. A laboratory demonstration of the integrated system capability was held in October at Lincoln Laboratory. Initial field tests will be conducted in March 1997 with the 18th Airborne Corps using the ETRAC ground station as a radar interface.

Counter-Sniper (User sponsor: Dismounted Battlespace Battle Laboratory)

Purpose: To rapidly provide counter-sniper sensor systems for evaluation by Army, Marine, and Special Forces users, provide training for users who will be prepared to quickly deploy sniper detection technology, and provide feedback to system developers. This 3-month ACTD was completed in October 1996. The sensors were delivered to the Dismounted Battlespace Battle Laboratory. Training, testing, and doctrine development are ongoing. The sensors and trained soldiers/marines are available for contingencies. *(Completed)*

Tactical High-Energy Laser (THEL) (User sponsor: U.S. Army Space and Strategic Defense Command)

Purpose: To jointly develop with the Israeli Ministry of Defense a THEL demonstrator focused on negating the Katyusha rocket threat to northern Israel. The THEL uses a deuterium fluoride laser and high-power uncooled optics, along with both radar and optical target acquisition systems, to acquire, track, and negate the terrorist rocket threats. A contract with TRW has been initiated, with system integration to start in late FY97, and full functional testing to be completed at the Capistrano Test Site by March 1998. The ACTD will culminate in a full functional demonstration of the integrated system, transmitting the high-power beam downrange, within specified performance parameters (e.g., jitter, wave front error, slew rates, timelines). This program is jointly funded by the United States and Israel.

Tactical Unmanned Aerial Vehicle (TUAV) (User sponsors: U.S. Army Training and Doctrine Command, U.S. Marine Corps Deputy Chief of Staff (Aviation), and Commander, Naval Air Forces, Atlantic Fleet)

Purpose: To procure and support low-cost TUAV systems for use by brigade-level commanders; to develop CONOPS; to refine the TUAV requirements of the U.S. Army, Navy, and Marine Corps; and, if successful, to develop a path to full production of the TUAV. A contract for the TUAV was awarded in May 1996, with first flight expected in 9 months. Delivery of the first system is expected 15 months after contract award.

The DUSD(AT) web site [<http://www.acq.osd.mil/at>] and the ACTD Master Plan (Reference 7) provide more details of the ACTD implementation process and discuss the current status of existing ACTDs. The DTO volume (Reference 6) for the JWSTP and the DTAP presents summary descriptions for all ACTDs cited in this plan.

C. JOINT WARFIGHTING EXPERIMENTS

JWEs are variable-scale warfighting experiments that enable organization, doctrine, and systems to be varied to explore new operational concepts for generating joint combat power. The compelling need for JWEs is provided by the realization that organization and doctrine must co-evolve with systems and technology to fully realize potential improvement in Joint Combat Power. JWEs are DoD-wide efforts enabled through variable-level horizontal integration of ACTDs, ATDs, development and technology base programs, and emerging commercial systems and capabilities.

An important emerging area of focus for JWEs is Information Superiority. JWEs are envisioned that are specifically focused on the operational capabilities associated with Information Superiority. These JWEs will provide valuable feedback on the significant operational benefit to the Joint Warfighter of the emerging operational capabilities of Information Superiority. The aggressive implementation of JWEs is required to pace the co-evolution of organization, doctrine, and system of the Joint Warfighting Concepts of JV 2010: Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimensional Protection.

CHAPTER IV

ACHIEVING JOINT WARFIGHTING CAPABILITY OBJECTIVES

CHAPTER IV

ACHIEVING JOINT WARFIGHTING CAPABILITY OBJECTIVES

This chapter describes the significant near-, mid-, and far-term technology efforts supporting each of the 10 Joint Warfighting Capability Objectives listed in Chapter II. Each section describes the plan for achieving one JWCO.

A. INFORMATION SUPERIORITY

1. Definition

Information Superiority (IS) is defined by the Joint Chiefs of Staff (JCS) as the “degree of dominance in the information domain that permits the conduct of operations without effective opposition” (Reference 8). To acquire, verify, and assimilate the information needed to effectively neutralize and dominate adversary forces, IS must combine the capabilities of command, control, communications, and computers (C⁴); intelligence, surveillance, and reconnaissance (ISR); and information warfare (IW).

Command and control (C²) is defined as the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. C² functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission (Reference 9). The C² process involves gathering information, assessing the situation, identifying objectives, developing alternative courses of action, deciding on a course of action, transmitting orders that can be understood by recipients, and monitoring execution (Reference 10). This requires maintaining a seamless, robust network linking all friendly forces and providing common awareness of the current situation (C⁴). The ISR component of IS provides near-real-time awareness of the location and activity of friendly, adversary, and neutral forces throughout the battlespace. For the purposes of this document, C⁴ and ISR will be referred to collectively as C⁴ISR. The IW component discussed in this chapter deals with the capability to defend one’s own information, information-based processes, information systems, and computer-based networks against outside infiltration and manipulation.

The term *information system* includes information, information-based processes, information systems, and computer-based networks either individually or in combination with each other. It should be noted that information superiority is a dynamic area. Doctrine, policy, and taxonomy are evolving as quickly as the supporting technology. Accordingly, this taxonomy describes the relevance of key technology initiatives to joint warfighter requirements, but is not representative of the entire spectrum of warfighter IS roles and missions.

Information superiority is essential to achieving virtually all other joint warfighting capabilities. U.S. information superiority requires an ability to protect the information collection, processing, and dissemination capabilities of the United States and its coalition partners.

2. Operational Capability Elements

Warfighters of the future must be able to respond rapidly and effectively, with little or no tactical warning, to a wide range of uncertain threats. These threats include conventional forces and weapons of mass destruction (WMD) of increasing technological sophistication. There is a decreasing likelihood of forward-based U.S. forces in a theater. An effective U.S. response is likely to require interoperation and sharing of resources with other coalition forces in the face of these threats. The Chairman of the Joint Chiefs of Staff’s *Joint Vision 2010* calls for the rapid deployment of forces capable of engaging the enemy on arrival and sustaining operations with a minimal logistics tail in the area of operations.

This demands significant advances in our ability to deliver the right data and information at the right time to commanders at all levels, to use that data and information to develop superior knowledge of the battlespace in real time, and to employ that knowledge effectively in planning and executing operations. The goal, as illustrated in Figure IV.A-1, is to enable the development of new concepts of operation that will ensure operational dominance of the battlespace supported by information superiority. This is accomplished by blending three broad areas of operational capabilities—battlespace awareness, effective force employment, and a grid of assured services, referred to simply as the grid—into an overall federated system. These capabilities are significantly more advanced than the initial capabilities of the Global Command and Control System (GCCS) and those recently successfully demonstrated in the Bosnia Command and Control Augmentation (BC²A) program.

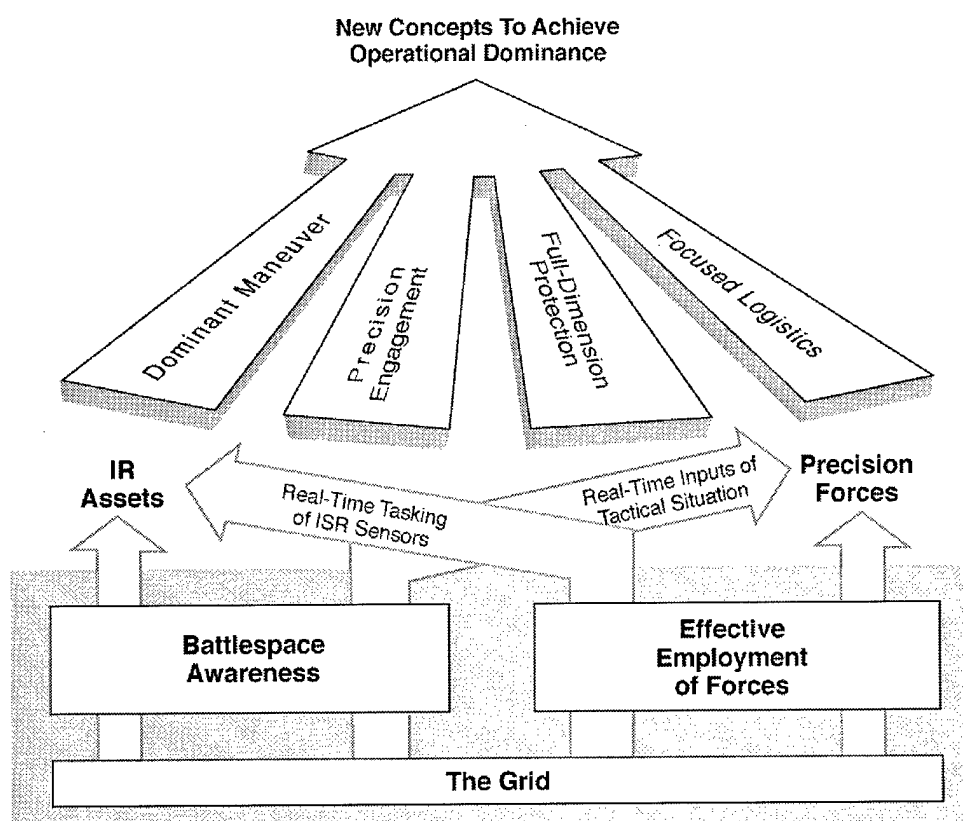


Figure IV.A-1. Concept—Information Superiority

The Advanced Battlespace Information System (ABIS) study defined three operational capability elements within each of the three broad operational capability areas (Reference 11):

- *Battlespace awareness—information acquisition, precision information direction, and consistent battlespace understanding.* These capabilities allow the joint warfighter to control and shape the pace of the battle by providing commanders with a broader perspective and better intuitive feel of the battlespace, including the environmental conditions and operational situation. Note that information acquisition was included as a subset under precision information direction in the ABIS report. However, because of its importance to battlespace awareness, it is included here as a separate operational capability.

- *Effective employment of forces—predictive planning and preemption, integrated force management, and execution of time-critical missions.* These capabilities allow the joint warfighter to plan and execute operations in a manner that achieves an overwhelming effect at precise places and times.
- *The grid—universal transaction services, distributed environment support, and high assurance of services.* These capabilities allow the joint warfighter to rapidly adapt to changing situations and environmental conditions and to attack high-priority targets throughout the battlespace. Information superiority empowers lower echelon force elements by distributing the commander's intent and the information needed for timely and effective execution. Because these capabilities inevitably degrade in the course of battle, a key objective of IS is to enable commanders to plan for this eventuality, to identify and protect essential capabilities, and to reconfigure C² structures to meet changing needs.

As a part of the ABIS operational capabilities, the joint warfighter must have a superior IW operational capability to defend information systems from both deliberate and accidental disruptions, intrusions, manipulations, and corruptions. This gives the joint warfighter a credible deterrent across the full spectrum of conflict, ensures information superiority, and permits the conduct of operations without effective opposition. Figure IV.A-2 represents a conceptual view of the IW environment. This capability is of increasing importance as information technology becomes more widely available throughout the world.

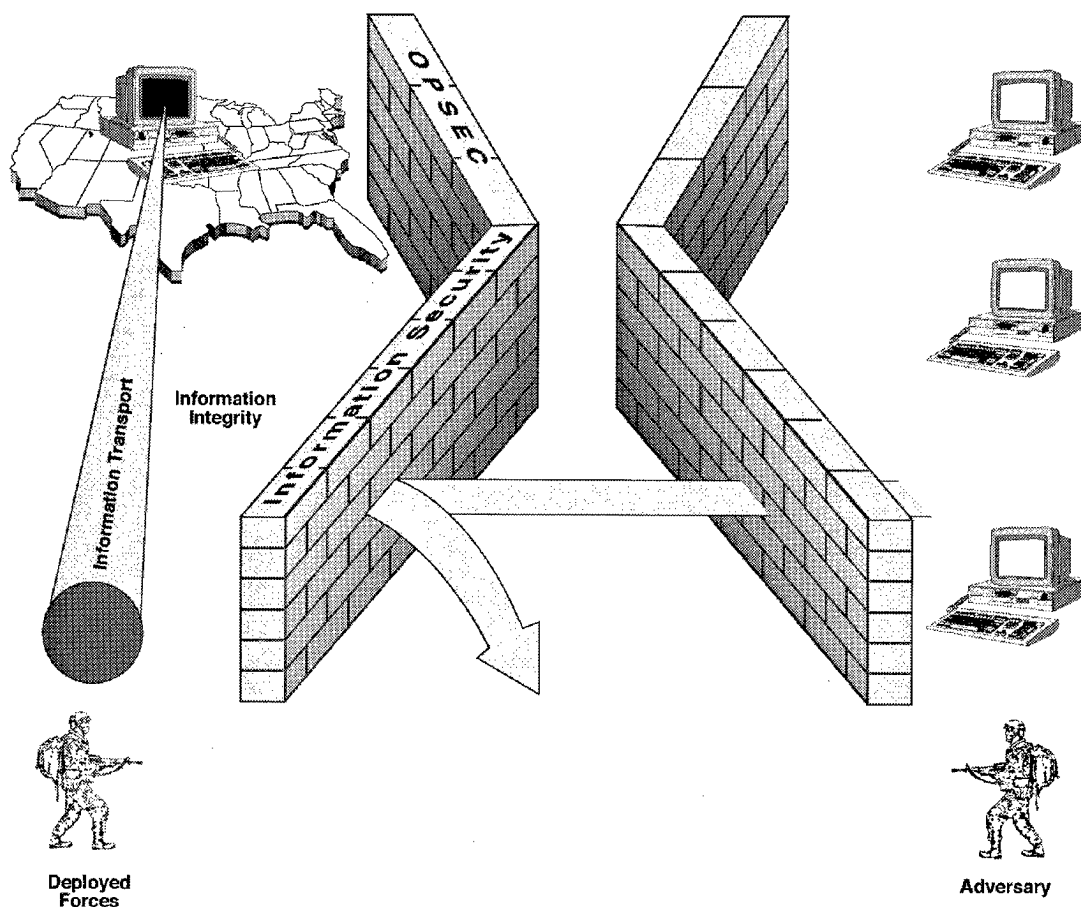


Figure IV.A-2. Concept—Information Warfare

The IW technology base must support joint warfighter requirements in both defensive information warfare (IW-D) and effective C⁴I. IW-D operational capabilities include information security, operations security, information integrity, attack detection, and restoration.

In the 1996 JWSTP, IW was a separate chapter. Here IW is integrated with Information Superiority. As in the ABIS study, IW-D operational capabilities are included under assurance of services as part of the grid. Effective C⁴I has been integrated into various other capability areas as appropriate.

Battlespace Awareness. Battlespace awareness includes the operational capability to acquire and assimilate information about the position and movement of friendly, adversary, and neutral forces, and about the geospatial situation (e.g., terrain, weather, space bathymetric conditions) in which they are deployed. It includes the capabilities to provide a common view and understanding of the situation across tactical and supporting forces, from joint force commanders to individual shooters. The effective integration of battlespace awareness within a federated system will provide the warfighter with an extended view of the battlespace and of current and projected operational conditions, and an enhanced ability to identify and localize features of the battlespace in the face of degraded environmental conditions and hostile countermeasures. This extended view will support and enhance the warfighters' intuitive feel for situations and command options.

The specific operational capabilities necessary to achieve battlespace awareness are as follows:

- *Information acquisition*—the provision of sufficient, timely, and high-quality surveillance, reporting, target designation, and assessment information on enemy, friendly, and U.S. units, events, activities, status, capabilities, plans, and intentions to ensure that joint or coalition commanders have dominant battlespace knowledge.
- *Precision information direction*—the capability to dynamically direct and integrate both tactical and supporting C⁴ and ISR resources for targeting, weaponeering, mission preview, battle damage assessment (BDA), and combat assessment to maintain the ability for the on-scene commander to exploit and shape the battlespace.
- *Consistent battlespace understanding*—the capability to elevate the level and speed of the warfighter's cognitive understanding of enemy, friendly, and geospatial situations, and to maintain consistency in that view across tactical and supporting forces.

Effective Employment of Forces. With information superiority, commanders will be able to exploit their superior understanding of the battlespace to shape and control the conflict. They will be able to do this by dynamically directing and integrating tactical and supporting ISR resources for mission planning and rehearsal, targeting, and weapon assignment; by BDA; and by combat assessments to ensure optimum application of precision weapons and forces. Specific operational capability elements are as follows:

- *Predictive planning and preemption*—the ability to be proactive in the planning process in order to avoid direct confrontation (by employing alternative means), to be prepared to react and exploit opportunities when direct confrontation must occur, and to shape expected actions in order to stay within an enemy's decision cycle and keep him out of ours.

- *Integrated force management*—the capabilities needed to achieve the dynamic synchronization of missions and resources from components and coalition forces.
- *Execution of time-critical missions*—the ability to provide processing languages, interface characteristics, and linkages that enable rapid target search and acquisition, battle coordination and target selection, handoff, and engagement for the prosecution of time-critical targets.

The Grid. The grid will support global connectivity with flexible, rapidly configurable network services, automated assistance to facilitate universal user access to information, and assured services in stressed environments. These services will also provide flexible command structures and support for time-critical, short-duration mission tasks such as “sensor-to-shooter” integration and support. The services of the grid are separate from command structures, disseminating battlespace awareness to users when they need it and in the form that they need it to facilitate the collaborative planning and execution of joint and coalition operations. The connectivity and flexibility across heterogeneous systems will also allow the creation of “virtual staffs” that expand and augment the capabilities of in-theater forces with collaborative services, reach-back capabilities, and reduced local footprint.

The critical operational capabilities of the grid are:

- *Universal transaction services*—the capability to provide warfighters and their systems the ability to exchange and understand information, unimpeded by differences in connectivity, on a “just-in-time” basis, regardless of location.
- *Distributed environment support*—the mechanisms and services required to allow the warfighters to craft their C⁴ISR information environments from the full set of assets connected through the grid, including the ability to establish distributed virtual staffs and task teams.
- *High assurance of services*—high-quality services that warfighters must have, when needed, to meet dynamically changing demands and defend against physical and information warfare threats. This includes adaptive network management that anticipates changing requirements, and the defensive IW operational capabilities of information security, operations security, information integrity, attack detection, and restoration. Information security encompasses confidentiality, integrity, authentication, nonrepudiation, and, to some extent, availability. Operations security ensures that critical friendly information and activities cannot be easily intercepted or observed by adversary intelligence systems. Information integrity ensures that the information to support battlefield awareness is unimpaired.

3. Functional Capabilities

Achieving the IS operational capability elements will require significant advances in numerous functional capabilities to manage the acquisition, simultaneous processing, and parallel dissemination and presentation of information in an assured and secure manner, and to effectively integrate mission planning functions. These functional capabilities are listed below. Table IV.A-1 provides a mapping of the functional capabilities to the operational capability elements and broad operational capabilities.

Table IV.A-1. Functional Capabilities Needed—Information Superiority

Functional Capabilities	Operational Capability Elements								
	Battlespace Awareness			Effective Employment of Forces			The Grid		
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services
1. Intelligence Processing and Broadcast	●		○	●	●	●			
2. Intelligent, Distributed MC&G	●		●						
3. Collaborative Situation Assessment and BDA			●			●			
4. Collection and Distribution of Weather and Environmental Conditions			●	●					
5. Common Understanding and Representation of the Battlespace			●	●					
6. Situation Projection		●	●	●					
7. Mission Rehearsal and Embedded Training		●			●				
8. Command Projection		●		●	●				
9. Support for Simultaneous, Coordinated Operation					●				
10. Repair and Consumables Management	○		○	●	●	●	●		○
11. Joint Force Automated Battle Rules of Engagement					●				
12. Theater Intelligence Processing and Broadcast	●		●						
13. Shared, Distributed Collaborative Planning		●		●	●	●			
14. Rapid, Accurate Battle Damage Assessment		●				●			
15. C ⁴ ISR System Management	●				●	●			
16. Force Status and Execution Management					●	●			
17. Parallel Dissemination of Intelligence/BDA						●			
18. Rapid, Accurate Automated Targeting	○	●	●		●	●			
19. Automated Mission and Weapon-to-Target Pairing						●			
20. Seamless Connectivity							●		
21. Automatic Adaptive Information Conditioning							●		
22. Location Independent Addressing							●		
23. Flexible, Adaptive Access Control							●		
24. Support for Heterogeneous Users and Interfaces								●	
25. Knowledge-Based Access, Retrieval, and Integration of Information								●	
26. Distributed, Collaborative Processing								●	

● Strong Support

○ Moderate Support

Table IV.A-1. Functional Capabilities Needed—Information Superiority (continued)

Functional Capabilities	Operational Capability Elements								
	Battlespace Awareness			Effective Employment of Forces			The Grid		
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services
27. Massive, Heterogeneous Distributed Information Management								●	
28. Automated Intelligent Grid System Management									●
29. Service Extension									●
30. Information Consistency									●
31. Access Controls/Security Services									●
32. Service Availability							●		●
33. Network Management and Control							●		●
34. Damage Assessment							●		●
35. Reaction (Isolate, Correct, Act)									●
36. Vulnerability Assessment and Planning							●		●
37. Preemptive Indication									●
38. Intrusion Detection/Threat Warning									●
39. IW and Spectrum Dominance Planning and Monitoring		●			●				

● Strong Support

○ Moderate Support

- *Intelligence processing and broadcast*
- *Intelligent, distributed mapping, charting, and geodesy (MC&G)*
- *Collaborative situation assessment and BDA*
- *Collection and distribution of weather and environmental conditions*
- *Common understanding and representation of the battlespace*
- *Situation projection*, whereby components viewed at any level are consistent with the total situation.
- *Mission rehearsal and embedded training*
- *Command projection*, resulting in wider sharing of the commander's intent, particularly at lower echelons.
- *Support for simultaneous, coordinated operation*
- *Repair and consumables management*

- *Joint force automated battle rules of engagement*
- *Theater intelligence processing and broadcast*
- *Shared, distributed collaborative planning*
- *Rapid, accurate BDA*
- *C⁴ISR system management*
- *Force status and execution management*
- *Parallel dissemination of intelligence/BDA*
- *Rapid, accurate automated targeting*
- *Automated mission and weapon-to-target pairing*
- *Seamless connectivity, including integration across communications media; automatic multilingual and multimodal adaptive interfaces, protocols, and standards.*
- *Automatic adaptive information conditioning, including automatic compression/encoding; automatic “brokering” of quality versus timeliness.*
- *See the enemy*
- *Location-independent addressing, including personal and group addressing, both stationary and on the move.*
- *Flexible, adaptive access control*
- *Support for heterogeneous users and interfaces*
- *Knowledge-based access, retrieval, and integration of information*
- *Distributed, collaborative processing*
- *Massive, heterogeneous distributed information management*
- *Automated intelligent grid system management, including grid system management based on user’s status and plans; tools for appraisal of grid status and capabilities.*
- *Service extension, including modular plug-and-play, projectability, and scalability.*
- *Information consistency, including integrity, protection, and authentication of information systems.*
- *Access controls/security services, including the ability to ensure information security and integrity by limiting access to information systems to authorized personnel; trusted electronic release, multilevel information security, and policies.*
- *Service availability, including communications support for distributed computing.*
- *Network management and control, including the use of reconfigurable, robust protocols and control algorithms, self-healing applications, and systems capable of managing distributed computing over heterogeneous platforms and networks.*
- *Damage assessment, including the ability to determine the effectiveness of attacks in a defensive capacity (e.g., where and how bad).*

- *Reaction (isolate, correct, act)*, including the ability to respond to a threat, intruder, or network or system disturbance; intrusion characterization; the capability to isolate, contain, correct, and monitor surreptitiously. The ability to correct includes recovery, resource reallocation, and reconstitution.
- *Vulnerability assessment and planning*, including the ability to realistically assess the joint warfighter's information system(s) and information processes; the use of critical protection functions such as risk management and vulnerability analysis.
- *Preemptive indication*, including the ability to provide system and subsystem precursors or indications of impending attack.
- *Intrusion detection/threat warning*, including the ability to detect attempted and successful intrusions (malicious and nonmalicious) by both insiders and outsiders.
- *IW and spectrum dominance planning and monitoring*.

4. Current Capabilities, Deficiencies, and Barriers

Currently fielded information systems do not support the kind of robust, assured, and timely flow of accurate and relevant information needed to meet future joint warfighting needs. Operational practices limit flexibility and effective employment, even though ongoing DoD efforts such as the Defense Information Infrastructure (DII, part of the National Information Infrastructure) and C⁴ISR Integration Task Force are making important improvements.

The structure for C⁴ISR remains divided along organizational and functional lines and is strongly tied to the hierarchical command structure, due in large part to inadequate capabilities for the automation of multilevel security. Users must know the secure network addresses of all the nodes with which they want to communicate—a daunting requirement in the heat of battle. Even when information can be provided, it may be in a form that has been tailored and optimized for some other mission. These divisions, tied to a rigid framework of battlefield geometry, limit a commander's ability to assign sensors to priority targets and to dynamically retask high-value assets across missions and services in response to changing situations and opportunities. Furthermore, communications bandwidths and connectivity are inadequate to support the flow of data under conditions of peak demand.

“Stovepiping”—the operational fragmentation and end-to-end segregation of information flow by type, command structure, and mission—makes it difficult to acquire, process, and disseminate essential information across joint forces, and makes it virtually impossible to develop a common picture of the battlespace. Although there is a high degree of assurance (i.e., confidence in the integrity, confidentiality, and availability) associated with information received via stovepiped classified systems, there is less assurance associated with information received across heterogeneous systems.

Current C⁴ISR systems provide only a limited ability to detect and monitor targets and events concealed in foliage, in structures, under ground, or in adverse weather or countermeasure environments. Rigid ISR systems and lack of visibility of independent tactical sensor tasking and coverage further limit our ability to manage and coordinate sensor assets for real-time operations.

IW-D limitations include:

- Inadequate management of distributed information
- Lack of high-assurance systems with multiple levels of security and multilevel security (MLS) that facilitate interoperability
- Countermeasures that are generally reactive to emergent IW rather than anticipatory
- Lack of predictive and anticipatory network management capabilities
- Limited IW sensors and processing capability for grid self-defense
- Intrusion detection techniques that do not scale or that do not facilitate damage assessment or automated response.

A number of technological, organizational, operational, and programmatic barriers make it difficult to overcome these limitations. Nonetheless, existing capabilities are being applied in unique ways and are being extended to provide more effective means of network protection. Ranging from advanced access control systems to effective means of encryption of databases and transmitted information, tools are becoming available that help ensure the availability, integrity, and confidentiality of critical information for the joint warfighter.

Technological advances alone are not sufficient. Traditional concepts of operation and rigid C⁴ISR structures will need to change if the warfighter is to realize the benefits of advancing technology. Battlespace awareness transcends individual service and organizational divisions and will require the effective integration of, and sustained commitment to, individual service and joint programs within a common architecture.

Table IV.A-2 provides a mapping of key technologies to limitations to functional and operational capabilities.

5. Technology Plan

Achieving information superiority and seamlessly integrating IS into warfighting operations will require both advances in technology and development of new operational concepts to exploit them. Table IV.A-3 provides a complete list of IS DTOs. Table IV.A-4 maps these DTOs to operational capabilities, while Figure IV.A-3 traces the flow of key technologies to operational capability elements. The volume on DTOs provides further information on demonstrations and DTOs. Figures IV.A-4 and IV.A-5 provide an integrated roadmap of key demonstrations and JWSTP DTOs. Note that the IS DTOs are closely linked with DTAP DTOs, especially in the areas of Information Systems Technology and Sensors, Electronics, and Battlespace Environment.

The current JWSTP program includes demonstrations recommended by the ABIS report (Reference 11), although most are demonstrations of partial ABIS capabilities. These provide the basis for immediate improvements in battlespace awareness and the integration of improved knowledge into mission planning and execution. These demonstrations also support new concepts of C⁴ISR operation and improvements in the warfighter's ability to use ISR assets. These will demonstrate the value of information superiority to the operational forces and provide a strong foundation on which to build an effective long-term program to achieve the JCS's future warfighting vision. In addition, new C⁴ISR capabilities and concepts will immediately begin to affect capabilities and concepts of operation in all other warfighting areas.

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority

Goal	Functional Capabilities	Limitations	Key Technologies
Battlespace Awareness			
Operational Capability Element: Information Acquisition			
Provide sufficient timely high quality surveillance, reporting, target designation and assessment information on enemy, friendly, U.S. units, events, activities, status, capabilities, plans/intentions to ensure that joint/coalition commanders have dominant battlespace knowledge.	Intelligence processing and broadcast Intelligent, distributed MC&G Repair and consumables management Theater intelligence processing and broadcast C ⁴ ISR system management Rapid accurate automated targeting	Limited coverage extent, quality, and continuity currency "Stovepipe" nature of systems/information by type, acquirer/dissemination Few systems have near-real-time capabilities for responding to tasking and providing direct-continuing support to forces Limited capability to detect, identify, and monitor targets/events in foliage, buildings, and underground Many capabilities can be denied by weather and countermeasures Manpower intensive—little automation of integration/fusion, target detection, target ID, and BDA capabilities	Small volume/weight, very high speed capacity processors and storage devices; application software that can be embedded with sensors/platforms Software applications for automated selection and following of coverage areas/targets Software applications for use with multiple data sources (including reference/ databases) to enhance target detection, tracking, and designation (e.g., detecting changes) Foliage penetrating moving target indicators (MTI) and synthetic aperture radar (SAR) Near simultaneous multispectral coverage Passive/multistatic MTI/SAR Small volume/weight, multispectral, rapidly deployable smart surface sensors Direct integration of Global Positioning Systems (GPS) with sensor outputs where appropriate Transfer/translation applications and storage devices/communications for near-real-time tactical aircraft sensors
Operational Capability Element: Precision Information Direction			
Maintain the ability of the on-scene commander to exploit and shape the battlespace by dynamically directing and integrating (in accordance with operation, battle, and mission priorities) both tactical and supporting ISR resources for targeting, weaponeering, mission preview, BDA, and combat assessment.	Situation projection Mission rehearsal and embedded training Command projection Shared, distributed collaborative planning Rapid, accurate battle damage assessment Rapid accurate automated targeting IW and spectrum dominance planning and monitoring	Limited response to battlespace changes; rigid ISR, lack of visibility into sensor tasking and coverage Sortie impact limitations, poor/slow BDA Limited comprehensive sensor tasking to support mission No just-in-time retargeting capability	Object-oriented, distributed, automated, and dynamic planning, scheduling, and target handoff Embedded, fault-tolerant, distributed modeling and simulation (M&S) for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Joint multisensor fusion, information fusion, and sensor cross-cueing Integrated cross-sensor tracking with unique target ID and real-time updates Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Distributed, collaborative virtual planning in real time Rapid M&S for sensor coverage analysis

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Battlespace Awareness (continued)			
Operational Capability Element: Consistent Battlespace Understanding			
Elevate the level of our cognitive understanding of the enemy, friendly, and geospatial situation; maintain consistency in that view across tactical and supporting forces.	Intelligence processing and broadcast (from CONUS; fused near-real-time (NRT) signals intelligence (SIGINT) and imagery; increased/fused sensor data in NRT) Intelligent, distributed MC&G Collaborative situation assessment and BDA Collection and distribution of weather and environmental conditions Common understanding and representation of the battlespace Situation projection Repair and consumables management Theater intelligence processing and broadcast Rapid accurate automated targeting	No common operational picture Inadequate information support for commander's decision needs Presently too much information without quality thresholds, not scaleable Text message intensive with no automated machine understanding Inadequate dissemination of understanding Intelligence preparation of the battlefield (IPB) of battlespace degrades when battle begins	Joint multisensor fusion, information fusion, and sensor cross-cueing Mass storage of information Intelligent products to support decision making Common integrated situation display with selectable detail and resolution High-rate broadcast Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Auto data validation and data validity tags Tailored search and retrieval of information Intelligent agent for knowledge retrieval, filtering, sanitization, and deconfliction Improved data and uncertainty visualization management Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Automated language translation and text understanding Automated language, syntax, and protocol translation Multilevel information security and information assurance Distributed, synchronized, large database

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Effective Employment of Forces			
Operational Capability Element: Predictive Planning and Preemption			
Lean forward in the planning process to (1) avoid direct confrontation (by employing alternatives); (2) be prepared to react and exploit opportunities when direct confrontation must occur; and (3) shape the expected actions to stay within the enemy's decision cycle and keep him out of ours.	Intelligence processing and broadcast Collection and distribution of weather and environmental conditions Common understanding and representation of the battlespace Situation projection Command projection Repair and consumables management Shared, distributed collaborative planning	Automated planning systems not dynamic Wargaming not effectively integrated in C⁴ISR and cannot be used for online planning evaluation Sensor tasking and countermeasures are "reactive" to emergent IW rather than anticipatory Information search and retrieval can choke at times of peak demand Lack of distributed, consistent data at all levels	Object-oriented, distributed, automated, and dynamic planning, scheduling, and target handoff Embedded, fault-tolerant, distributed modeling and simulation (M&S) for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Continuous sliding collaborative planning across battlespace Just-in-time mission package construction and delivery Automated nodal analysis and weaponizing Automated target/weapon pairing and update Easily deployable, evolvable, scalable, plug-and-play architecture Cross-functional virtual teams
Operational Capability Element: Integrated Force Management			
Achieve dynamic integration of force operations by collaborative execution monitoring, repair, and retasking of shared assets across echelons, missions, components, and coalition forces (control of "coherent" joint/simultaneous operations to optimized dynamic use of resources without preempting "intuitive" use).	Intelligence processing and broadcast Mission rehearsal and embedded training Command projection Support for simultaneous, coordinated operation Repair and consumables management Joint force automated battle doctrine Shared, distributed collaborative planning C⁴ISR system management Force status and execution management Rapid accurate automated targeting IW and spectrum dominance planning and monitoring	Present coordination via rigid framework of battlefield geometry Limited ability to apply all assets to formulate and support coherent defensive situation Limited understanding of what needs to be done (strategy, commander's intent) and relationship of individual tasks to overall campaign objectives Manually intensive development of plans to support simultaneous operations Limited real-time insight into conduct of plan No responsive way to dynamically retask high-value assets across missions and services in response to changing situations and opportunities	Embedded, fault-tolerant, distributed modeling and simulation (M&S) for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Automated nodal analysis and weaponizing Distributed, collaborative, and virtual situation awareness Dynamic shared war plan that deals with uncertainty Dynamic allocation of shared resources in real time Decision support to assess and replan consumables

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Effective Employment of Forces (continued)			
Operational Capability Element: Execution of Time-Critical Missions			
Provide a real-time fused battlespace picture with integrated decision aid tools which ensures coordinated dynamic planning and execution of a broad spectrum of missions from time phased attack of fixed targets to reconnaissance of battle areas and prosecution of time-critical targets by integrated hunter-controller-killer assets. Provide processing and linkages which enable rapid target search and acquisition, battle coordination and target selection, handoff and engagement for prosecution of time-critical targets.	Intelligence processing and broadcast Collaborative situation assessment and BDA Repair and consumables management Shared, distributed collaborative planning Rapid, accurate battle damage assessment C⁴ISR system management Force status and execution management Parallel dissemination of intelligence/BDA Rapid accurate automated targeting Automated mission and weapon to target pairing	Slow decision and resource allocation process with respect to target cycle times Poor detection of fleeting target entities in crowded battlespace Slow fusion process Best sensor information not incorporated Human-intensive BDA Targets appear after force package commitments, pop-up targets, movement cycles Execution status unknown Inability to counteract target reaction to threat and engagement Simultaneous pulls on sensors Insufficient connectivity Sensor management not tied to commander's intent	Automated nodal analysis and weaponizing Wideband communications and interconnectivity Real-time, cognition aiding displays Automated planning/decision support tools Data interoperability/synchronization Automated IPB process Fusion and integrated target tracking Automatic target recognition Advanced adaptive, multilevel security ISR management and integration tools
The Grid			
Operational Capability Element: Universal Transaction Services			
Provide warfighters and their systems the ability to exchange and understand information, unimpeded by differences in geography, connectivity, processing, language, or interface characteristics on a "just-in-time" basis.	Repair and consumables management Seamless connectivity Automatic adaptive information conditioning Location independent addressing Flexible, adaptive access control Service availability Network management and control Damage assessment Vulnerability assessment and planning	Information transport generally tied to C² hierarchy Lack of interoperability Unacceptable limitations on connectivity to tactical users Lack of adaptive conditioning of information to optimize services Users burdened with requirement to know network addresses Limited ability to support multiple levels of security and multilevel security, especially in coalition operations Limited capability to support continued operations during network partition	Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Automated nodal analysis and weaponizing Automatic target recognition Advanced adaptive, multilevel security Adaptable tactical/mobile networking Rapidly deployable tactical fiber extensions Tactically extensible, high-rate, asymmetric mobile communications Advanced compression and coding abstracting for conditioning of information Dynamic reallocation of computing resources MLS secure commercial off-the-shelf (COTS)-based clusters Secure GPS Fault avoidance and recovery mechanisms

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
The Grid (continued)			
Operational Capability Element: Distributed Environment Support			
Provide all mechanisms and services required to allow the warfighters to craft their C ⁴ I information environments from the full set of assets connected through the grid, including ability to establish distributed virtual staffs, to share a common consistent perception of the battlespace and to construct distributed task teams among sensors, shooters, movers, and command posts.	Support for heterogeneous users and interfaces Knowledge-based access, retrieval, and integration of information Distributed, collaborative processing Massive, heterogeneous distributed information management	Limited ability to integrate processes across heterogeneous system domains Inadequate knowledge of navigation and retrieval for massive, distributed, heterogeneous systems Minimal capability for exploiting information within the network to provide users with knowledge and advisory cues Minimal capability to manage distributed information, especially in asymmetric and broadcast communication environments Limited flexibility and adaptability of information security for coalition operations	Tailored search and retrieval of information Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Automated nodal analysis and weapon-eering Multimode, multilingual interface services Heterogeneous multimedia conferencing Automated mediators and database management system tools Massive data storage and management Flexible information security for information exchange, access, and conferencing
Operational Capability Element: High Assurance of Services			
Provide high quality services to the warfighters that will be available whenever and wherever needed, that can be adapted, scaled, and projected to meet dynamically changing demands, and that can be defended against physical and information warfare threats.	Automated intelligent grid system management Service extension Information consistency	Limited ability to support multilevel security, especially in coalition operations Lack of modular plug-and-play to allow adaptation of services and to project information-intensive support globally Lack of confidence that nonorganic assets will be available when needed Lack of predictive/anticipatory network management capabilities Lack of IW sensors and processors for grid self defense Limited ability to provide both capability and "hardness"	Automated nodal analysis and weapon-eering Management tools for anticipatory services Tools for projecting and visualizing grid capabilities in terms of projected operational needs Multilevel, adaptive information security IW surveillance and defense tools Software integrity validation Secure distributed systems

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
The Grid (continued)			
Operational Capability Element: High Assurance of Services (continued)			
Provide protection from deliberate or inadvertent unauthorized disclosure, acquisition, manipulation, modification, or loss of sensitive information under various complex security policies, using distributed open systems architectures and different security attributes.	Information consistency Access controls/security services Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited ability to support multilevel security, especially in coalition operations Countermeasures generally reactive to emergent IW rather than anticipatory Limited network discovery, management, security management, and expert systems capabilities Limited availability of trusted operating systems Vulnerabilities in application of commercial off-the-shelf items Inadequate tools for validating system security and robustness Limited authentication and identification capabilities Inadequate automated intrusion detection techniques Inadequate data contamination recovery techniques	Secure firewalls and guards (B3 Level) Dynamic reallocation of computing resources Automated network discovery, intrusion detection, and response capabilities MLS secure COTS-based clusters Trusted systems Malicious code detection tools Security analysis tools Security engineering for systems
Eliminate, or reduce to an acceptable level, the vulnerabilities that an adversary could exploit by obtaining information about friendly capabilities, limitations, and intentions.	Access controls/security services Reaction (isolate, correct, act) Vulnerability assessment and planning	Limited network discovery, management, security management, and expert systems capabilities Limited authentication and identification capabilities Limited ability to manage distributed information Limited classification management capability of data objects	Robust, adaptive, automated, context-based information distribution infrastructure Advanced high-speed protocol/encryption and advanced key management for tactical and strategic networks
Ensure that information is sound and unimpaired.	Information consistency Access controls/security services Service availability Network management and control Damage assessment Reaction (isolate, correct, act) Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited ability to support multilevel security, especially in coalition operations Limited availability of trusted operating systems Vulnerabilities in application of commercial off-the-shelf items Limited authentication and identification capabilities Limited classification management capability of data objects Limited scaleable encryption	Secure firewalls and guards (B3 Level) MLS secure COTS-based clusters Trusted systems Advanced high-speed protocol/encryption and advanced key management for tactical and strategic networks

Table IV.A-2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
The Grid (continued)			
Operational Capability Element: High Assurance of Services (continued)			
Provide early warning of potential attacks so as to (1) alert all defensive mechanisms; (2) initiate available, reactive measures; and (3) minimize or obviate attack effectiveness.	Damage assessment Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited predictive and anticipatory network management capability Limited IW sensors, processing, and reporting for grid self defense Inability of intrusion detection techniques to scale or to facilitate BDA or automated response	Automated network discovery, intrusion detection, and response capabilities Security analysis tools Secure GPS
Achieve an ability to continue to operate at some nominally acceptable level through attacks so as to avoid catastrophic failure of the system and endure into the postattack period for recovery and/or reconstitution.	Service availability Network management and control Damage assessment Reaction (isolate, correct, act) Vulnerability assessment and planning	Limited predictive and anticipatory network management capability Limited IW sensors, processing, and reporting for grid self defense Inability of intrusion detection techniques to scale or to facilitate BDA or automated response Limited IW damage assessment and damage control capability Limited capability to support continued operations during network partition	Dynamic reallocation of computing resources Automated network discovery, intrusion detection, and response capabilities Security analysis tools Fault avoidance and recovery mechanisms

The IS DTOs listed in Table IV.A-3 also cover a wide range of initial IW needs. The Navigation Warfare ACTD (A.16) is aimed toward improving the survivability of GPS information. Information Operations C² (A.04) will provide an electronic attack capability against advanced communications in use today as well as those that are being further developed as recognizable potential threats in future conflicts.

Near-term demonstrations will provide a basis for further improvements in tactical integration, real-time management of C⁴ISR, and dynamic retasking of forces; and for better integration of concurrent planning and execution at the system level in the 2000–2005 timeframe. The prototype grid capabilities demonstrated in the near term will begin to evolve into the type of massive, heterogeneous, distributed, and responsive information services environment envisioned in the long-term ABIS objectives.

Further advances and demonstrations are required for the 2000–2010 timeframe to ensure the availability of information superiority, and the secure and effective services that the warfighters will need in future conflicts. The Information Systems and Technology DTOs cover a number of longer term objectives, discussed in the *Defense Technology Area Plan*. These DTOs will demonstrate IS capabilities in support of new operational concepts to achieve overwhelming effect across the full spectrum of dominant maneuver, precision engagement, full-dimension protection, and focused logistics capabilities envisioned by the ABIS study. Transitions from demonstrations associated with DTOs into fieldable systems integrated with a common architecture are critical to providing the joint warfighter with these technical capabilities.

**Table IV.A-3. Defense Technology Objectives—
Information Superiority**

DTO No.	Title
A.02	Robust Tactical/Mobile Networking
A.03	Joint Power Projection/Real-Time Support (Navy)/Rapid Force Projection Initiative Command and Control TD (Army)
A.04	Information Operations C ²
A.05	Integrated Collection Management ACTD
A.06	Rapid Battlefield Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.09	Semiautomated Imagery Processing ACTD
A.10	High-Altitude Endurance Unmanned Aerial Vehicle ACTD
A.11	Counter-Camouflage Concealment and Deception ATD
A.12	Information Security
A.13	Satellite C ³ I/Navigation Signals Propagation Technology
A.14	Tactical Unmanned Aerial Vehicle ACTD
A.16	Navigation Warfare ACTD
A.17	Joint Task Force ATD
A.18	Advanced Cooperative Collection Management
A.19	Extending the Littoral Battlespace (Sea Dragon) ACTD
F.14	Joint Decision Support Tools
IS.01.01	Consistent Battlespace Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.13.01	Simulation Interfaces
IS.21.01	Assured Communications
IS.23.01	Digital Warfighting Communications
IS.31.02	Intelligent Control
IS.34	Joint Force Air Component Command Battle Management Program
SE.01.02	Low-Cost Electronically Scanned Antennas
SE.02.01	Foliage Penetration Detection Algorithm Demonstration
SE.03.01	Enhanced Moving Target Detection Development
SE.04.02	High-Frequency Surface Wave Radar Shipboard Demonstration
SE.05.01	Automatic Radar Periscope Detection and Discrimination
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	ATR for Reconnaissance and Surveillance
SE.26.01	Millimeter-Wave Power Modules
SE.27.01	Microwave SiC High-Power Amplifiers
SE.28.01	Low-Power Radio Frequency Electronics
SE.33.01	Advanced Focal Plane Array Technology

**Table IV.A-3. Defense Technology Objectives—
Information Superiority (continued)**

DTO No.	Title
SE.35.01	Optical Processing and Memory
SE.37.01	High-Density Radiation-Resistant Microelectronics
SE.38.01	Microelectromechanical Systems
SE.45.01	Forecast of Littoral Currents and Waves
SE.47.01	Autonomous Ocean Sampling Network: Mapping of Ocean Fields
SE.52.01	Weather/Atmospheric Impact on Sensor System

Table IV.A-4. Demonstration Support—Information Superiority

Demonstration	Operational Capability Elements									Service/ Agency	Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			The Grid				DTO	ACTD	ATD	TD
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services					
Robust Tactical/Mobile Networking									●	DARPA	A.02		X	
Joint Power Projection/Real-Time Support (JPPRTS) (Navy)/Rapid Force Projection Initiative Command and Control (RFPICC) TD (Army)					●	●				Navy	A.03			X
Information Operations C ²				●		●				CECOM	A.04		X	
Integrated Collection Management		●								DIA	A.05	X		
Rapid Battlefield Visualization	●		●							JPSD	A.06	X		
Battlefield Awareness and Data Dissemination			●							DARPA	A.07	X		
Semiautomated Imagery Processing	●									DARPA	A.09	X		
High-Altitude Endurance Unmanned Aerial Vehicle	●									DARPA	A.10	X		
Counter-Camouflage Concealment and Deception (CC&D)	●									DARPA	A.11		X	

● Strong Support

○ Moderate Support

Table IV.A-4. Demonstration Support—Information Superiority (continued)

Demonstration	Operational Capability Elements									Service/ Agency	Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			The Grid				DTO	ACTD	ATD	TD
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time- Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services					
Information Security									●	CECOM	A.12		X	
Satellite C ³ I/Navigation Signals Propagation Technology									●	Air Force, Phillips Lab.	A.13		X	
Tactical Unmanned Aerial Vehicle	●									Joint UAV Office	A.14	X		
Navigation Warfare									●	GSP/JPO	A.16	X		
Joint Task Force					●					DARPA	A.17		X	
Advanced Cooperative Collection Management	●									DARPA	A.18		X	
Extending the Littoral Battlespace (Sea Dragon)								●		USMC	A.19	X		
Joint Decision Support Tools		○	●	○	●	○				MARCOR- SYSCOM	F.14	X		
Consistent Battlespace Understanding			●							CECOM	IS.01.01			
Forecasting, Planning, and Resource Allocation				●						CECOM	IS.02.01			
Integrated Force and Execution Management				●	●	●				CECOM	IS.03.01			
Simulation Interfaces			●							STRICOM	IS.13.01			
Assured Communications							○		●	Air Force/ RL	IS.21.01			
Digital Warfighting Communications			○		○	○			●	CECOM	IS.23.01			
Intelligent Control	●	●				○				ARL	IS.31.02			
Joint Force Air Component Command Battle Manage- ment Program			●	○	●	●				DARPA	IS.34			
Low-Cost Electronically Scanned Antennas	●		●	●		●				Army ARL	SE.01.02			
Foliage Penetration Detec- tion Algorithm	●		●	●		●				Air Force WL	SE.02.01			

● Strong Support

○ Moderate Support

Table IV.A-4. Demonstration Support—Information Superiority (continued)

Demonstration	Operational Capability Elements									Service/ Agency	Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			The Grid				DTO	ACTD	ATD	TD
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time- Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services					
Enhanced Moving Target Detection Development	●		●	●		●				Air Force RL	SE.03.01			
High-Frequency Surface Wave Radar Shipboard Demonstration	●		●	●						Navy NCCOSC	SE.04.01			
Automatic Radar Periscope Detection and Discrimina- tion	●		●	●						Navy ONR	SE.05.01			
Affordable ATR via Rapid Design, Evaluation, and Simulation	●									Army, Air Force	SE.19.01			
ATR for Reconnaissance and Surveillance	●									Joint	SE.20.01			
Millimeter-Wave Power Modules		○				○			●	ONR	SE.26.01			
Microwave SiC High- Power Amplifiers				●						ONR	SE.27.01			
Low-Power Radio Frequency Electronics	○					○			●	ONR	SE.28.01			
Advanced Focal Plane Array Technology	●		○							DARPA	SE.33.01			
Optical Processing and Memory	○	○	○						●	Air Force/ RL	SE.35.01			
High-Density Radiation- Resistant Microelectronics (HRRM)						●		○	●	DSWA	SE.37.01			
Microelectromechanical Systems (MEMS)	○								●	DARPA	SE.38.01			
Forecast of Littoral Currents and Waves	○			●		○				ONR	SE.45.01			
Autonomous Ocean Sampling Network: Map- ping of Ocean Fields	○			●		○				ONR	SE.47.01			
Weather/Atmospheric Impact on Sensing System	●		●	●	○	●		●	○	Air Force Phillips Lab.	SE.52.01			

● Strong Support

○ Moderate Support

Joint Warfighting Capability

Operational Capability Element

ACTD/
ATD

Supporting Technology

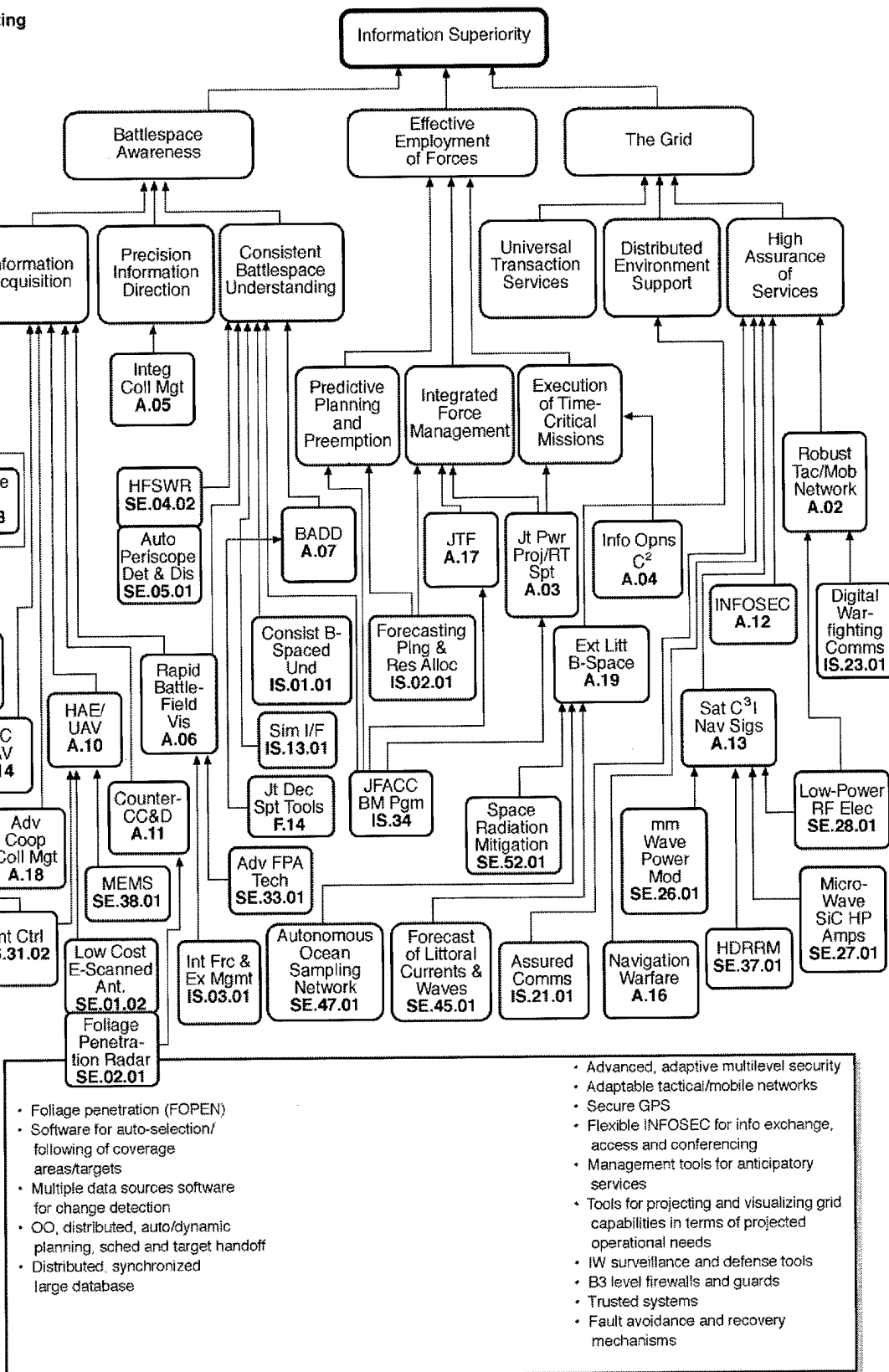


Figure IV.A-3. Technology to Capability—Information Superiority

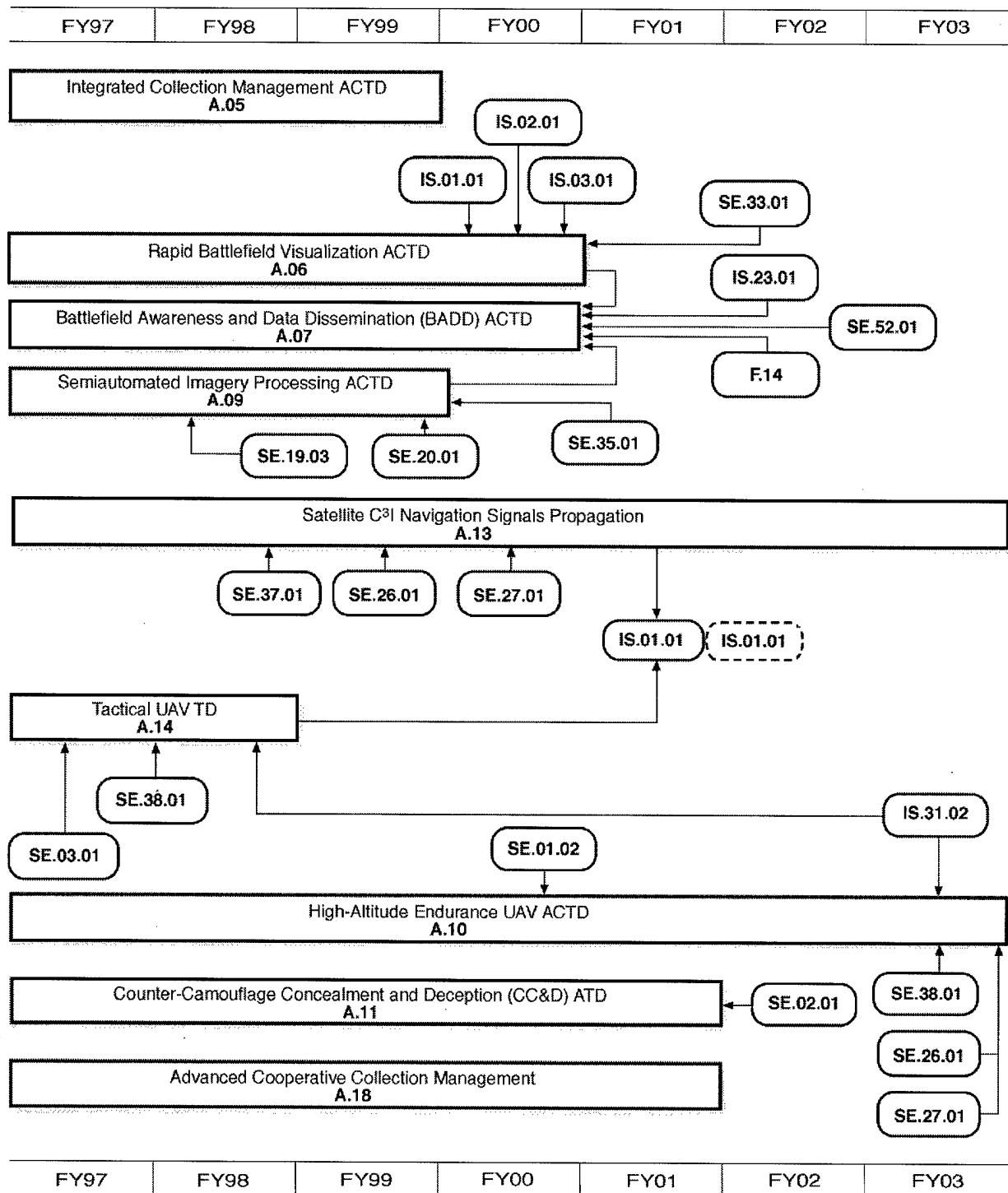


Figure IV.A-4. Roadmap—Information Superiority, Battlespace Awareness Capability Area

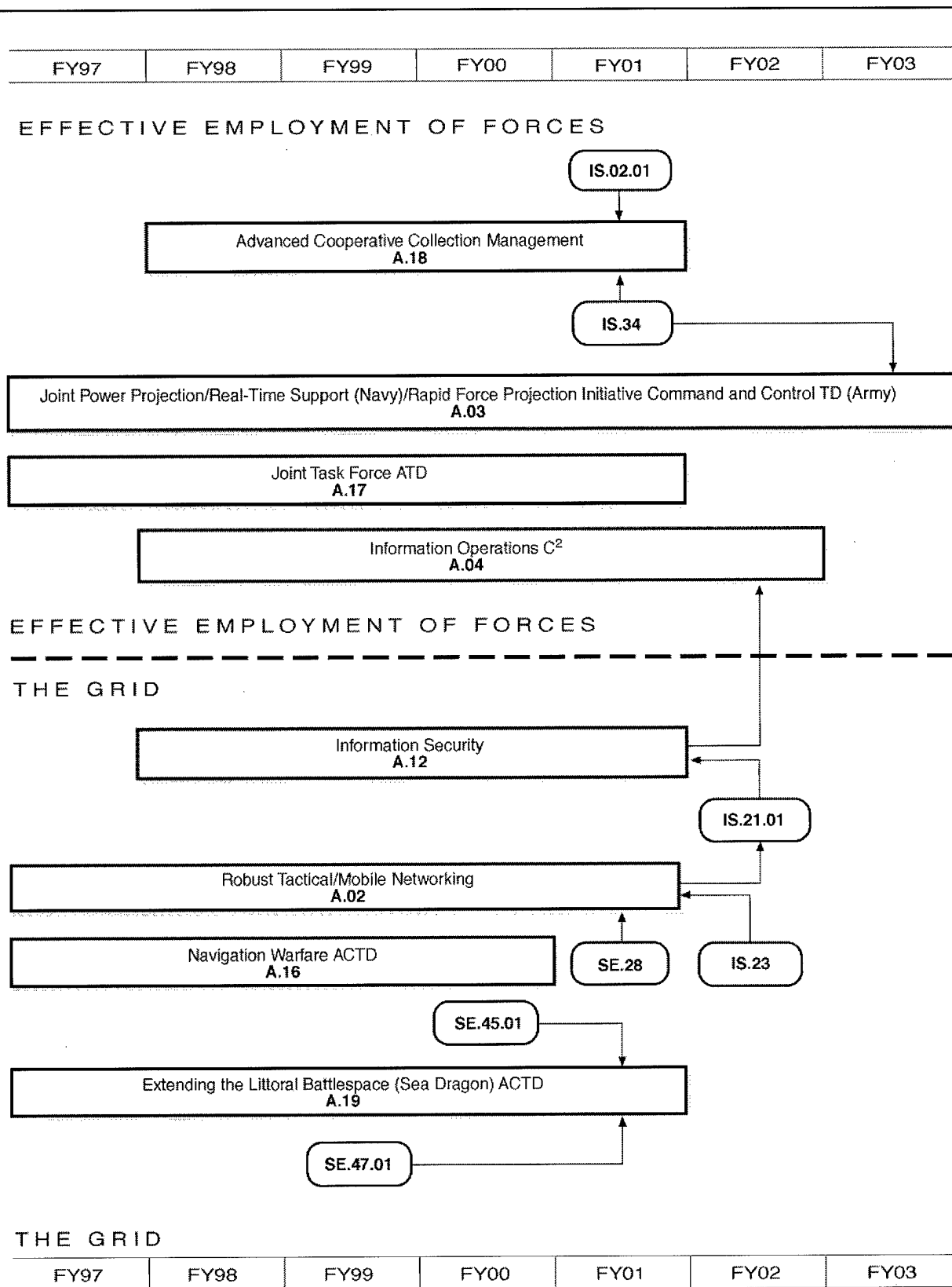


Figure IV.A-5. Roadmap—Information Superiority, Effectiveness Employment of Forces and The Grid Capability Areas

6. Summary

The programs described above will demonstrate and evaluate a wide range of potential IS improvements over the next 3 to 5 years. Realizing the incremental improvements that lead to the JCS chairman's revolutionary vision of overwhelming dominance in the battlespace will require a continuing long-term commitment not only within the S&T program but also to integrating these capabilities into systems. These efforts, coupled with the projected continued doubling every 2 years of the performance of the underlying information system hardware, should result in significant incremental improvements in the warfighters' visibility and command of the battlespace, as well as in the availability of accurate, detailed sensor-to-shooter information (see Figure IV.A-6).

Between now and the year 2000, improvements in force employment capabilities will largely be based on better target recognition and timely attack, improved C² early in the campaign, the beginnings of a defensive IW capability, and an improved information environment for collaborative work. Battlespace awareness will be improved by providing a consistent situational picture and an ability for the integrated tasking of signals intelligence (SIGINT) and imagery intelligence (IMINT) capabilities. Improved awareness capabilities will support tactical needs and provide real-time sensor information directly to shooters. Grid capabilities will be improved to support the rapid configuration of tactical networks (including nodes for mobile users) with enhanced abilities to integrate and distribute information securely in a broadly heterogeneous environment.

In the longer term (2000-2010), the continued evolution of operational concepts and the availability of new technologies will provide a basis for the full development of ABIS concepts. Further improvements in force employment capabilities will be possible through wider dissemination of each commander's intent. Improved automated tools for local decision making, coupled with better status information and an ability to forecast likely future options and contingencies, would enhance the ability of commanders at all levels to reason from ambiguous information and to tailor force and mission packages to meet the needs of an ongoing conflict. Battlespace awareness capabilities will be enhanced by continuously projecting friendly and enemy moves and their likely outcomes, by adaptively supporting cognitive functions of diverse users, and by providing tailored information for mission execution when and where it is needed. Grid capabilities will be made more robust by advances in adaptive network management and information warfare, and by providing end users with an ability to tailor and adapt their information environment and access to information.

Information warfare is a relatively new joint warfighting area that is integrated into all three IS broad operational capability areas. Near-term capabilities will internetwork warfighters at the tactical level, improve the security and reliability of distributed databases, and provide improved protection techniques. Midterm capabilities will take advantage of high-bandwidth, encrypted links to internetwork warfighters at varying levels of security, and provide a suite of IW planning tools and effectiveness models. The successful advancement of these technologies will ensure the availability, confidentiality, and integrity of information by providing the warfighter with a robust, adaptive, automated, context-based information infrastructure and suites of tools to protect friendly information systems, while adaptively managing our own information management services.

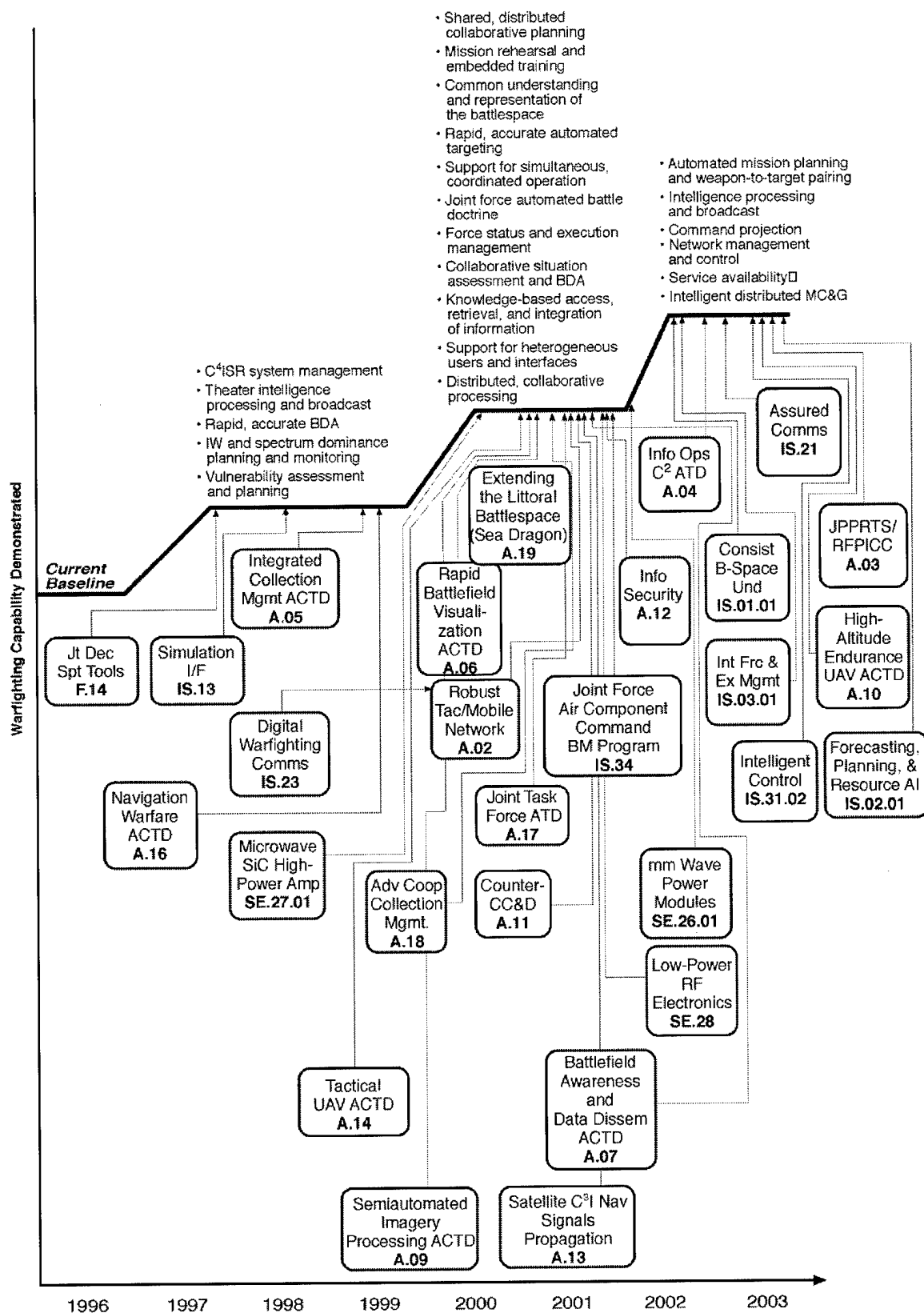


Figure IV.A-6. Progress—Information Superiority

It is important to recognize that the information warfare threat is real. IW capabilities, at various levels, are widely available throughout the world. DoD systems, particularly those that are unclassified, are currently vulnerable. While a concerted, coordinated attack against DoD interests would require considerable resources, significant focused damage to DoD information systems is already possible. The S&T community takes this threat seriously and will continue to focus funding on key technologies that support the joint warfighter IW requirements.

These recommended DTOs take fully into account commercially available technology and often utilize such technology. However, even with the continued capability improvements of commercial information systems, it will be a great challenge to meet the demand for greater bandwidth, processing throughput and faster response time. In addition, unique technology will be required for capabilities needed only by the military. Also, in some areas military capability is needed earlier than the commercial market has sufficient demand to justify.

While all the DTOs listed here are important critical components of the IS capability envisioned by *Joint Vision 2010* and articulated in ABIS, they are insufficient. Out-year demonstrations will be needed to illustrate and validate additional advances. The emphasis in the out-year program will need to be on development and demonstration of essential intelligent, adaptable capabilities to ensure availability and security of services at all echelons and to support dominance in all types of conflict.

Information superiority, with integrated information warfare capabilities, represents a new tenet in military doctrine. The appropriate investment in the supporting technologies will enable DoD to achieve military superiority through information superiority.

B. PRECISION FORCE

1. Definition

Precision Force is the capability to destroy selected high-value and time-critical targets or to inflict damage with precision while limiting collateral damage. This capability supports mission requirements to rapidly neutralize hostile assets for communication, command and control, mobile or fixed weapons of mass destruction (WMD), attacking force projection elements and supporting infrastructure. Precision Force includes surveillance, targeting capabilities, and precision-guided munitions. It requires advances in sensors, C² interoperability, battle management, and lethality. It also requires precision-guided munition enhancements for increased weapon range, accuracy, and effectiveness. Additionally, *sensor-to-shooter* enhancements in C⁴ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) are necessary for responsive and timely force application.

The C⁴ISR enhancements needed for Precision Force are included in Section A, Information Superiority. Additionally, the Precision Force capabilities addressed in this section support the attack operational elements of Joint Theater Missile Defense (Section D) by providing capabilities for quick-response strikes against mobile and fixed missile launchers. Furthermore, many of the Precision Force JWCOs are enabled or enhanced by incorporating advanced sensor technologies.

Figure IV.B-1 shows a typical concept of precision force. Additional components include land- and sea-launched fighter and bomber aircraft, Tomahawk Land Attack Missiles (TLAMs), and naval gunfire.

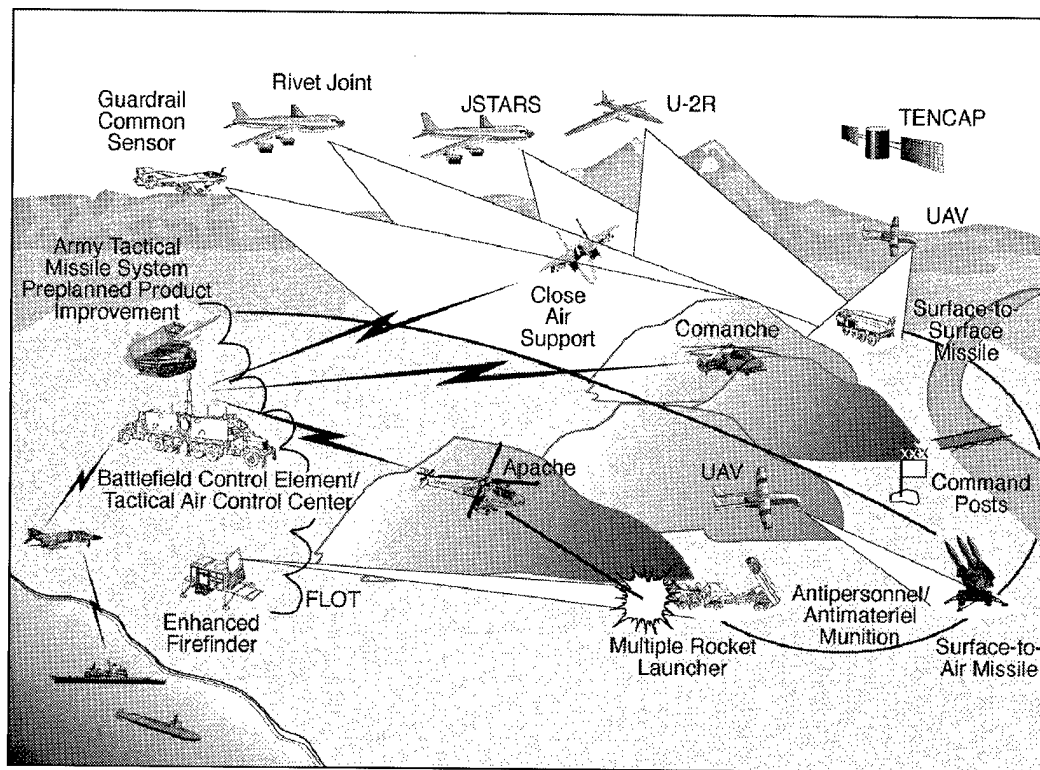


Figure IV.B-1. Concept—Precision Force

2. Operational Capability Elements

Mission space is no longer linear or sequential. Given a digitized battlespace environment with C⁴ISR, the partitioning between land, sea, and air mission space disappears. The precision force concept is achievable only with heavy reliance on many technologies being developed to support other Joint Warfare Capability Objectives (JWCOs). By drawing on these capabilities, the joint area commander will be able to attack and neutralize enemy forces and capabilities throughout the breadth and depth of the mission space to break the coherence and continuity of the enemy's operations.

The key operational capability elements are:

- Mission planning
- C⁴ISR
- Weapon employment
- Combat assessment.

Operational capability elements for precision force are supported by selected Defense Technology Objectives (DTOs) of the Information Superiority and joint missile defense JWCOs and selected DTOs for the weapons, sensors, electronics, and battlefield environment technical areas. Many of the required precision force technologies will be demonstrated in ACTDs, ATDs, and TDs within these JWCO and DTAP areas.

Mission Planning. The mission planning operational capability element is strongly dependent on, but not limited to, battlespace management, target prioritization, long-range sensors, and timely intelligence dissemination to the user. Once the target has been identified (by national assets or by air or ground targeting systems) and a strike requested, the mission planning process begins. As part of this process, target surveillance is continued and situational awareness is maintained. Target priorities are set and primary strike assets selected. Mission planning continues into weapon employment, as a seamless function, as described below.

C⁴ISR. C⁴ISR technologies are the enabling technologies for the precision force concept. Without the ability to communicate in near-real time between the battlefield and fire support elements (air, land, or ground based), the destruction of time-critical targets becomes problematic. To fulfill future battlespace demands, targets must be identified and destroyed quickly—a function highly dependent on effective correlation and fusion of data from different sensors. The technology exhibited as part of the Rapid Battlefield Visualization ACTD will allow both key decision makers and planners to rapidly share a common perception of the battlefield. Also the capabilities demonstrated during the PRCMRL ACTD—such as Matrix, Terrain Evaluation Module (TEM), and Top Scene—will greatly assist in the intelligence preparation of the battlefield.

Weapon Employment. Once the strike asset is selected (e.g., air- or sea-launched cruise missile) and target acquisition is made either by the strike munition or the system selected to interface with the strike munition, the weapon is launched. With a real-time update of the battlespace situation, including continuous target surveillance, the strike munition can be retargeted after launch, should the initial target be destroyed by another asset, or should another target become a more serious, time-critical threat.

Combat Assessment. Combat assessment (which is vital for gauging attack effectiveness), planning followup strikes, and assessing the enemy's ability to continue are strongly dependent on, but not limited to, 24-hour, all-weather sensors, responsive targeting and planning products, and counter-camouflage, concealment, and deception (CC&D) penetration.

3. Functional Capabilities

Precision force operational capability elements are made possible by a number of functional capabilities. Table IV.B-1 identifies these functional capabilities and shows the linkages with operational capabilities.

Recent RAND studies summarize the potential implications of enhanced operational concepts associated with the Rapid Force Projection Initiative that are based on emerging technologies such as standoff weapons, unattended sensors, intelligent minefields, and hunter vehicles (References 12 and 13). These studies have shown that the vulnerability of light forces—such as a Division Ready Brigade (DRB)—to current *and future* heavy forces can be substantially reduced or, in many cases, eliminated. The combination of Army, Navy, and Air Force standoff weapons and sophisticated reconnaissance and targeting systems—coupled with efficient counterbattery systems—has been shown to be more effective than current forces that rely on direct-fire, line-of-sight (LOS) technologies.

A DRB—operating with the support of Air Force or Navy precision weapons—would have significantly enhanced lethality against a heavily armored foe employing widespread Soviet equipment and Soviet-style tactics by employing hunter/standoff killer (HSOK) systems. HSOK weapons introduce the benefits of an indirect, precision-fire battlefield. The HSOK systems attain viability because of emerging technologies that enable the battle to commence earlier at greater range, extend the battle to non-LOS battlespace, and meter surviving enemy heavy forces at a reduced rate such that direct-fire systems become increasingly effective.

4. Current Capabilities, Deficiencies, and Barriers

Operational capability elements and associated limitations are presented in Table IV.B-2. Major deficiencies confronting the area of mission planning are the timely combat decision and resource allocation processes in relation to target cycle time, the detection of highly mobile targets in crowded mission space, slow processes for fusing various service automated mission planning systems for target information, and time consuming and incomplete battle damage information and assessments.

Inadequacies in the area of weapon employment include the inability to satisfy the simultaneous need for sensor information; the limited ability of some sensors to acquire and track multiple targets; inadequate coordination of sensor information among battle managers; lack of an all-weather/day-night precision (<3-meter CEP) weapon capability; sortie efficiency for attacks against hard, buried, and strategic targets; GPS jamming; and more affordable precision-guided munitions.

Deficiencies confronting combat assessment revolve around timeliness (either real time or near-real time rather than the current capability of several hours) and accuracy. A major challenge is to counter an adversary's camouflage, concealment, and physical/electronic deception techniques to obtain accurate battle damage assessments and to measure weapons effectiveness.

Table IV.B-1. Functional Capabilities Needed—Precision Force

Functional Capabilities	Operational Capability Elements						
	Mission Planning		Weapon Employment			Combat Assessment	C ⁴ ISR
	Planning	Surveillance and Reconnaissance	Target Acquisition	Weapon System Employment	Survivability		
1. Scheme of Operations	●	●	●	●	●	●	●
2. Battlespace Management	●	●	○	○	○	○	●
3. Intelligence Preparation of the Battlefield	●	●	●	○	○	●	●
4. Target Priorities	●	●	●	●	○	○	○
5. Weapons (resource) Allocations	●	○	○	●	●	○	○
6. Target Database	●	●	○	●	●	○	○
7. Round-the-Clock, Day/Night, All-Weather Coverage (sensors)	●	●	●	●	○	●	○
8. Counter CC&D Penetration	○	●	●	●	○	●	○
9. Responsive Targeting/Planning Products	●	●	●	●	○	●	●
10. Long-Range Sensors (deep look)	●	●	●	○	○	●	●
11. Survivable	●	●					
12. Area Coverage	●	●	●	○	○	●	○
13. Correlation/Fusion	●	●	●			●	●
14. Timely Intelligence Dissemination to User (planner and shooter, RTIC)	●	●	●	○	●	●	●
15. Timely Sensor Retasking		○	●			●	●
16. Timely and Accurate Location or Track Data		○	●				
17. Combat ID			●			●	●
18. Automatic Target Recognition		●	●	●		●	●
19. All-Weather, Day/Night Capable	○	●	●	●		○	
20. Responsive				●		○	
21. Long Range				●			
22. Flexible Weapon Platform (precision)	○			●			
23. Lethal (precision)		○		●			
24. Discriminate/Combat Identification			○	●	○		
25. Base Defense/Force Protection					●		
26. Air Superiority			○	○	●		
27. Suppression of Enemy Air Defense (SEAD)	○			○	●	○	
28. Timely Product	○	○				●	●
29. Accuracy		●	●			●	

● Strong Support

○ Moderate Support

Table IV.B-1. Functional Capabilities Needed—Precision Force (continued)

Functional Capabilities	Operational Capability Elements						
	Mission Planning		Weapon Employment			Combat Assessment	C ⁴ ISR
	Planning	Surveillance and Reconnaissance	Target Acquisition	Weapon System Employment	Survivability		
30. Updates to Targeting Database	○					●	
31. Secure, Interoperable C ⁴ Structure (communications, databases, protocols, etc.)	●	●	○	○	○	○	●
32. Dynamic Database	●	●	○	○		●	
33. Proactive Architecture ("pull" right information at the right time system)	●		●	●	●	●	
34. Geopositioning	●	●	●	●	●	●	●
35. Joint Battlefield Architecture	●	●	○			○	●

● Strong Support

○ Moderate Support

Table IV.B-2. Goals, Limitations, and Technologies—Precision Force

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Mission Planning			
Provide a real-time, fused, battlespace picture with integrated decision aid tools. This will ensure coordinated and dynamic planning and execution of a broad spectrum of missions from time-phased attack of targets to reconnaissance of battle areas and prosecution of time critical targets by integrated hunter-killer controller assets.	<i>Planning</i> Scheme of operations Battlespace management Intelligence preparation of the battlefield Target priorities Weapons (resource allocation) Target database <i>Surveillance and Reconnaissance</i> Round-the-clock, day/night/all-weather coverage (sensors) Counter CC&D penetration Responsive targeting/planning product/timely dissemination Long-range sensors Survivable Area coverage Correlation/fusion	Costly Required training Real-time response Integration with aircraft is limited; may have to type in data after planning Cannot do mission planning/replanning in aircraft Services use different systems	Integrated target track Multisensor ATR Real-time cognizant aiding display Hunter sensor suite Remote sentry Strike weapon adaptable video and communications technology Battlespace C&C Real-time template/weapons retargeting

Table IV.B-2. Goals, Limitations, and Technologies—Precision Force (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Weapons Employment			
Provide processing and linkages that enable rapid target search and acquisition, battle coordination and target selection, and hand-off and engagement for prosecution of time-critical targets.	<i>Target Acquisition</i> Timely intelligence dissemination to user (planner and shooter) Timely sensor retasking Timely and accurate location or track data Combat ID—cooperative and non-cooperative systems ATR <i>Weapon System Employment</i> All-weather, day/night capable Responsive Sufficient range Flexible weapon platform (precision)—retargetable Lethal (precision) Discriminate/combat ID <i>Survivability</i> Base defense/force protection Air superiority Suppression of enemy air defense	Mobile target engagement GPS jamming Affordability Battle damage assessment (BDA) Following capabilities required: All-weather 3m CEP weapon Low collateral hard target weapon Hypersonic weapons IFF High off-boresight high angle of attack Nonlethal weapons	Multisensor ATR Real-time cognizant aiding display Hunter sensor suite Remote sentry Real-time template/weapons retargeting Miniaturizing GPS and laser radar Advanced unitary penetrator Antijam GPS technology flight test SAR guidance Hard target smart fuze Differential GPS and terminal guidance EFOG sensor system Miniature navigation system High g-load IR target seeker Sensor fusion and NLOS weapons Shallow-water torpedo G&C Smart skins arrays High stress/load structure Multimode warhead MEMS
Operational Capability Element: Combat Assessment			
Provide ability to determine near-real-time physical effect of force application to targets and quickly assess impact on in-theater operations.	Timely sensor retasking All-weather, day/night capable Real-time response Accuracy Interoperable updates to targeting database	Real-time response Services use different systems BDA Tasking Limited tactical assets F-14 (TARPS) + UAV Counter CC&D	Strike weapon adaptable video and communications technology Sensor fusion and NLOS weapons Joint precision strike
Operational Capability Element: C⁴ISR			
Provide joint core mission planner, with fully automated "virtual battlefield view" (100 percent consistent across echelons, with aggregation), which results in direct sensor/shooter tasking in <1 minute with predictive delivery of electronic mission support	Survivable Secure, interoperable C⁴ structure (communications, databases, protocols, etc.) Dynamic database Proactive architecture (pull right information at the right time) Geopositioning Joint battlefield architecture	Real-time response Services use different systems Too much or too little data No/limited fusion of data (i.e., same track from multiple sources or sensors) UHF limited to line of sight	Strike weapon adaptable video and communications technology Real-time template/weapons retargeting Digital battlefield communications Battlespace C&C Precision SIGINT target Low probability of intercept (LPI) communication systems LPI sensors Tactical UAV

Shortcomings in C⁴I focus on two trends. First is the need to handle ever-increasing amounts of information more quickly than ever before. Second is the steady integration of C⁴I functions into a modular “system-of-systems” architecture that maximizes information availability and aids the planners and warfighters in making the most effective use of that information. The ability to conduct rapid, accurate target identification and selection requires substantial development, as does the ability to follow up attacks with comprehensive combat assessments. Technology that will facilitate the completion of real-time, collaborative planning both in the area of operations and at distributed staff locations must be a priority. To support planning improvements, staff and commanders need to be able to track force status and execution. Rapid, precise strike planning will be improved by the development of a capability to quickly pair mission requirements, target locations, and physical characteristics to weapon delivery systems. The capability to better manage and integrate intelligence, surveillance, and reconnaissance analysis will enhance development of the precision force concept. The automatic target weapon pairing developed during the Precision Rapid Counter-MRL ACTD will definitely enhance the U.S. ability to conduct precision force missions.

5. Technology Plan

The science and technology program to correct the deficiencies in mission planning, weapon employment, combat assessment and C⁴ISR is shown in Figure IV.B-2. These technologies offer the potential for a significant increase in today’s capability. Their need is underscored by experience in Operation Desert Storm.

Table IV.B-3 identifies the joint warfighting precision force DTOs. Definitions, points of contact, and funding profiles for the Joint Precision Force DTOs are provided. Table IV.B-4 shows the DTOs that, when attained, will enable the operational capability elements. The schedule for achieving the DTOs is in the technology roadmap in Figure IV.B-3. This roadmap represents activities in mission planning, weapon employment, combat assessment, and C⁴ISR.

The technology efforts include projects in the Army, Air Force, Navy, Marine Corps, and DARPA S&T program. Below is a list of the efforts by DTO:

- **B.01** *The Precision Rapid Counter Multiple Rocket Launcher (PRCML) ACTD* will develop and demonstrate a joint, adverse-weather, day/night, end-to-end, sensor-to-shooter, precision deep-strike capability to locate, identify, and kill high-value, short-dwell, time-sensitive targets and assess damage within tactically meaningful timelines.
- **B.02** *The Rapid Force Projection Initiative (RFPI) ACTD* will demonstrate automated target transfer from forward sensors to standoff killer weapon systems with the capability to engage high-value targets beyond traditional direct-fire ranges. A “tactical internet”-based digital communications architecture will network hunters, standoff killers, and commanders.
- **B.03** *The Precision Signals Intelligence Targeting Systems (PSTSs) ACTD* is an effort to develop and demonstrate a near-real-time, precision targeting, sensor-to-shooter capability using existing national and tactical assets.
- **B.05** *The Target Acquisition (TA) ATD* will provide the warfighter a system for night or poor-visibility usage that will offer knowledge of the battlespace in real time and will improve light/armored combat vehicle lethality and survivability.

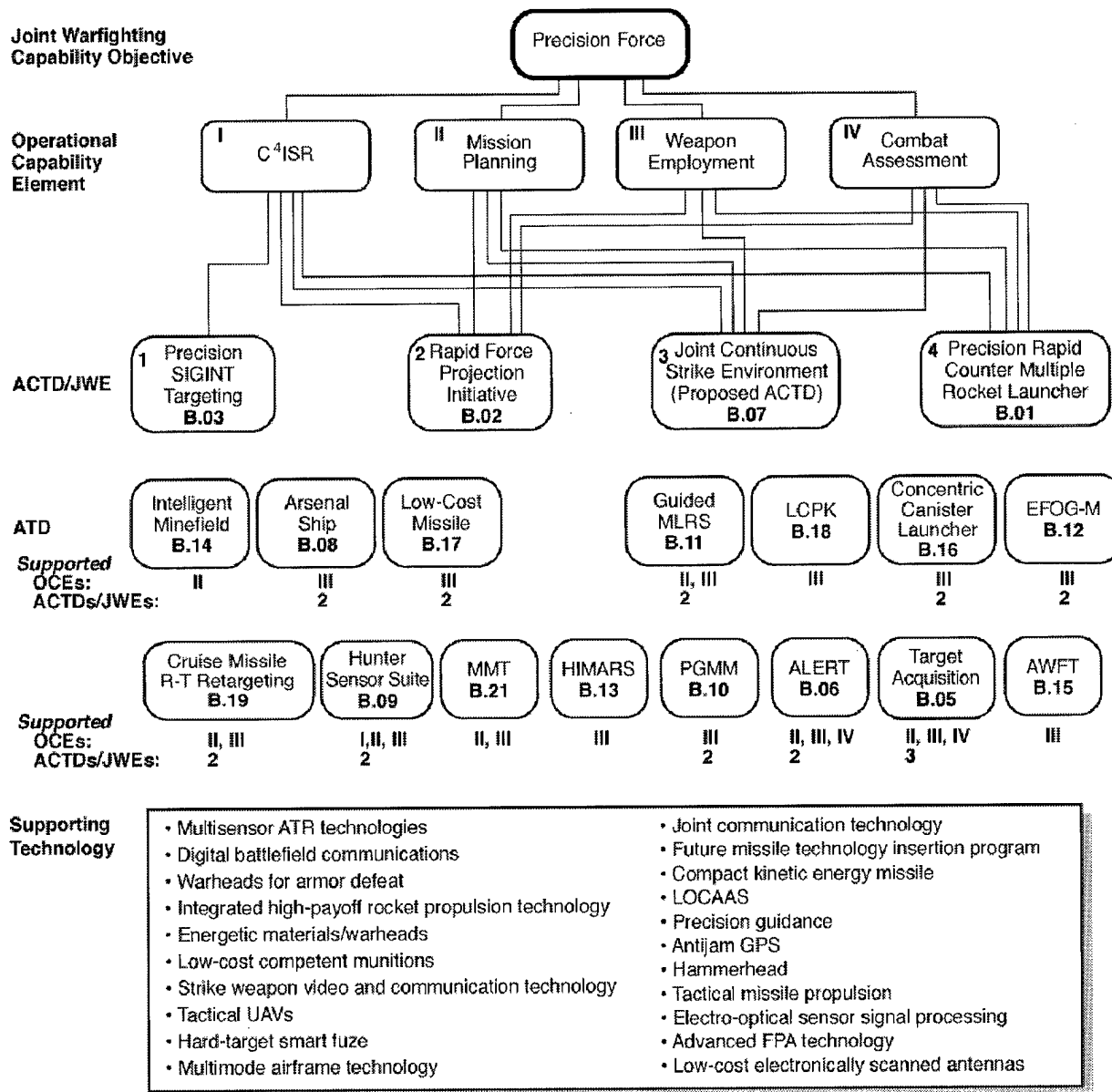


Figure IV.B-2. Technology to Capability—Precision Force

Table IV.B-3. Defense Technology Objectives—Precision Force

DTO No.	Title
B.01	Precision Rapid Counter Multiple Rocket Launcher ACTD
B.02	Rapid Force Projection Initiative ACTD
B.03	Precision Signals Intelligence Targeting Systems ACTD
B.05	Target Acquisition ATD
B.06	Air/Land Enhanced Reconnaissance and Targeting ATD
B.07	Joint Continuous-Strike Environment (Proposed ACTD)
B.08	Arsenal Ship
B.09	Hunter Sensor Suite ATD
B.10	Precision Guided Mortar Munitions ATD
B.11	Guided MLRS
B.12	Enhanced Fiber Optic Guided Missile ATD
B.13	High-Mobility Artillery Rocket System
B.14	Intelligent Minefield ATD
B.15	Antimateriel Warhead Flight Test ATD
B.16	Concentric Canister Launcher ATD
B.17	Low-Cost Missile ATD
B.18	Low-Cost Precision Kill
B.19	Cruise Missile Real-Time Retargeting ATD
B.21	Miniaturized Munition Technology Guided Flight Tests
C.01	Battlefield Combat Identification ATD
H.09	Sensor Fusion/Integrated Situation Assessment TD
HS.19.05	Rotorcraft Pilot's Associate
SE.02.01	Foliage Penetration Detection Algorithm Demonstration
SE.03.01	Enhanced Moving Target Detection Development
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	ATR for Reconnaissance and Surveillance
SE.33.01	Advanced Focal Plane Array Technology
WE.12.02	Antijam GPS Flight Test
WE.17.02	Hammerhead
WE.21.02	Fiber Optic Gyro-Based Navigation Systems

Table IV.B-4. Demonstration Support—Precision Force

Demonstration	Operational Capability Elements				Service/Agency	Type of Demonstration		
	Mission Planning	C ⁴ ISR	Weapon Employment	Combat Assessment		DTO	ACTD	ATD
Precision Rapid Counter Multiple Rocket Launcher	●		●		Joint	B.01	X	
Rapid Force Projection Initiative	●	●	●	●	Joint	B.02	X	
Precision Signals Intelligence Targeting Systems		●			Navy	B.03	X	
Target Acquisition	●		●	○	Army	B.05		X
Air/Land Enhanced Reconnaissance and Targeting	●	○	●	○	Army	B.06		X
Joint Continuous-Strike Environment	●	●	●		Joint	B.07	X (P)	
Arsenal Ship	○		●		Navy	B.08		
Hunter Sensor Suite	○	○	●	●	Army	B.09		X
Precision Guided Mortar Munitions	●		●		Army	B.10		X
Guided MLRS	●		●		Army	B.11		X
Enhanced Fiber Optic Guided Missile	●	○	●	●	Army	B.12		X
High-Mobility Artillery Rocket System	●	○	●		Army	B.13		X
Intelligent Minefield	●	○	●	○	Army	B.14		X
Antimateriel Warhead Flight Test	○		●		Air Force	B.15		X
Concentric Canister Launcher	○		●		Navy	B.16		X
Low-Cost Missile	○		●		Navy	B.17		X
Low-Cost Precision Kill	○		●		Army	B.18		
Cruise Missile Real-Time Retargeting	●	●	●	○	Navy	B.19		X
Miniaturized Munition Technology Guided Flight Tests	○		●		Air Force	B.21		X
Battlefield Combat ID		●		●	Army	C.01		X
Sensor Fusion/Integrated Situation Assessment	●	●	○	●	Joint	H.09		X
Rotorcraft Pilot's Associate				●	Army	HS.19.05		X
Foliage Penetration Detection Algorithm Demonstration	●	●	●		Air Force	SE.02.01		
Enhanced Moving Target Detection Development	●	●	●		Air Force	SE.03.01		
Affordable ATR via Rapid Design, Evaluation, and Simulation	●				Air Force	SE.19.03		
ATR for Reconnaissance and Surveillance	●				DARPA	SE.20.01		
Advanced Focal Plane Array Technology	●		●	●	DARPA	SE.33.01		
Antijam GPS Flight Test	●		●		Joint	WE.12.02		X
Hammerhead	●	●	●		Air Force	WE.17.02		X
Fiber Optic Gyro-Based Navigation Systems	●		●		DARPA	WE.21.02		X

● Strong Support

○ Moderate Support

(P) Proposed

IV-B-11

- **B.06** *The Air/Land Enhanced Reconnaissance and Targeting (ERT) ATD* will provide the helicopter pilot/gunner the ability to automatically acquire and identify stationary and moving targets from an on-the-move, high-speed aerial platform such as a scout/attack helicopter.
- **B.07** *The Joint Continuous-Strike Environment (JCSE) (proposed ACTD)* will optimize the use of air, land, and sea-based weapons to prosecute emerging targets within their cycle times. It will continuously update target priorities, assess weapon status, match weapon(s) to targets, and ensure execution by deconflicting airspace.
- **B.08** *The Arsenal Ship (AS)* will develop and fabricate the lead ship in half the time of previous naval vessels. The ship will contain four times the VLS cells of a CG-52 class ship, require 80 percent fewer crew members as employed on current vessels (maximum of 50 persons), and support the precision force concept by acting as a remote magazine for air-directed and shore-based targeting and as a cooperative engagement capability ship.
- **B.09** *The Hunter Sensor Suite (HSS)* will demonstrate a lightweight, low-observable, advanced long-range sensor suite with automatic target recognition (ATR) that provides rapid, multiple target acquisition and precision targeting handoff, integrated on stealthy Hunter vehicles operating in station-keeping and mobile modes.
- **B.10** *The Precision Guided Mortar Munitions (PGMM) ATD* will demonstrate the ability to engage, detect, and defeat armored vehicles and high-value point targets, command posts, and logistic sites at ranges out to 12 km.
- **B.11** *The Guided MLRS* will integrate inertial and GPS-based guidance and control packages with the current MLRS extended-range rocket.
- **B.12** *The Enhanced Fiber Optic Guided Missile (EFOG-M) ATD* will develop and confirm precision standoff capability (out to a range of 15 km) against high-priority ground and airborne targets under day, night, and adverse weather conditions.
- **B.13** *The High-Mobility Artillery Rocket System (HIMARS)* will develop and demonstrate a lightweight, C-130-transportable M-270 MLRS launcher variant mounted on a 5-ton Family of Medium Tactical Vehicle (FMTV) truck chassis that uses the same C³ system and crew as the M-270 MLRS.
- **B.14** *The Intelligent Minefield ATD* will integrate new minefield munition systems and technologies (acoustics, decision aids) into an autonomous antiarmor/antivehicle system.
- **B.15** *The Antimateriel Warhead Flight Test* will demonstrate and integrate advanced laser radar (LADAR) sensor technology in combination with a multimode warhead and advanced submunition airframe.
- **B.16** *The Concentric Canister Launcher ATD* will demonstrate the feasibility of a universal launching system employing concentric canisters that can be applied to future combat ships capable of firing a wide range of missiles, including ESSM, Tomahawk, Standard Missile Block IV and the ATACMS.

- **B.17** *Low-Cost Missile ATD* will demonstrate a unique, finless, low-drag, bending annular missile body (BAMB) airframe and ramjet propulsion concept that will provide the capability to attack time-critical and hardened targets in a timely and affordable manner.
- **B.18** *The Low-Cost Precision Kill (LCPK)* will demonstrate a very low cost, accurate guidance and control retrofit package for the 2.75-inch Hydra-70 rocket. This rocket will provide a standoff capability against specified nonheavy armor targets, which are often engaged in large numbers.
- **B.19** *The Cruise Missile Real-Time Retargeting ATD* will develop technologies for brilliant autonomous missiles that have onboard mission planning and control systems.
- **B.21** *Miniaturized Munition Technology (MMT) Guided Flight Tests* will provide the Air Force with a 250-pound smart weapon capable of defeating 85 percent of the JDAM MK83/BLU-109-2010 fixed- and hard-target threats. Offers increased loadout of existing bombers and smaller weapons bay requirements for future aircraft.
- **C.01** *The Battlefield Combat Identification ATD* will attempt to solve the combat identification (ID) problem underscored by the lessons learned from Operation Desert Storm.
- **H.09** *The Sensor Fusion/Integrated Situation Assessment TD* will develop and demonstrate offboard, all-source information correlation (fusion) with onboard multispectral receiver/sensor information and enhanced emitter ID algorithms to provide platform self-defense at long interdiction/strike ranges, enhanced combat ID, and dynamic route planning/retargeting.
- **HS.19.05** *The Rotorcraft Pilot's Associate* program will develop and demonstrate, through simulation and flight test, a knowledge-based associate system for real-time cognitive decision aiding.
- **SE.02.01** *The Foliage Penetration Detection Algorithm Demonstration* provides a capability to detect adversary forces in "hiding" under tree canopies.
- **SE.03.01** *The Enhanced Moving Target Detection Development* provides the warfighter with targeting superiority by detecting moving targets in all battlefield environments.
- **SE.19.03** *The Affordable ATR via Rapid Design, Evaluation, and Simulation* reduces cost and development time for ATR while enhancing and providing evaluation of performance.
- **SE.20.01** *The ATR for Reconnaissance and Surveillance* demonstrates ATR for both fixed and moving targets using standoff radar sensors aboard surveillance and UAV platforms.
- **SE.33.01** *The Advanced Focal Plane Array Technology* provides "on-chip" processing to reduce target acquisition timelines. Reduction of FPA costs will allow more weapon systems to incorporate arrays capable of high-resolution imaging for increased spatial precision, thereby having direct application to some Precision Force FPA requirements.
- **WE.12.02** *The Antijam GPS Flight Test* will develop and demonstrate Global Positioning System (GPS) antijam technology that ensures that the increased accuracy provided by any munition GPS/IMU navigation system is maintained in a jamming environment.

- **WE.17.02** *Hammerhead* will demonstrate a synthetic aperture radar (SAR) seeker that physically, electrically, and logically will integrate with a GBU-15 weapon to perform autonomous, precision guidance in adverse weather.
- **WE.21.02** *Fiber Optic Gyro-Based Navigation Systems* will demonstrate a new generation of affordable and reliable navigation systems.

The three ACTDs—PRCMRL, RFPI, and PSTS—address the deficiencies in the four precision force operational capability elements. The proposed ACTD—JCSE (B.07)—will demonstrate the seamless battlespace environment provided by the digitized C⁴ISR capability. The JCSE goals must be achieved to demonstrate a precision force joint engagement capability.

The ATDs and supporting key technology efforts are advancing work on data fusion and combining ATR technologies with precision location so that weapons can find the types of target specified, or even the particular target specified, and guide a weapon to within a few feet of a designated impact point. Other initiatives to destroy time-critical targets will demonstrate the capability to redirect missiles and attack aircraft while on a mission so as to exploit real-time retargeting.

A major focus is demonstrating GPS applications to both existing and new weapons. Examples include a Navy effort to demonstrate an inexpensive cruise missile and an Air Force effort to develop small smart bomb technology. The Air Force Miniaturized Munition Technology guided flight test will demonstrate the use of GPS guidance on a small penetrator munition. This new capability will dramatically improve the sortie efficiency for attacks against all but the very hardest fixed targets. Another flight demonstration by the Air Force, called Antijam GPS Technology Flight Test (AGTFT), will demonstrate an affordable solution for protecting against an enemy jamming a GPS guided munition. This technology will be demonstrated on a JDAM vehicle in FY98.

The Army Guided MLRS program will increase the accuracy of the Extended-Range MLRS rocket to a 3-mil system. The BAT Preplanned Product Improvement (BAT P³I) will be delivered by the Army TACMS Block II, extended-range Block IIa, and MLRS. BAT P³I employs acoustic, millimeter-wave, and imaging infrared (IIR) seekers while expanding the BAT target set to include cold, stationary armor, moving armor, SSMs, and MRLs. It includes a selectable warhead that will be switched to hard or soft target mode prior to impact. The BAT P³I is currently in the demonstration/validation phase with two competing seeker concepts. The Air Force and Army are jointly pursuing another antimateriel munition called LOCAAS, which uses a LADAR seeker to search, identify, and track ground mobile targets and attacks with a multimode warhead. LOCAAS is being designed for delivery by MLRS and by Air Force fighter and bomber aircraft.

The Air Force is also developing an expanded, more capable air command and control network based on the air operations center, but distributed to the Airborne Command and Control Centers, the Airborne Warning and Control System, and the Joint Surveillance Target Attack Radar System. These systems receive tactical information from their own sensors and from other intelligence platforms and processing systems. They can rapidly direct combat elements to air superiority, ground attack, or interdiction missions.

The Joint Precision Strike Demonstration program includes the Integration and Evaluation Center (IEC), a simulation facility providing real, virtual, and constructive elements. It can use pre-recorded and scripted events on a virtual battlefield and integrates this data line input. The IEC has a special capability to collect and record data during a demonstration, compute and display

user-defined measures of effectiveness in real time, and provide for assessment and evaluation of critical mission parameters. The Rapid Force Projection Initiative ACTD also utilizes extensive simulation.

6. Summary

The collective capability demonstrated for each DTO scheduled between 1997 and 2004 shows a stepped improvement in operational capability over the previous demonstrations. The capabilities and schedule of availability are depicted in Figure IV.B-4. Integration of the DTOs over time will provide a greater ability to accurately locate, identify, and destroy all classes of high-value and time-critical targets with precision while limiting collateral damage.

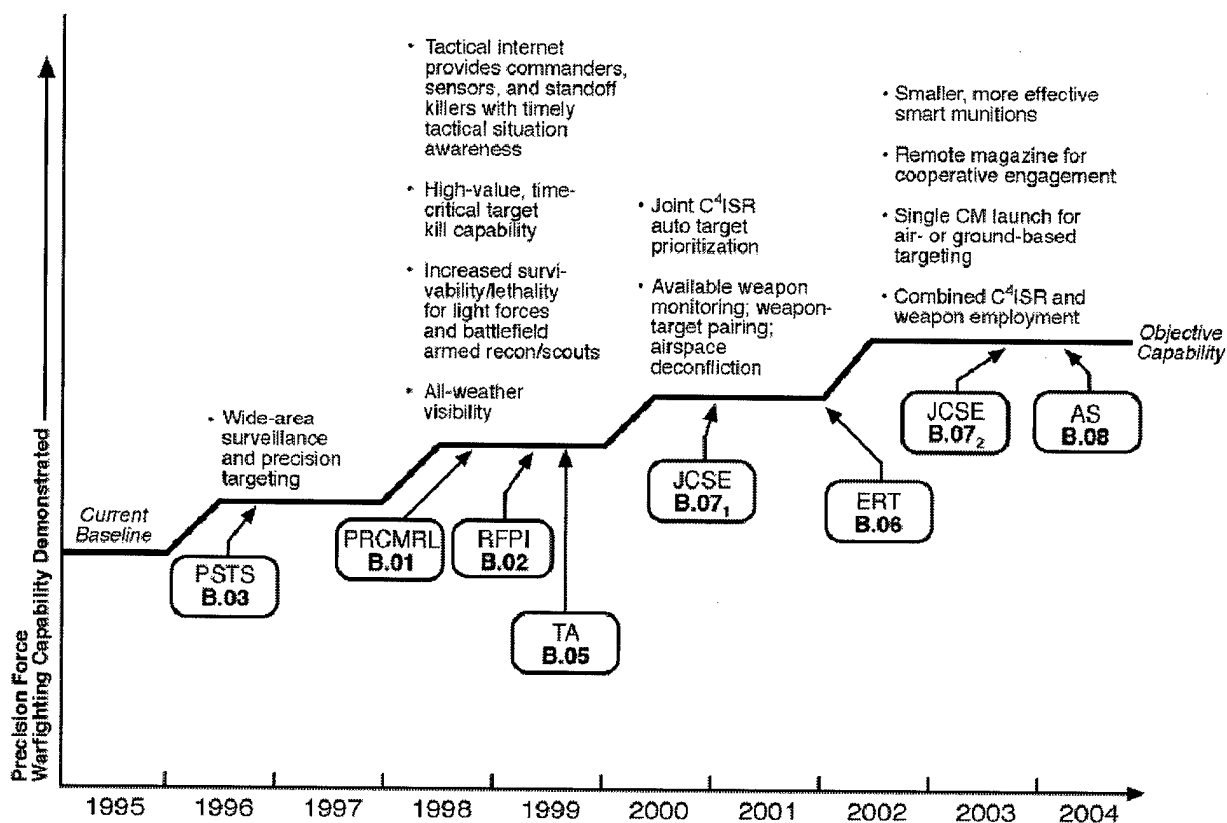


Figure IV.B-4. Progress—Precision Force

C. COMBAT IDENTIFICATION

1. Definition

Combat Identification (CID) is the capability to differentiate potential targets—mobile and fixed, over large areas with corresponding long distances—as friend, foe, or neutral in sufficient time, with high confidence, and at the requisite range to support engagement decisions and weapon release.

2. Operational Capability Elements

U.S. forces must be able to positively identify all targets in the battlespace for all combat mission areas—air to air, air to surface, surface to surface, and surface to air. Surface includes land, sea, and subsurface—otherwise known as ground and maritime (Figure IV.C-1). The CID need is essential in order for commanders to effectively field, at any time, fighting forces that can rapidly and positively identify enemies, friends, and neutrals in the battlespace; manage and control the battle area; optimally employ weapons and forces; and minimize the risk/occurrence of fratricide.

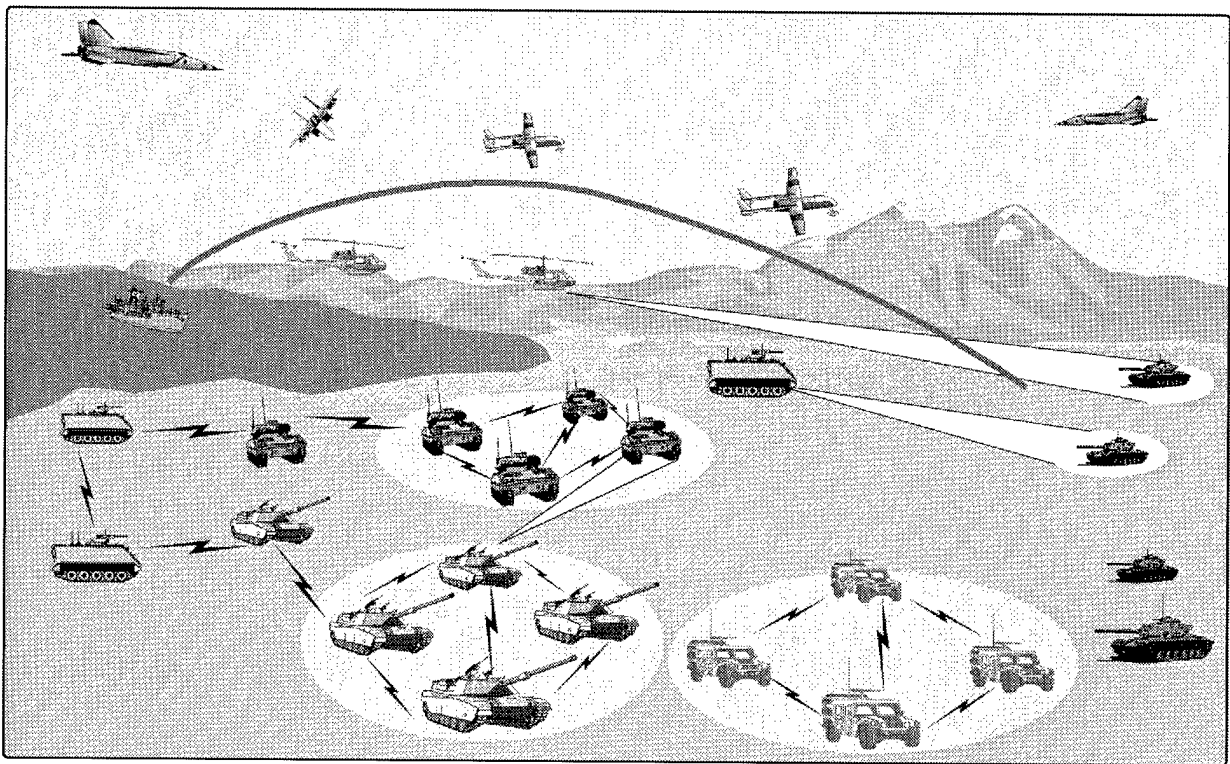


Figure IV.C-1. Concept—Combat Identification

In 1992, the Joint Requirements Oversight Council (JROC) validated the Joint Mission Need Statement (MNS), which defines the broad-based requirements for CID. These include positive, timely, and reliable identification of friends, foes, and neutrals; classification of foes by class, type, and nationality; and interoperability required among the U.S. military and desired with allied

nations. The challenges presented by the requirements necessitate a CID architecture that blends both nonmateriel and materiel solutions.

Nonmateriel solutions include doctrine; tactics, techniques, and procedures (TTP); and training. From a cost perspective, the nonmateriel solution to resolving a CID deficiency is compelling if it does not carry untenable constraints on the warfighter. However, nonmateriel solutions often need to be augmented by materiel solutions. These can be characterized as cooperative/non-cooperative sensor systems and command, control, and communications (C³) systems—in particular, digital datalinks and radios, each of which contributes a portion to the CID solution. As such, CID is viewed as a capability, not a single system or program. A “system-of-systems” approach is required.

CID is the result of a process that appropriately and accurately characterizes the entities present in a combatant’s area of responsibility. Effective CID can take place with varying degrees of target identification, depending on the conditions of the battlespace. At times, the extent of required identification is only to rapidly distinguish among friendly, neutral, and adversary forces with high enough confidence to support weapon employment decisions. At other times, identification of target class (e.g., cruise missile, fighter, or bomber) or target recognition (e.g., target vs. decoy) is required to select the correct defensive or offensive tactical weapon response. In other cases, a more extensive characterization that identifies specific target parameters, such as platform type (e.g., MiG-29 vs. MiG-21) and intent (e.g., an active interceptor vs. a defector) is required to select optimal defensive weapons and to support weapon release decisions. In all cases, the goal for CID is to provide the necessary level of identification to make correct weapon decisions. This CID approach supports the attainment of military objectives while minimizing total casualties.

The primary objective for CID is to correlate and assign a foe, friend, or neutral identification label to a “target.” The identification label can be assigned at any time from initial detection of the potential target to weapon employment. To be useful for a direct-fire engagement, the correct target label must be correlated to a sensor return that is in a “weapon sight” (e.g., radar, laser, or thermal sight). Indirect-fire weapons or supporting fire weapons operate from a different perspective as they cannot “see” the target. The identification is made and sent to the weapon by the fire requestor or a surveillance/reconnaissance platform; the weapon is correlated to the specified target position.

As discussed earlier, there are two classes of materiel solutions:

- *Sensors*—the target is characterized either noncooperatively (e.g., jet engine modulation, high-range resolution radar, or electronic support measures) or cooperatively (e.g., MK XII identification friend or foe (IFF) system or Battlefield Combat Identification System (BCIS)).
- *C³ (particularly digital datalinks and radios)*—the target declares (either periodically or when queried) its identification and position in a reference frame that the “shooter” can correlate with its own weapon and sensor system (e.g., Link 16).

Both approaches have their strengths and limitations. If the identification is determined by an offboard sensor, there is the added necessity to pass and correlate the required information in a timely fashion. This requirement to correlate an identification label with a sensor return in the “weapon sight” is a key discriminator and a source of significant cost for the systems.

The vision is a fielded CID capability that ensures that all combatant platforms will have available the required identification information in a timely fashion that is commensurate with the

range and lethality of the platforms' weapons and sensors. The approach toward realizing this vision is through an integrated CID architecture that combines noncooperative and cooperative identification sensors and systems with C³ (particularly digital datalinks and radios) capabilities. Such an architecture supports the development of situational awareness—the overall, general knowledge of the tactical battlefield environment, including the location of friendly, neutral, and enemy forces as well as the plan of action for battle. The required operational capability will then be achieved by combining onboard data from multiple sensors and systems with indirectly supplied offboard information.

Due to the fundamental differences of their operating environments, the operational capability elements can be aggregated into three categories: air, ground, and maritime target platforms. Air platforms are more dispersed, move at much higher speeds, and are engaged at relatively long ranges with imaging or nonimaging sensors. Ground platforms are closely spaced, move slowly, and are engaged at close ranges with imaging sensors. Maritime platforms are relatively slow compared to air platforms, can be either closely spaced (i.e., several hundreds of yards) or more dispersed (i.e., several nautical miles), and are engaged at longer ranges compared to ground platforms due to the nonimaging sensors indigenous to the maritime platform or the imaging/nonimaging sensors of the aircraft attached to the maritime unit.

In general, the current CID capability against all platforms must be improved. The current CID capability in many cases does not allow for maximum use of a weapon's range and engagement of targets in highly mixed, fast-moving environments. The result is that combat effectiveness is often restricted by confining rules of engagement and procedures.

For ground targets (air-to-surface and surface-to-surface mission areas), the current capability is extremely limited. The objective is to have an initial level of high confidence CID capability fielded for all early-deploying, first-line combatant platforms within 10 years. The CID capability must provide the required identification information with very high confidence.

For air targets (surface-to-air and air-to-air mission areas) as well as maritime targets (surface-to-surface and air-to-surface mission areas), CID needs improvement in some areas. In some cases, effective systems have been developed that could fill some of the needs but are not widely fielded. In other cases, noncooperative sensor/technique databases need to be updated and more fully populated. In still other areas, correlation/fusion issues need to be resolved. The objective is to provide nearly perfect identification information.

With respect to CID, automatic target recognition (ATR) is best viewed as an enabling technology tool that contributes, in part, to an operational CID capability, as already defined. ATR pertains to the implementation of cooperative and noncooperative sensor systems. The need for ATR systems stems from the increased complexity of tactical and strategic battlespaces, the unprecedented amount of raw information produced by modern sensor systems, and the effectiveness of C³ systems. Collectively these can overwhelm the capability of human operators and decisionmakers. The magnitude and rate of information produced may exceed the operator's ability to absorb and process it in a timely fashion; performance declines with operator fatigue and varies with operator training. Consequently, ATR systems are being developed to provide an assortment of technological services that range from operator prompting (cueing) tools to fully automated ATR systems requiring no human operator intervention.

More precisely, the goal of ATR is to support rapid and reliable detection, geolocation, tracking, recognition, and prioritization of targets. In general, the output will provide a human operator or decision maker with target recommendations, weapon options, and the level of confidence associated with each proposed action.

The degree to which the constituent functions can or should be automated depends not only on the efficacy of the ATR technology but also on sensor performance, target complexity and density, target environment, mission requirements, and required response times. For example, particular mission or battlespace conditions may only require an ATR system to sort through a very large potential target density and alert an operator to the presence and location of a change in battlespace conditions (e.g., deployment of troop positions or bomb damage assessment) since the previous battlespace analysis. In this example, image analysts would be required to infer appropriate information from the data; such systems, which are predicated on active human participation, are sometimes referred to as *assisted target recognition* or *aided target recognition*.

In summary, ATR provides enabling technologies for CID. The amount of automation that can be provided by ATR relates to the varying degrees of target identification required for a functional CID capability. For additional information on ATR, see *Defense Technology Area Plan*, Chapter VII, Sensors, Electronics, and Battlespace Environment.

3. Functional Capabilities

The functional capabilities for CID include foe identification (including platform type, class, nationality, allegiance, and intent information), friend identification, neutral identification, and interoperability (for cooperative sensors, C³ datalinks/radios, and databases on noncooperative sensors and techniques). The functional capabilities required to meet the CID operational capability elements and the strength of their support are shown in Table IV.C-1. The relative importance of these functional capabilities to the operational capability elements varies due to the fundamental differences in the missions and the operating environments of the potential targets.

**Table IV.C-1. Functional Capabilities Needed—
Combat Identification**

Functional Capabilities	Operational Capability Elements			
	Air to Surface	Surface to Surface	Surface to Air	Air to Air
1. Foe Identification	●	○	●	●
2. Friend Identification	●	●	●	●
3. Neutral Identification	○	○	●	●
4. Interoperability	●	●	●	●

● Strong Support

○ Moderate Support

Noncooperative identification sensors and systems have the advantage of identifying foes, friends, and neutrals. Cooperative identification sensor systems, which only identify friends, have

the advantage of less technical challenge; however, they require all friendly potential targets to be equipped with the same corresponding identification equipment. C³ systems (particularly digital datalinks and radios) are also cooperative systems that provide (1) friend identification automatically (for all participants on the network), (2) a medium for passing hostile/neutral identification generated from other sensors/sources, and (3) a medium for passing friend identification (for those platforms not on the network) generated from other sensors/sources. In addition to doctrine/TTP, all of these systems are critical contributors to a system-of-systems approach in providing both situational awareness and identification to use lethal weapons in the battlespace. The functional capabilities of all CID systems must work synergistically to provide a robust, high-confidence CID capability.

4. Current Capabilities, Deficiencies, and Barriers

The U.S. baseline varies according to operational capability element mission area. Some technological capabilities have not been fielded while others have only been fielded to a small segment of the force.

Current Air-to-Surface Capability

Foe Identification

- Use of tactical reconnaissance or surveillance aircraft to exploit electronic signals emitted by a set of targets (e.g., electronic support measures (ESM)).
- Recognition of classes of maritime platforms using inverse synthetic aperture radar (ISAR).
- Recognition of classes of ground platforms using synthetic aperture radar (SAR).
- Communication by ground or air forward air controller (FAC)—via voice or automated ground target information passing systems (e.g., Improved Data Modem or Automatic Target Handoff System)—for close air support (CAS) information, including target location and identification, nearest friendly position, and clearance to drop ordnance.

Friend Identification

- Use of marking schemes for ground platforms that can be readily detected visually or via available sensors.
- Query and identification of maritime platforms with cooperative sensor/C³ system (e.g., MK XII Mode 4 or Link 16, the latter still being fielded).

Neutral Identification

- Visual identification only.

Interoperability

- Voice communications.
- Digital links (limited; fielding still in progress).

Current Surface-to-Surface Capability

Foe Identification

- Visual identification of ground platforms.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).

Friend Identification

- Query and identification of potential targets with cooperative sensor/C³ system (e.g., for ground platforms, Battlefield Combat Identification System, not yet funded for production; for maritime platforms, MK XII Mode 4 or Link 16).
- Use of marking schemes for ground platforms that can be readily detected visually or via available sensors.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).
- Improved location of friendly ground forces using Global Positioning System (GPS).

Neutral Identification

- Visual identification of ground platforms.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).

Interoperability

- General location of friendly ground battle participants based on tactical radios and Enhanced Position Location and Reporting System (EPLRS), which is still being fielded and is not yet interoperable with the tactical radios.
- Location of friendly maritime battle participants based on digital datalinks (e.g., legacy Link 11 and current/future Link 16), which have mixed levels of interoperability.

Current Surface-to-Air Capability

Foe Identification

- Classification of platform type via detailed analysis of radar return (e.g., jet engine modulation (JEM), radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Friend Identification

- Query and identification of potential targets with cooperative sensor/C³ system (e.g., MK XII Mode 4 or Link 16).

Neutral Identification

- Classification of platform type via detailed analysis of radar return (e.g., JEM, radar painting).

- Exploitation of electronic signals emitted by target (e.g., ESM).

Interoperability

- Big picture of battlespace via Link 16 and other legacy datalinks that are not yet interoperable across services.
- Voice communications with other agencies and sensors.

Current Air-to-Air Capability

Foe Identification

- Classification of platform type via detailed analysis of radar return (e.g., JEM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Friend Identification

- Query and identification of potential targets with cooperative sensor/C³ system (e.g., MK XII Mode 4 or Link 16).
- Classification of platform type via detailed analysis of radar return (e.g., JEM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Neutral Identification

- Classification of platform type via detailed analysis of radar return (e.g., JEM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Interoperability

- Big picture of battlespace via Link 16 and other legacy datalinks that are not interoperable across services.
- Voice communications with other agencies and sensors.

Addressing the issue of C³/digital datalink and radio interoperability, the United States is migrating towards a J-series family of datalinks to include Link 16 for air operations, Link 22 for maritime operations, and variable message format (VMF) for ground operations. All datalinks/digital radios are to comprise J-series (TADIL-J) protocols and message sets to facilitate communications across the battlespace. For air, maritime, and ground weapons, doctrine/TTP plays a significant role in sorting friend from foe or neutral in the battlespace.

The JROC has reviewed the CID joint warfighting needs by mission areas and has stated a need for CID in all mission areas. Additionally, the JROC ranked the mission areas in terms of available CID equipage from the most deficient to the least deficient as follows:

- Air-to-surface
- Surface-to-surface

- Surface-to-air
- Air-to-air.

The JROC noted that many U.S. platforms are currently deficient in CID systems and data-links. No ground combatants have a long-range identification capability, and many maritime and air platforms have only limited CID suites.

There are two principal barriers to having universal CID capability on all air, maritime, and ground platforms: affordability and signature exploitability.

Affordability. The cost of CID suites that are properly integrated with the weapon sight (both cooperative and noncooperative) are usually prohibitive if they are not a P³I of an existing sensor or system. Additional functionality in the form of communications, situational awareness, or sensing is helpful in making CID more affordable. The affordability of a system will also vary significantly depending on the environment in which it is considered. Aviation/maritime systems are generally more expensive than ground-based systems. As a result, solutions that are programmatically “affordable” for aircraft/maritime platforms are often prohibitively expensive for combat vehicles. Technology that eases the integration overhead of a CID-related system or reduces its component cost is required.

Signature Exploitability. Noncooperative techniques of identification are most attractive to warfighters due to their ability to generate labels for foe, friend, and neutral contacts, and because they can provide additional identification information on adversaries (e.g., platform type, class, nationality). For air/maritime targets, the current capabilities of these systems are limited in range, aspect, and timeliness of reporting. The result is that the indications from this class of systems are frequently in the “unknown” or “not available” state. Improvements in sensors and target databases that expand the envelope of performance for these systems are necessary. For combat vehicles, the signal environment is such that reliable identification at maximum weapon range remains a significant technical challenge. Limitations in sensor resolution—coupled with variations in target aspect, state, countermeasures, and the battlespace signal propagation environment—complicate the job of target labeling. Technology improvements for improved sensors and automatic target recognition that can interpret imaging and nonimaging sensor data to reliably identify the platform type are necessary. The key technologies for reaching the combat identification joint warfighting capabilities are shown in Table IV.C-2. Several Defense Technology Objectives (DTOs) in the Sensors, Electronics, and Battlespace Environment area of the DTAP also support Combat Identification. These include Multifunction Electro-Optical Sensor Signal Processing (SE.06.01), Affordable ATR via Rapid Design, Evaluation, and Simulation (SE.19.03), Enhanced Moving Target Detection Development (SE.03.01), ATR for Reconnaissance and Surveillance (SE.02.01), Multifunction Laser (SE.09.02), and Advanced Focal Plane Array Technology (SE.33.01)

CID can be highly useful only when it is fully integrated with both C³ and weapon systems. It often develops time-urgency far exceeding that for most other C⁴I functions. In addition, CID requirements need to be refined through simulation and military exercises. If not defined within that sort of environment, past history suggest that some requirements will be so stringent as to discourage serious development, while others may not be sufficient to satisfy the needs.

Table IV.C-2. Goals, Limitations, and Technologies—Combat Identification

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Air to Surface			
Robust, high confidence ID capability at range and lethality of weapons Maximize combatants military effectiveness Minimize fratricidal situations Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperable Secure operations Nonexploitable	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) CCD technologies Friends/foes/neutrals not clearly defined Lack of standardized datalink Affordability Vulnerability	Fusion technology Database management Moving surface target imaging radar Radar imaging/processing Laser development/processing IR focal plane array Advanced IR sensors ESM Secure datalinks ATR development Target phenomenology and modeling
Operational Capability Element: Surface to Surface			
Robust, high confidence ID capability at range commensurate with range and lethality of weapons Maximize combatants military effectiveness Minimize fratricidal situations Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperable Secure operations Nonexploitable	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) CCD technologies Friends/foes/neutrals not clearly defined Lack of standardized datalink Affordability Vulnerability	Fusion technology Database management Radar imaging/processing Laser development/processing IR focal plane array Advanced IR sensors ESM Secure datalinks ATR development Target phenomenology and modeling Low cost north reference unit/inclinometer
Operational Capability Element: Air to Air			
Robust, high confidence ID capability at range commensurate with range and lethality of weapons Maximize combatants military effectiveness Minimize fratricidal situations Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperable Secure operations Nonexploitable	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) CCD technologies Friends/foes/neutrals not clearly defined Lack of standardized datalink Affordability Vulnerability	Fusion technology Database management Radar imaging/processing Laser development/processing ESM Secure datalinks ATR development Target phenomenology and modeling

Table IV.C-2. Goals, Limitations, and Technologies—Combat Identification (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Surface to Air			
Robust, high confidence ID capability at range commensurate with range and lethality of weapons	Foe identification	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting)	Fusion technology
Maximize combatants military effectiveness	Friend identification	CCD technologies	Database management
Minimize fratricidal situations	Neutral identification	Friends/foes/neutrals not clearly defined	Radar imaging/processing
Automated position reporting and correlation for battlespace (i.e., datalink capability)	Interoperability	Lack of standardized datalink	Laser development/processing
Interoperable		Affordability	ESM
Secure operations		Vulnerability	Secure datalinks
Nonexploitable			ATR development
			Target phenomenology and modeling

CID requires effective and timely synchronization of communications systems with data from real-time surveillance, target tracking, and intelligence systems. The CID output must be coupled with the weapon systems in real time to maximize their effectiveness against enemies. In the past, inability to take advantage of all available information has made CID systems add-ons rather than integrated features of all tactical systems.

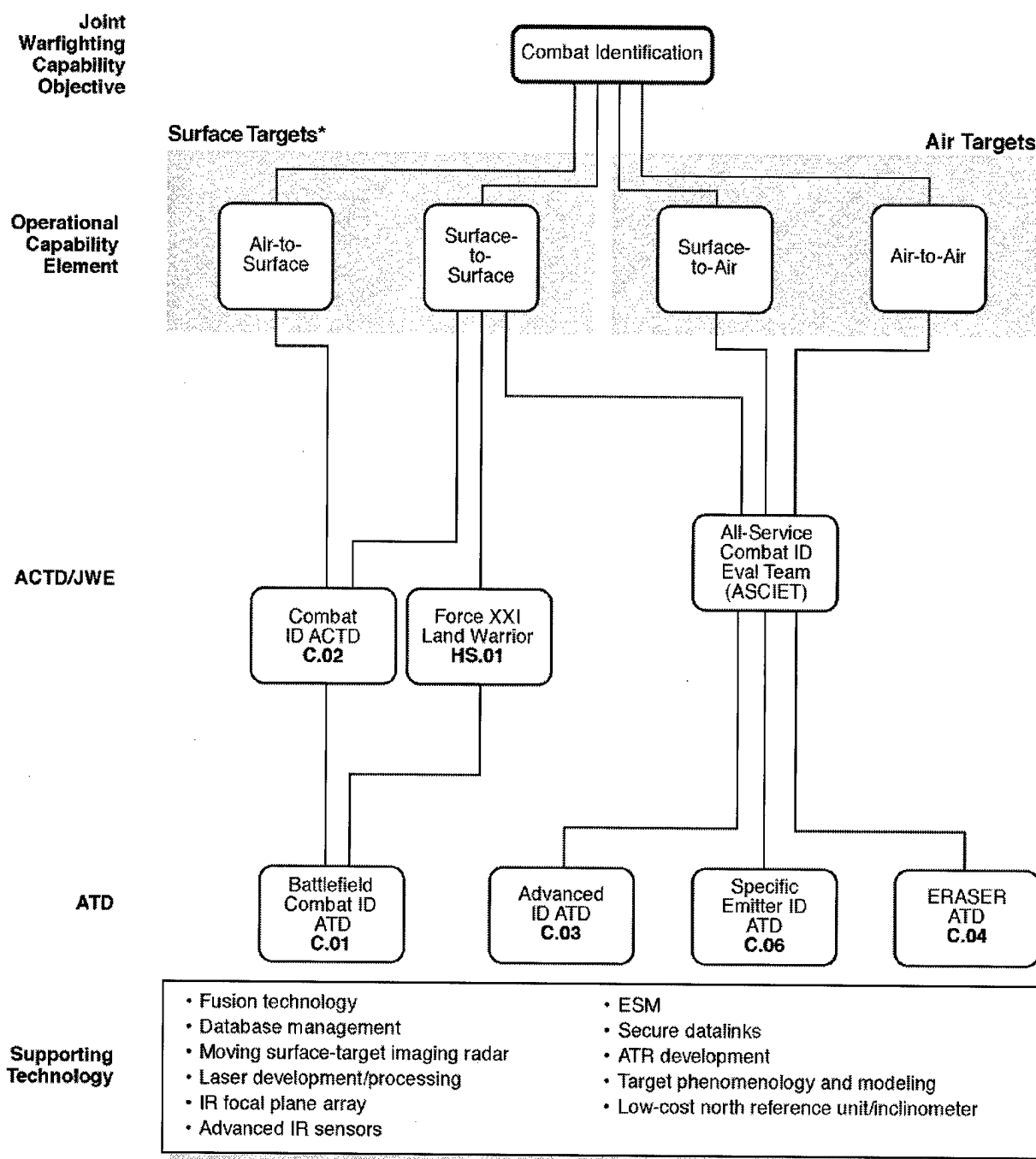
CID capabilities are also vulnerable to enemy exploitation or countermeasures. Vulnerability analyses and evaluations must accompany system design and test programs.

5. Technology Plan

The roadmap for developing and demonstrating these technologies has two main elements: surface target identification and air target identification. Each element addresses both the affordability and signature exploitability barriers. An overview of the relationship of the CID operational capability elements, functional capabilities, demonstrations, and supporting technologies is shown in Figure IV.C-2.

The primary Defense Technology Objectives (DTOs) and their corresponding demonstrations that address the CID operational capabilities are shown in Tables IV.C-3 and IV.C-4. Additionally, the Military Operations in Urban Terrain (MOUT) ACTD (E.02) will explore small-unit operations in an urban terrain and will include some CID issues. The DTO CID roadmap is shown in Figure IV.C-3.

Surface Target Identification. This element first addresses an integrated air-to-surface (ground) and surface-to-surface CID capability through the Battlefield Combat Identification (BCID) ATD (C.01), the Combat Identification ACTD (C.02), and the associated EW/Sensor Fusion/Integrated Situation Assessment Technology demonstrations. These demonstrations combine primarily friend identification and limited foe identification with improved battlefield situational awareness resulting from the Army's Force XXI initiative. The North Finding Module demonstration addresses a key technology needed for affordable correlation of identification labels within the weapon sight on ground platforms.



* Surface = Ground + Maritime

Figure IV.C-2. Technology to Capability—Combat Identification

**Table IV.C-3. Defense Technology Objectives—
Combat Identification**

DTO No.	Title
C.01	Battlefield Combat Identification ATD
C.02	Combat Identification ACTD
C.03	Advanced Identification ATD
C.04	Enhanced Recognition and Sensing Laser Radar ATD
C.06	Specific Emitter Identification ATD
SE.03.01	Enhanced Moving Target Detection
SE.06.01	Multifunction EO Sensor
SE.09.02	Multifunction Laser
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	ATR for Reconnaissance and Surveillance
SE.33.01	Advanced Focal Plane Array Technology

Table IV.C-4. Demonstration Support—Combat Identification

Demonstration	Operational Capability Elements				Service/ Agency	Type of Demonstration		
	Air to Surface	Surface to Surface	Surface to Air	Air to Air		DTO	ACTD	ATD
Battlefield Combat Identification ATD	●	●			Army	C.01		X
Combat Identification ACTD	●	●			All	C.02	X	
Advanced Identification ATD	●		○	●	Air Force	C.03		X
Enhanced Recognition and Sensing Laser Radar ATD	●	○	○	○	Air Force	C.04		X
Specific Emitter Identification ATD	●		○	○	Navy	C.06		X
Enhanced Moving Target Detection		●			Air Force	SE.03.01		
Multifunction EO Sensor Signal Processing	●	●	●	●	Navy	SE.06.01		
Multifunction Laser	●	●			Army	SE.09.02		
Affordable ATR via Rapid Design, Evaluation, and Simulation	●	●		●	Army	SE.19.03		
ATR for Reconnaissance and Surveillance	●	●		●	DARPA	SE.20.01		
Advanced Focal Plane Array Technology	●	●	●	●	DARPA	SE.33.01		

● Strong Support

○ Moderate Support

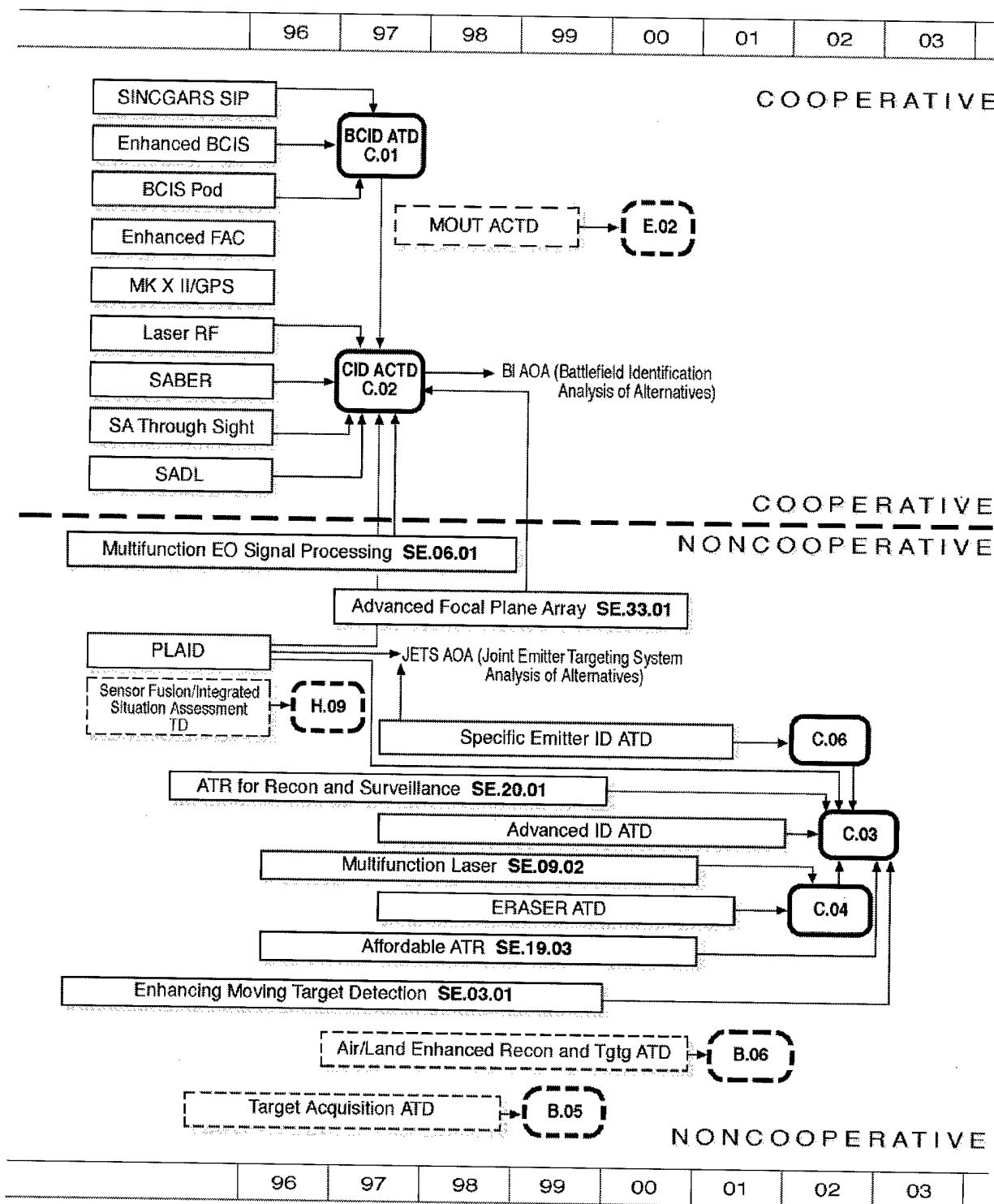


Figure IV.C-3. Roadmap—Combat Identification

The next several steps focus on foe identification using noncooperative techniques. A number of ATDs are critical to this effort including the Target Acquisition ATD (B.05), Air/Land Enhanced Reconnaissance and Targeting (ALERT) ATD (B.06), and Enhanced Recognition and Sensing Laser Radar (ERASER) ATD (C.04). Furthermore, the DARPA/Air Force Moving and Stationary Target Acquisition and Recognition (MSTAR) Program and the Air Force System-oriented High-range resolution Automatic Recognition Program (SHARP) Program support the Advanced Identification ATD (C.03). Additionally, maritime targets are being addressed as part of the Specific Emitter Identification (SEI) ATD (C.06). Improving the ease of integration will allow for the CID solutions that are evolving or extant to be hosted within the architecture with a minimal expenditure of time or money. This element addresses the integration of multiple functions within a CID suite to reduce costs and improvements in the case of physical and functional integration onto combat platforms to achieve more rapidly deployable and affordable CID solutions.

The air target identification element represents a more information-rich approach. This element includes both fusion and noncooperative target identification techniques. The Advanced Identification ATD (C.03), ERASER ATD (C.04), Air Target Algorithm Development Program (part of C.01), and SEI ATD (C.06) address the signal exploitation issues associated with the noncooperative air target identification challenge. These efforts are multidimensional and proceed in parallel. They each include their own data collection efforts. These signature exploitability efforts are crucial to advancing the capability in noncooperative sensing to support all target identification. It is the intent of this path in the roadmap to have a wide variety of experiments to examine the issues of signature presence, discrimination, and reliability over a broad range of engagement scenarios and battlespace environmental conditions. Each of the integrated CID suite approaches would be used to demonstrate improved operations (enhanced effectiveness and reduced fratricide) in field exercises with both joint and combined forces.

All CID techniques have a limited period of operational effectiveness before they are degraded or compromised by enemy countermeasures. It is therefore necessary to have an ongoing process to overcome these vulnerabilities by developing new technologies for CID, demonstrating new capabilities in appropriate operational environments, and deploying new or upgraded CID appliques to maintain a superior operational CID capability.

Identification issues associated with weapons of mass destruction (WMD) are addressed in Section J, Counter WMD.

6. Summary

Providing an accurate CID capability when and where it is needed requires an integrated architecture that includes noncooperative/cooperative identification sensor systems, C³ systems, and doctrine/TTP. Improvements in joint warfighting operational capabilities will be demonstrated using suites of the materiel capabilities on various platforms in joint operational environments.

A significant initial improvement is expected for ground target identification with the inception of new cooperative identification techniques combined with C³/digital datalinks and radios. This will later be augmented with a foe and neutral identification capability for selected weapon systems.

Air target identification improvements will be achieved by increasing the robustness of overall CID capabilities by improving noncooperative techniques, providing more capable datalinks,

adding data fusion/correlation capabilities, and expanding the number of platforms equipped. The improvements in demonstrated warfighting capabilities over time are shown in Figure IV.C-4.

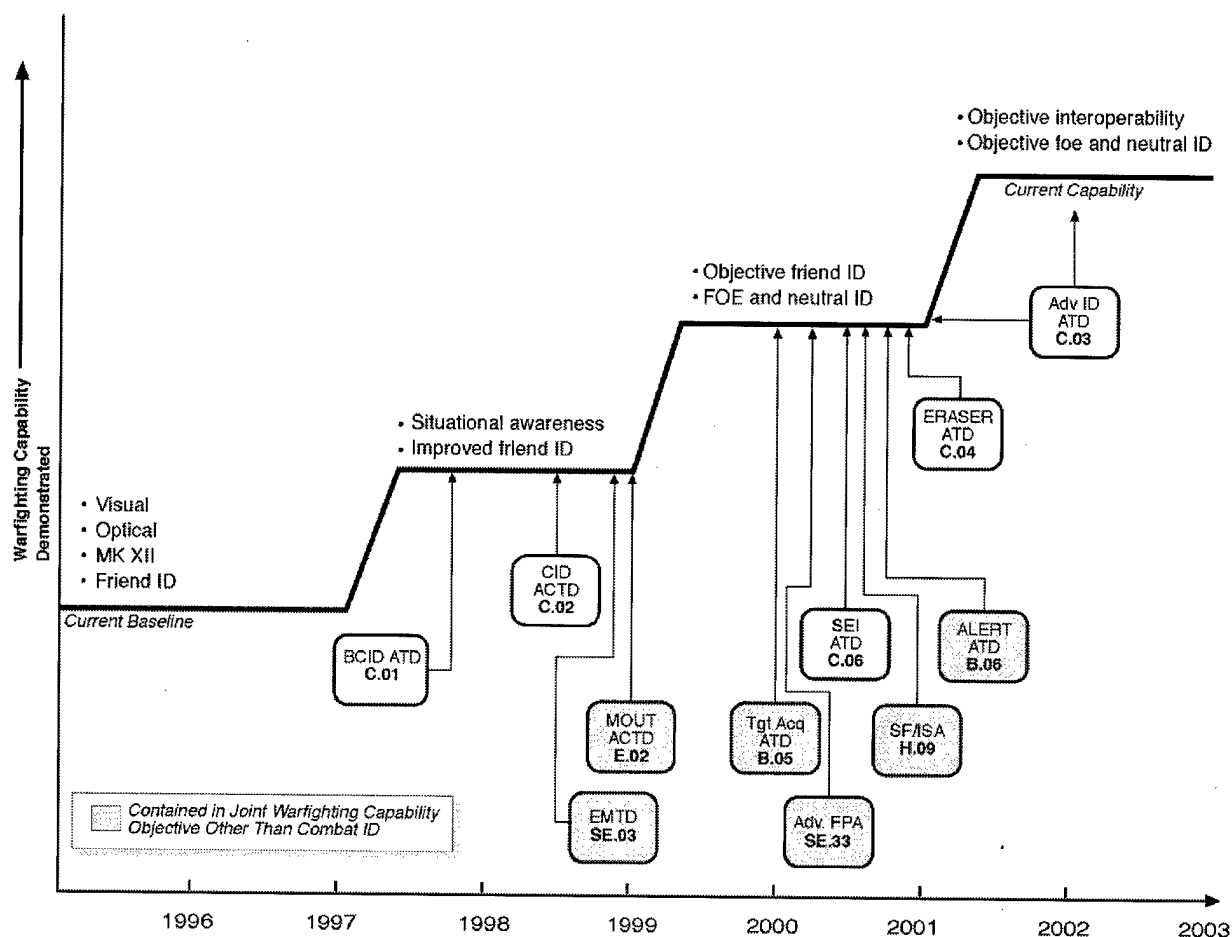


Figure IV.C-4. DTO Progress—Combat Identification

D. JOINT THEATER MISSILE DEFENSE

1. Definition

Joint Theater Missile Defense (JTMD) is the capability to use the assets of multiple services and agencies to detect, track, acquire, and destroy enemy theater ballistic missiles and cruise missiles. It includes the seamless flow of information on missile launches by specialized surveillance capabilities, through tracking by sensors from multiple services and agencies, to missile negation or destruction.

The vision for a future JTMD architecture is shown conceptually in Figure IV.D-1. It depicts a theaterwide set of surveillance systems, multiple layers of defensive weapons systems, and a highly responsive C³I network to integrate the surveillance and weapon capabilities. The internettted set of surveillance systems depicted includes airborne, shipborne, and land-based radars plus space surveillance systems to detect launches of theater ballistic and cruise missiles and track them until they are successfully intercepted.

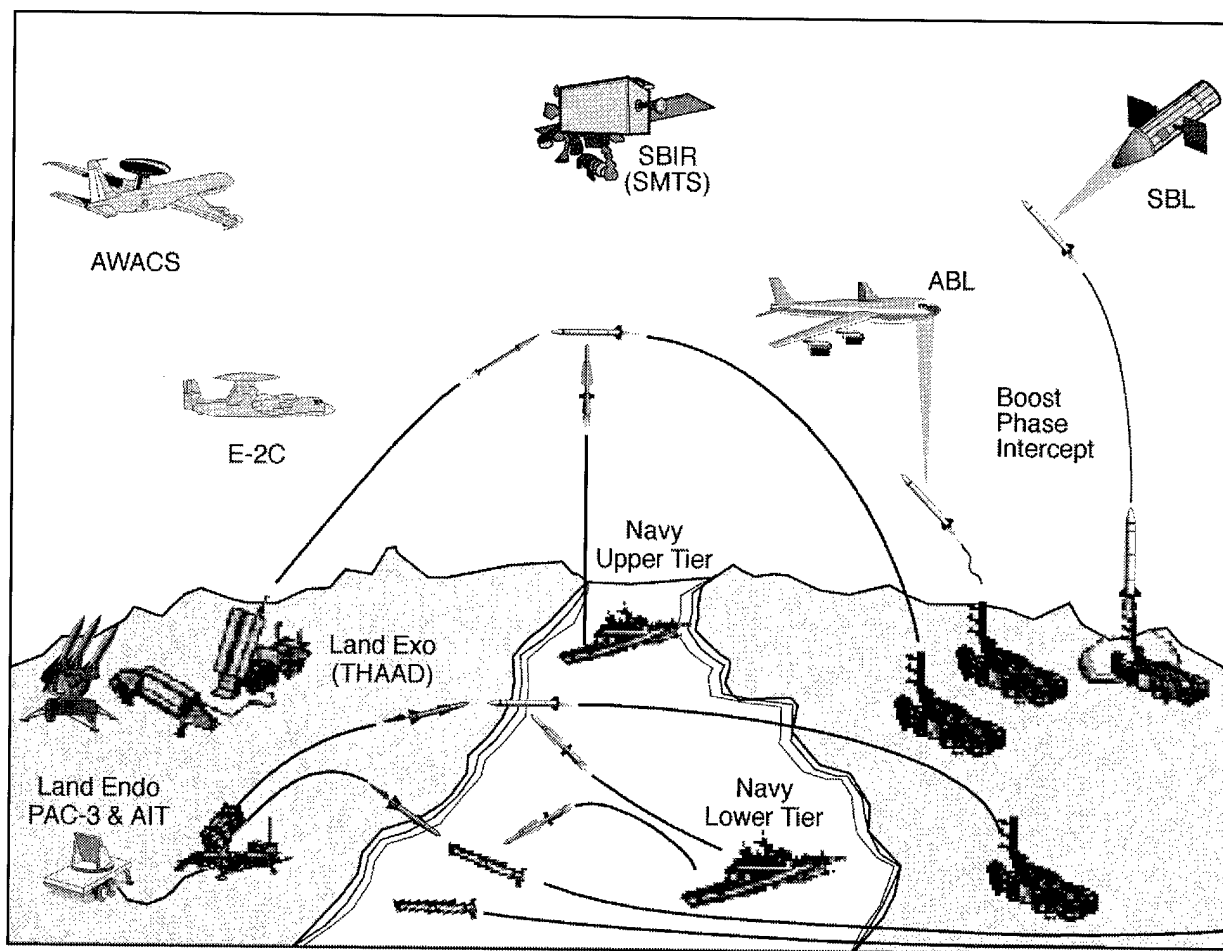


Figure IV.D-1. Concept—Joint Theater Missile Defense

In this future JTMD architecture, the first of the defensive layers is *boost phase intercept* of ascending ballistic missiles by airborne and/or space-based high-power laser weapon systems, as

shown conceptually in Figure IV.D-1. This boost-phase intercept layer offers a special contribution to deterring or defeating attacks by missiles armed with weapons of mass destruction (WMD) (chemical, biological, or nuclear warheads), because lethal warhead materials could fall on the attacker's own territory. For the next defensive layer, or *upper tier*, long-range interceptor missiles from land or shipboard launchers are depicted intercepting at high altitude the missiles that avoided boost-phase intercept. The final defensive layer, or *lower tier*, includes shorter range defensive missiles from land- or sea-based launchers to provide a final round of lower altitude terminal intercepts above the defended area. Similarly, cruise missiles detected by the surveillance sensors could be intercepted first by longer range sea- and land-based surface-to-air and air-to-air missiles and then by the shorter range terminal defense missiles.

JTMD capabilities are critical elements of the new operational concept of *full-dimensional protection* envisioned in *Joint Vision 2010*. The Theater Missile Defense Mission Need Statement defines the mission of JTMD as protecting U.S. forces, U.S. allies, and other important countries, including areas of vital interest to the U.S., from theater missile attacks. The JTMD mission includes the protection of population centers, fixed civilian and military assets, and mobile military units.

2. Operational Capability Elements

The four operational capability elements, or pillars, of JTMD are *attack operations*, *active defense*, *passive defense*, and *command, control, communications, and intelligence (C³I)*. These are shown in Table IV.D-1.

This section focuses on the *active defense* pillar and those aspects of the *C³I* pillar that are unique to the JTMD mission. Capabilities for the *attack operations* pillar such as quick-response, precision strikes against mobile theater missile launchers are addressed in Section B, Precision Force. In addition, *attack operations* against WMD capabilities—including prompt attacks against WMD-armed theater missiles on the battlefield and counterforce attacks against hardened WMD storage and production facilities—are addressed in Section J, Counter WMD. Similarly, responsive, theaterwide command, control, communications, computers, and intelligence (C⁴I) systems and enhanced theater intelligence, surveillance, and reconnaissance (ISR) capabilities that support all theater operations (including JTMD) are addressed in Section A, Information Superiority. Finally, *passive defense* capabilities—including rapidly assessing and disseminating chemical and biological (CB) threat information and providing effective protection against CB attack for personnel and platforms—are described in Section I, Chemical/Biological Warfare Defense and Protection.

3. Functional Capabilities

The functional capabilities needed to support the four operational capability elements or pillars of JTMD are listed in Table IV.D-1. The detailed functional capabilities are grouped into those supporting the three functional areas of *acquisition sensor*, *target intercept*, and *C³I*.

In the *acquisition sensor* area, the four functional capabilities are detection, tracking, discrimination, and communications. Rapidly detecting theater missile launches and establishing current and accurate tracks for those missiles are essential for cueing the active defense against the attacking missiles. In addition, the detection, tracking, and communications functional capabilities strongly support passive defense by providing attack warning and impact point predictions to threatened areas. Those three functional capabilities also strongly support attack operations by accurately

**Table IV.D-1. Functional Capabilities Needed—
Joint Theater Missile Defense**

Functional Capabilities	Operational Capability Elements			
	C ³ I	Active Defense	Passive Defense	Attack Operations
Acquisition Sensor				
1. Detection	○	●	●	●
2. Tracking		●	●	●
3. Discrimination		●	○	●
4. Communications	●	●	●	●
Target Intercept				
5. Lethality—Interceptor		●		
6. Footprint—Interceptor		●		
7. Divert—Interceptor		●		
8. Acquisition		●		
9. Tracking		●		
10. Discrimination		●		
11. Communications	●	●	○	○
12. Boost Phase Intercept—Laser	○	●		○
C³I				
13. Datalinks	●	●	●	●
14. Waveform	●	●	○	●
15. Data Processing	●	●	●	●
16. Data Fusion	●	●	●	●

● Strong Support

○ Moderate Support

identifying missile launch locations so that the launchers can be promptly attacked. The discrimination functional capability to distinguish a ballistic missile warhead from accompanying missile components or fragments and decoys is essential for cueing the active defense to attack the right target. In addition, the attack characterization information about the missile type and potentially the type of warhead from discrimination sensors moderately supports both the attack operations and passive defense operational capabilities, as shown in Table IV.D-1.

In the *target intercept* area, the first three functional capabilities—lethality, footprint, and divert—specifically refer to capabilities of interceptor missiles (often called *kinetic energy* interceptors in contrast to *directed-energy* or laser intercept). The first, lethality, is the capability to effectively destroy the warhead payload of an attacking missile when the interceptor impacts the target (for hit-to-kill interceptors) or passes near the target and detonates a fragmenting warhead. The second function, footprint, is the capability of an interceptor missile to intercept targets over the required defended area because of its speed, range, and altitude performance capabilities. The related third function, divert, is the lateral acceleration capability of the interceptor missile to

maneuver during the final phase, or *end game* of the intercept in order to impact the target or pass within the interceptor warhead's lethal envelope of the target.

The next three functional capabilities are the capabilities of the sensors on board the interceptor missile or laser weapon platform to: acquire the right target based on cuing and handoff information passed from acquisition sensors through the C³I system; discriminate between the target warhead and missile fragments or decoys; and maintain tracking of that target until the intercept is completed. The communications functional capability links the interceptor missiles or laser platforms to the acquisition sensor functional capabilities. The final target intercept functional capability is boost-phase intercept with laser weapons, either airborne or space based. As indicated in Table IV.D-1, because of the onboard acquisition sensor and communications capabilities envisioned for them, the laser weapon platforms would also support the C³I and attack operations operational capabilities by forwarding missile launch and tracking data they acquired.

The C³I area includes functional capabilities for high-capacity datalinks to rapidly pass acquisition sensor data; and for specialized waveforms to forward missile tracks among elements of the joint TMD forces. C³I also includes the functional capabilities of very-high-throughput data processing to capture, analyze, and disseminate the sensor data with minimum delays; and data fusion capability to synergistically combine tracking and discrimination data from multiple sensors of different types.

4. Current Capabilities, Deficiencies, and Barriers

Joint Theater Missile Defense includes a number of surveillance, weapons, and C³I systems that are currently deployed or under development by the services. The Ballistic Missile Defense Organization (BMDO) is responsible for the family-of-systems approach to ensure integration of these systems into a joint warfighting capability. Current theater C³I systems are being upgraded for interoperability, and future JTMD systems will be linked by interoperable C³I networks to provide joint connectivity.

Current JTMD capabilities are limited to terminal point defense missile intercepts at low to medium altitudes; there is no capability for upper tier intercepts at higher altitudes and longer ranges or for boost-phase intercept. However, higher performance missiles and surveillance systems now under development will extend intercept capabilities to the higher altitudes and longer ranges required for theaterwide upper tier missile defense. In addition, technology development and demonstration efforts are underway to establish the feasibility of laser weapons for boost-phase intercept, as will be described in Section 5.

The current capability for low-altitude, terminal point defense missile intercepts is based on the PATRIOT and HAWK interceptor missile and radar systems. PATRIOT upgrades, including software enhancements and improved fuzing, have increased engagement capability beyond the level available during Operation Desert Storm. The fielded PATRIOT system allows for rapid, accurate fire unit emplacement, remote launcher placement up to 12 km from the radar, and radar enhancements to improve theater ballistic missile (TBM) detection and increase system survivability. Upgrades to the lower altitude, shorter range HAWK system will yield a near-term defense capability for expeditionary forces through modifications to allow detection, tracking, and engagement of short-range TBMs.

To improve these lower tier defense capabilities, upgrades to both the Army PATRIOT and Navy missile systems are under development. The PATRIOT Advanced Capability 3 (PAC-3) version now under development will enhance PATRIOT system engagement performance by adding a new hit-to-kill missile interceptor with a millimeter-wave seeker and side-firing, divert propulsion thrusters for enhanced maneuverability during the final phase of intercepting a target. In addition, an upgraded version Block IV A of the Navy Standard Missile 2 (SM-2 Block IV A) is under development to provide a sea-based, lower tier interceptor capability. These upgraded PAC-3 and SM-2 Block IV A missiles will also provide improved intercept performance against cruise missiles. In addition, project definition and concept validation are beginning for the Medium Extended Air Defense System (MEADS), a highly mobile system to be deployed with maneuver forces to provide coverage against short-range TBMs, cruise missiles, and other aerodynamic threats.

However, these lower tier systems with moderate velocity missiles have only limited capability against longer range TBM threats with higher reentry velocities, particularly if the attacking missiles are fitted with WMD warheads. Chemical or biological warheads intercepted at low altitude could still disperse hazardous materials over defended areas, particularly if the warheads contained submunitions.

Therefore, upper tier TMD systems with high-performance interceptor missiles capable of defending larger areas and intercepting targets including WMD warheads at higher altitudes are under development for both land and sea basing. The Army Theater High-Altitude Area Defense System (THAAD) includes a new interceptor missile and a ground-based phased-array acquisition and tracking radar. The Navy Upper Tier Theater-Wide system includes a high-performance interceptor missile and upgrades to the AEGIS shipboard phased-array radar.

The characteristics of the land attack cruise missile threat present special challenges for the JTMD mission. Cruise missiles can fly at low altitudes to avoid detection, can maneuver unpredictably to evade intercept, and can be launched from both aircraft and mobile surface carriers, thus reducing the likelihood of prelaunch suppression. Furthermore, advanced cruise missile designs can have very low radar and infrared signatures that make the missiles very difficult to detect against low-altitude background clutter. Therefore, current surveillance systems and interceptor missiles have only limited capabilities to detect, track, and intercept cruise missiles.

In response to these limitations of current capabilities against cruise missiles, during FY96 the Cruise Missile Defense Phase I ACTD demonstrated the feasibility of the air-directed surface-to-air missile (ADSAM) concept for over-the-horizon engagement of cruise missiles. Under this ACTD, radars on a mountaintop site simulating airborne radars were used to detect and track missiles that would have been over the horizon for ground- or sea-based radars. Engagement data were transmitted to interceptor missiles via the Navy's Cooperative Engagement Capability links, and successful live-fire intercepts with SM-2 missiles and simulated intercepts with PATRIOT PAC-3 seekers were demonstrated. This ACTD was a significant step toward demonstrating the feasibility of concepts for the cruise missile defense component of JTMD.

For space surveillance capabilities beyond those available from the current Defense Support Program (DSP) infrared missile launch detection satellites, development of the Space-Based Infrared Systems (SBIRS), including both low- and high-altitude surveillance satellite constellations, is programmed.

Key limitations of current technologies that now preclude development of the functional capabilities needed to fully satisfy the JTMD goals are highlighted in the third column of Table IV.D-2, Goals, Limitations, and Technologies for JTMD. For example, for the target intercept functional capability, key limitations include discrimination of the actual target in the face of a sophisticated threat including decoys, tracking of maneuvering targets, lack of a current capability for boost-phase intercept, and the inability to defeat early-release submunitions.

Table IV.D-2. Goals, Limitations, and Technologies—Joint Theater Missile Defense

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Command, Control, Communications, and Intelligence (C³I)			
Coordinate exchange of information among sensors, radars, launch platforms, interceptors, and command centers.	<i>Acquisition Sensor</i> Communications <i>Target Intercept</i> Communications <i>C³I</i> Datalinks Waveform Data Processing Data Fusion	Network latency Datalink capacity	Laser communications High-speed optical datalinks Solid-state nonvolatile memory High-capacity computer interface
Operational Capability Element: Active Defense			
Acquire and track target and handover/communication data to command centers, interceptor launch sites, and laser platforms.	<i>Acquisition Sensor</i> Detection Tracking Discrimination Communications	Full constellation coverage Radar survivability Target recognition Radar power constraints Lack of airborne TMD disseminator	Advanced lightweight signal processor High-power T/R modules Large format high uniformity LWIR focal plane arrays Lightweight antennas Cryogenic power Eyesafe laser radar
Negate the threat.	<i>Target Intercept</i> Lethality—interceptor Footprint—interceptor Divert—interceptor Acquisition Tracking Discrimination Communications Boost phase intercept—laser	Discrimination of sophisticated threat Tracking of maneuvering vehicles No capability for boost phase intercept Inability to defeat early release submunitions	Solid propellant divert Onboard sensor signal processor and algorithms Lightweight laser radar High sensitivity multispectral IR sensor Fast framing seeker Sensor windows (IR and RF) for hypersonic atmospheric interceptors Sensor data fusion Target discrimination algorithms Lightweight chemical laser Adaptive optics and beam control Atmospheric compensation and tracking High stiffness, lightweight structures

Table IV.D-2. Goals, Limitations, and Technologies—Joint Theater Missile Defense (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Active Defense (continued)			
Receive, process, and transfer data.	<i>C³I</i> Datalinks Waveform Data processing Data fusion	Network latency Datalink capacity Data fusion delays	Omni-EHF antenna Advanced fusion algorithm
Operational Capability Element: Passive Defense			
Early, long range, and accurate threat acquisition, tracking, and data distribution.	<i>Acquisition Sensor</i> Detection Tracking Discrimination Communications <i>C³I</i> Datalinks Waveform Data Processing Data Fusion	Delayed detection of launch Slow impact point projection Detection of early release submunitions	Laser communications Satellite electric propulsion High-efficiency photovoltaics LWIR GaAs sensor Active pixel visible sensor
Operational Capability Element: Attack Operations			
Coordinate cooperative acquisition, tracking, decision making, and kill assessment.	<i>Acquisition Sensor</i> Detection Tracking Discrimination Communications <i>C³I</i> Datalinks Waveform Data Processing Data Fusion	Noninteroperable communications links Inaccurate kill assessment of CB threats	High-speed datalinks Target discrimination algorithms CDMA spread-spectrum communications modem

Discrimination is a key limitation for defense against TBMs because an approaching group of apparent targets could include multiple missile components or fragments and, potentially, decoys in addition to the actual reentry vehicle containing the warhead. Without effective discrimination sensors to confidently identify the actual warhead, multiple missile or laser shots would be required to destroy all of the potentially threatening objects to ensure a high probability of protecting the defended area. Therefore, effective discrimination technology has very high payoff for JTMD. For endoatmospheric interceptors, a limitation on using onboard sensors for discrimination and target tracking is the limited availability of IR and RF window materials that are transparent at the required wavelengths, have low distortion, and can survive the high temperature and pressure of hypersonic flight within the atmosphere.

Target maneuvering is another key limitation that imposes additional lateral acceleration and divert propulsion requirements on missile interceptor technology. Current TBMs may maneuver unpredictably during reentry because of missile dynamics or reentry vehicle asymmetries, and advanced reentry vehicles could potentially take evasive maneuvers, thus reducing the probability

of successful intercept. Therefore, technologies that enhance interceptor maneuverability and improve interceptor probability of kill would allow a reduction in interceptor inventory and could significantly reduce JTMD costs.

Two other significant barriers for JTMD are sensor/data fusion and target signature data. Sensor fusion is a challenging technical barrier for TMD because fusion must take place in near-real time in order to be useful for guiding intercepts. Sensor data fusion is a technique in which multiple sensors provide individual data sets on targets and backgrounds, which are then processed into a single merged set of data. The fused data present a much more accurate picture of the battlespace to the field commanders than the sum of the individual data sets. The data fusion process occurs in one of three ways: (1) the fusion of data from several sensors on the same platform (e.g., a thermal imaging sensor and laser radar onboard an interceptor or a space surveillance satellite); (2) the transfer or handover of data from one sensor platform to another (e.g., target object map data handover from one surveillance sensor to an interceptor); or (3) the merging of track files recorded and processed from two or more geographically separated sensors (e.g., ground radar and space surveillance sensor data track files).

Availability of accurate target signature data is also a key barrier because successful TMD detections and intercepts, particularly hit-to-kill intercepts, require accurate and reliable target signatures. Threat signatures drive the designs of the detection and tracking radars and optical sensors and the seeker hardware selections. They also establish requirements for the supporting detection, discrimination, aimpoint selection, and kill assessment algorithms. The primary limitation on obtaining accurate signatures is generally the lack of access to the actual missile threats operating in their deployed environment. To compensate for this, BMDO supports a robust threat and signatures flight and phenomenology program where both simulated threats and acquired threats are flown and measured.

5. Technology Plan

Some of the key technologies needed to breach the limitations to achieving the JTMD functional capabilities and to enable the JTMD operational capability elements are shown in Figure IV.D-2. Most of these key technologies are being addressed by the technology development and demonstration efforts encompassed by the eight DTOs listed in Table IV.D-3 that are cited in this chapter as most directly supporting JTMD. In addition, as discussed in Section 2 above, related technology efforts described in other sections of this JWSTP also support JTMD operational capabilities: technology demonstrations under Precision Force (Section B) that support the JTMD attack operations capability, efforts under Information Superiority (Section A) that support C³I capabilities applicable to JTMD, and technologies under Chemical/Biological Warfare Defense and Protection (Section I) that support the JTMD passive defense operational capability.

Technology development and demonstration efforts directly supporting JTMD are focused on the following four areas. First, enhance ground and airborne radar and space and airborne optical sensor capabilities to improve missile launch detection, tracking, and discrimination. Second, improve interceptor missile performance, including onboard discrimination and divert maneuvering capabilities for both exo- and endo-atmospheric interceptors. Third, demonstrate the feasibility of boost-phase intercept with airborne and space-based laser technologies. Fourth, increase the capabilities of theater C³I systems to rapidly process and transfer the massive amounts of sensor and tracking data required to support defensive intercepts.

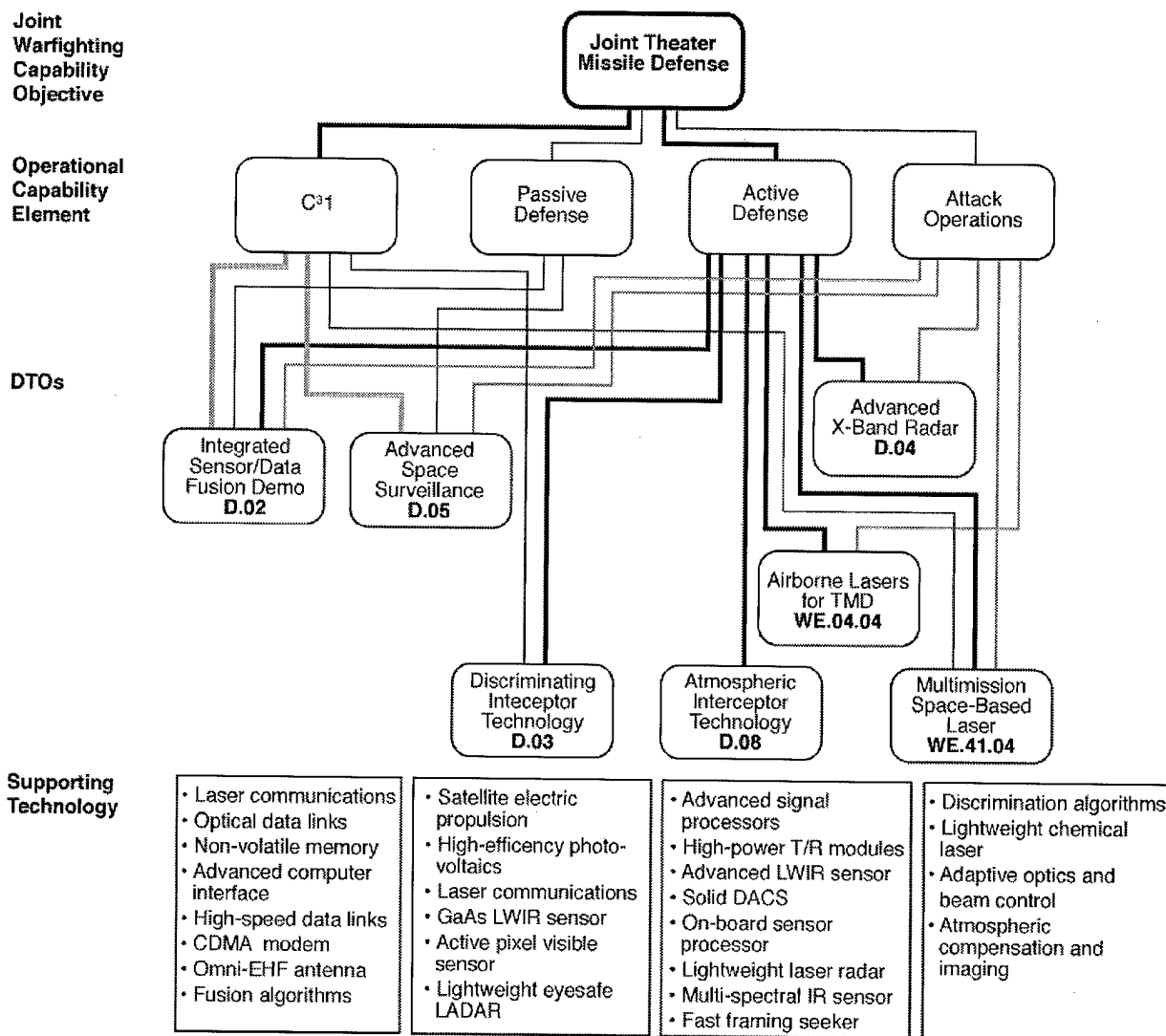


Figure IV.D-2. Technology to Capability—Joint Theater Missile Defense

Table IV.D-3. Defense Technology Objectives—
Joint Theater Missile Defense

DTO No.	Title
D.02	Integrated Sensor/Data Fusion Demonstration
D.03	Discriminating Interceptor Technology Program
D.04	Advanced X-Band Radar Demonstration
D.05	Advanced Space Surveillance
D.08	Atmospheric Interceptor Technology
WE.04.04	Airborne Lasers for Theater Missile Defense
WE.41.04	Multimission Space-Based Laser

In the area of enhanced surveillance, tracking, and discrimination sensor technologies, the three key DTOs are D.02, D.04, and D.05. Technology efforts under D.02, Integrated Sensor/Data Fusion Demonstration, will establish the feasibility of near-real-time sensor data fusion. D.04, Advanced X-Band Radar Demonstration, will develop new technology transmit/receive modules that could significantly increase the tracking and discrimination capabilities of the THAAD radar. The Advanced Space Surveillance DTO, D.05, includes technologies for advanced satellite sensors and subsystems that could be inserted into new and upgraded space surveillance systems, including the SBIRS.

Additional details on the seven DTOs that most directly contribute to achieving JTMD warfighting capabilities are given below. These DTOs directly support the four JTMD operational capability elements of attack operations, active defense, passive defense, and C³I, as presented in Table IV.D-4. The DTOs are structured to demonstrate incrementally increasing capability over time. These technology advances can potentially be inserted into JTMD surveillance, weapons, and C³I systems at the component and subsystem level to provide warfighting capability that incrementally increases over time. Full-page descriptions of the DTO technical content, milestone schedules, funding, and performing organizations are presented in the accompanying DTO volume.

Table IV.D-4. Demonstration Support—Joint Theater Missile Defense

Demonstration	Operational Capability Elements				Service/Agency	Type of Demonstration		
	Attack Operations	Active Defense	Passive Defense	C ³ I		DTO	ACTD	ATD
Integrated Sensor/Data Fusion Demonstration	○	●	○	○	BMDO, Army, Air Force, Navy	D.02		
Discriminating Interceptor Technology Program		●		○	BMDO, Army, Air Force, Navy	D.03		
Advanced X-Band Radar Demonstration	○	●	○	○	BMDO, Army	D.04		
Advanced Space Surveillance	○	●	○	○	BMDO, Air Force	D.05		
Atmospheric Interceptor Technology		●			BMDO, Army	D.08		
Airborne Lasers for Theater Missile Defense	○	●	○	○	Air Force	WE.04.04		
Multimission Space-Based Laser	○	●	○	○	BMDO	WE.41.04		

● Strong Support

○ Moderate Support

- **D.02** *The Integrated Sensor/Data Fusion Demonstration* is a series of experiments performed on the ground and on an aircraft, focusing on integrating a suite of novel optoelectronic sensors with a lightweight laser radar. These experiments use a state-of-the-art neural network image processor to perform high-speed sensor signal processing, and perform multisensor onboard sensor data fusion in real time, simulating a space- or UAV-based sensor platform with enhanced tracking and surveillance capability.
- **D.03** *The Discriminating Interceptor Technology Program* develops and demonstrates in flight experiments the key technologies required to provide an exoatmospheric

interceptor with the advanced discrimination capabilities required to distinguish a reentry vehicle from accompanying missile fragments and decoys. The key technologies include a two-color, long-wavelength infrared focal plane array and an active laser radar coupled to advanced data fusion algorithms and the compact, very-high-throughput processing required to perform reliable intercepts of complex, sophisticated target threat clouds.

- **D.04** *The Advanced X-Band Radar Demonstration* will demonstrate a fivefold increase in the output power of solid-state transmit/receive (T/R) modules by exploiting advanced gallium arsenide and wide bandgap semiconductor device technologies and advanced monolithic microwave integrated circuit (MMIC) packaging technologies. This advanced T/R module design could directly replace the current module design in the THAAD phased-array ground-based radar (GBR). This upgrade would increase detection range by approximately a factor of two and would improve sensitivity for discrimination by a factor of five, thus greatly enhancing the THAAD GBR's capabilities for JTMD.
- **D.05** *The Advanced Space Surveillance* DTO includes development of innovative technologies for key space surveillance subsystems. These technologies include advanced multiband (ultraviolet plus infrared) focal plane arrays, gigabyte-per-second laser communications, image data fusion algorithms and processors, high-efficiency spacecraft solar panels, and high-performance satellite electric propulsion. These technologies could be incorporated into the programmed space surveillance system development programs (SBIRs) or integrated and demonstrated in a subsequent flight experiment.
- **D.08** *The Atmospheric Interceptor Technology* DTO includes development and demonstration at the prototype component level of several key technologies that would be required for a hypersonic hit-to-kill missile for intercepts within the lower atmosphere. The challenge of discriminating between actual reentry vehicles and decoys or missile fragments is partially alleviated for such endoatmospheric intercepts because atmospheric drag strips away lighter decoys and fragments. Under this DTO, prototypes of a strapdown infrared seeker and an externally helium-cooled missile forebody with an optical window will be developed. Development of other missile components and flight demonstrations could potentially be conducted under an augmented or follow-on program.
- **WE.04.04** *The Airborne Lasers for TMD* DTO develops the technologies for boost-phase intercept using a high-power laser beam from an airborne platform. Technologies from efforts supporting this DTO are now being incorporated into the design for the demonstration phase of the Air Force Airborne Laser Program, which is scheduled to conduct an airborne lethality demonstration against a ballistic missile target by FY02. Advanced technologies subsequently developed under this DTO will then be incorporated into the design for the engineering and manufacturing development phase of the Airborne Laser System. Technologies under development include advanced target tracking and atmospheric compensation using adaptive optics to achieve laser beam propagation over long paths through the upper atmosphere. Advanced chemical laser technology to increase the

efficiency and reduce the laser weight and size for aircraft installation is also being developed.

- **WE.41.04** *The Multimission Space-Based Laser* DTO is demonstrating the technologies for high-power space-based laser systems that could be used for boost-phase intercept of TBMs as well as against longer range missiles and other targets. This DTO integrates a high-power chemical laser designed for space operation with a laser beam director and tracking components in a lightweight, flight-representative ground test configuration. This integrated ground demonstration will establish the engineering basis for a potential follow-on space demonstration at 25 to 50 percent of the scale that would be required for an operational space-based laser weapon system.

The schedules for key technology efforts supporting these DTOs and the relationships among the technology efforts and DTOs are depicted in Figure IV.D-3.

In addition to the seven DTOs cited above that exclusively or primarily support JTMD, there are other DTOs in the DTAP that are advancing technologies important to future JTMD capabilities. For example, for space-based surveillance systems detecting TBMs against the earth background, the complexity and variability of the background clutter are key limitations for detecting dimmer missile targets. Therefore, the development, validation, and demonstration of advanced background clutter algorithms and prediction codes under the Satellite Infrared Surveillance Systems Backgrounds DTO (SE.56.01) are crucial for future JTMD space surveillance systems. From the same Sensors, Electronics, and Battlespace Environments technology area of the DTAP, the technologies for dual-band, cooled infrared focal plane array (FPAs) and highly uniform, uncooled FPAs that are being developed under DTAP DTO SE.33.01, Advanced Focal Plane Array Technology, support and are closely integrated with efforts under the JWSTP DTOs D.02 and D.03.

From the same technology area, radiation tolerant and hardened microelectronics technologies from DTO SE.37.01, High-Density Radiation-Resistant Microelectronics, will be needed for some JTMD surveillance systems and interceptor missiles facing natural space radiation and potential nuclear weapon environments. Processing analog signals from FPAs in surveillance sensors or on interceptor missiles to detect dim targets against complex backgrounds or digitizing radar signals to detect cruise missiles in ground clutter requires very high resolution, high-speed analog-to-digital converter technology from this technology area. Similarly, the technology efforts under DTAP DTO SE.27.01, Microwave SiC High-Power Amplifiers, complement the advanced transmit/receive module technology efforts under JTMD DTO D.04. Finally, efforts under the photonics thrust DTOs SE.35.01, Optical Processing and Memory, and SE.36.01, Photonics for Control of Radio Frequency Signals, support key technology needs in lasercomm, high-speed optical datalinks, solid-state nonvolatile memory, and high-capacity computer interfaces under the JTMD C³I Operational Capability Element (Table IV.D-2).

6. Summary

The incremental advances in demonstrated technology available to support JTMD warfighting capabilities are depicted in Figure IV.D-4. The dates shown in the figure are the timeframes in which JTMD technologies are projected to have been successfully demonstrated based on ongoing or programmed technology development and demonstration efforts; they are *not* the timeframes in

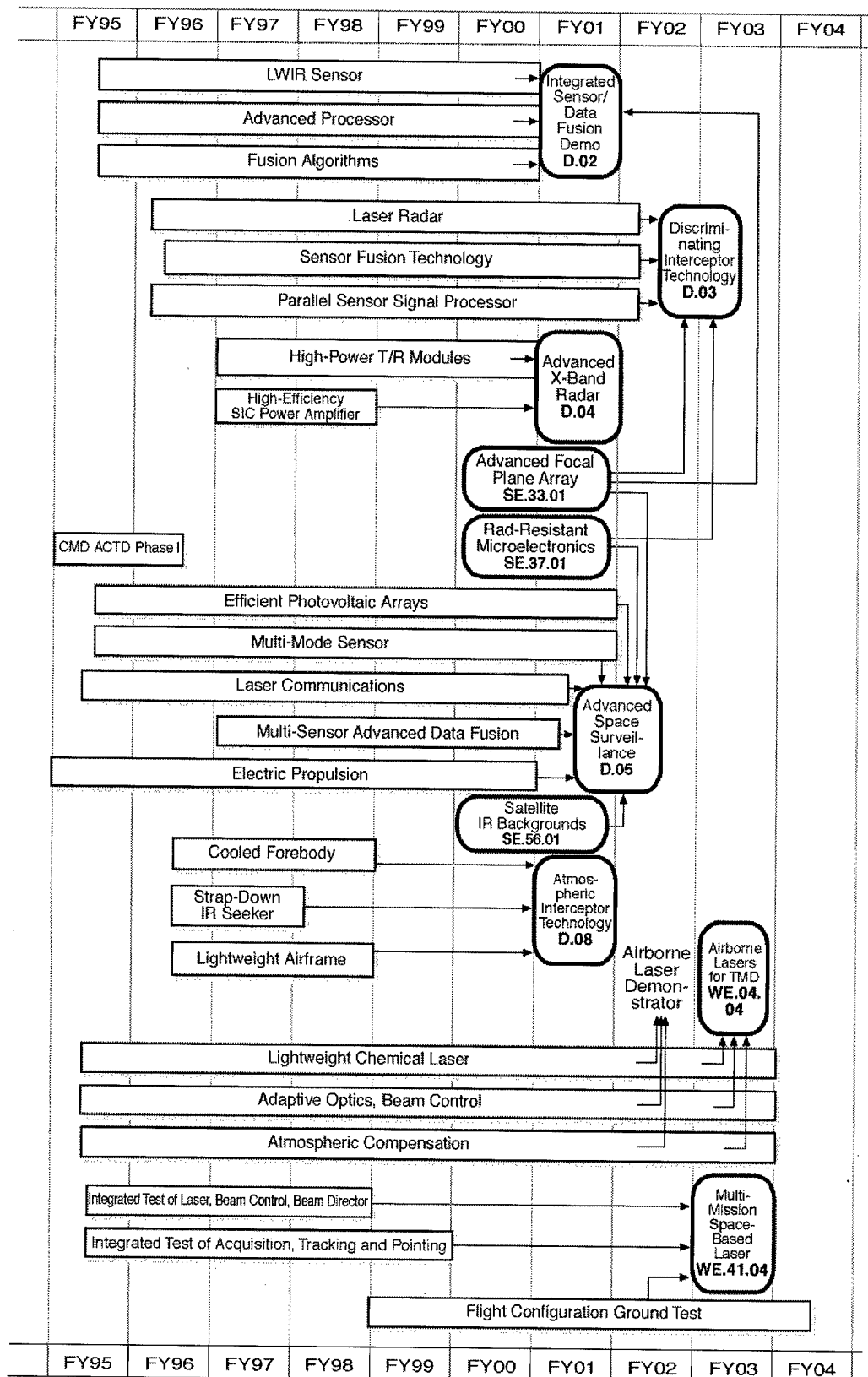


Figure IV.D-3. Roadmap—Joint Theater Missile Defense

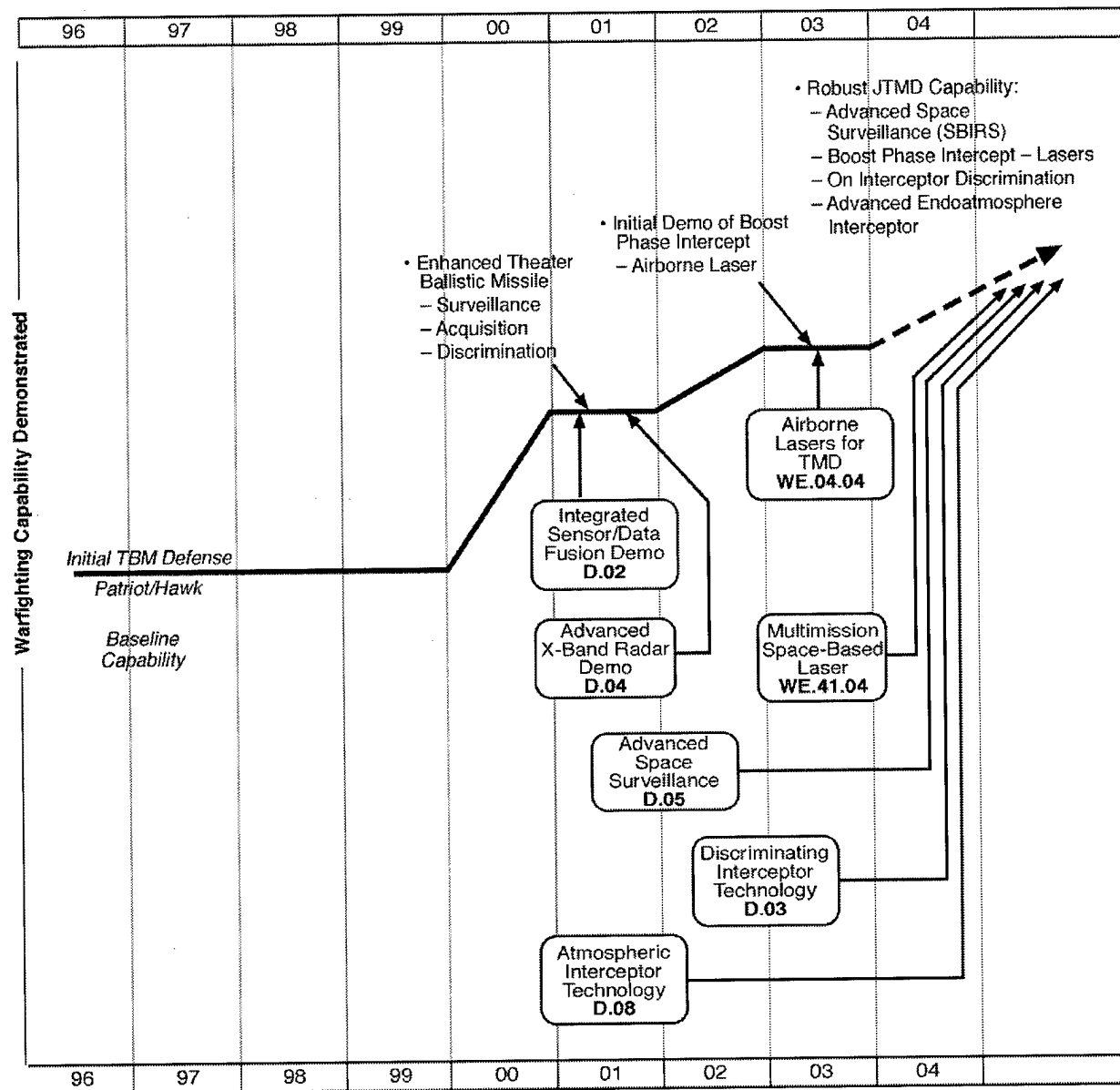


Figure IV.D-4. Progress—Joint Theater Missile Defense

which operational systems incorporating those technologies would be deployed. Once the technology demonstrations are completed, the technologies are expected to be sufficiently mature and the engineering risk sufficiently low that those technologies could be incorporated into the designs for modifications to deployed systems or into new systems. Development, production, and deployment of those operational systems incorporating the advanced technologies would require additional time and funding. For some technologies that could be retrofitted at the component or subsystem level as modification kits into systems already deployed, the development and upgrade period could be relatively short. However, for other technologies that would require major modifications to systems already deployed or in development or that would require development of new systems, the time from a technology demonstration milestone to a deployed operational JTMD capability could be many years.

By FY 2001, enhanced surveillance, acquisition, tracking, and discrimination capabilities against TBMs will be accessible by exploiting the technologies demonstrated under the Integrated Sensor/Data Fusion Demonstration and the advanced X-band T/R module program. Next, the initial demonstration of boost-phase intercept of a ballistic missile is scheduled for FY02 under the Air Force's Airborne Laser program using technology developed under the Airborne Lasers for TMD DTO.

Beyond FY04, robust JTMD capabilities—including advanced space-based surveillance, boost-phase intercept by airborne and space-based lasers, and onboard discrimination for both exo- and endo-atmospheric interceptors—will become attainable from the technology demonstrations under the surveillance, laser, and advanced interceptor DTOs, as shown in Figure IV.D-4. As depicted conceptually in Figure IV.D-1 at the beginning of this section, such a robust future JTMD architecture would provide a full theater defense against ballistic and cruise missiles that would include over-the-horizon targeting and tracking of TBM launches, precision targeting of land attack cruise missiles, TBM intercept above the atmosphere by exoatmospheric interceptors with superior discrimination capability, and high endoatmospheric intercept of TBMs.

E. MILITARY OPERATIONS IN URBAN TERRAIN (MOUT)

1. Definition

Military Operations in Urban Terrain (MOUT) is the capability to operate and conduct military operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. MOUT includes nonlethal weapons, precise weapons, surveillance, and situation awareness via communications effective in urban areas.

MOUT is not so much a unique capability as an environment in which the operational concepts of *Joint Vision 2010*—specifically precision engagement, full-dimensional protection, and dominant maneuver—will be tested under the most demanding conditions. In the near term, the emphasis will be on the exploitation and integration of existing technologies into systems offering improved capability for engagement, force protection, and maneuver in the urban environment. The long-term emphasis—which will form the basis for a true transformation of the traditional functions of strike, protection, and maneuver—will be a flattened command, control, and intelligence structure that will permit the warfighter, at any level, to employ forces and mass effects in revolutionary ways.

In a broad sense, MOUT is not unlike general warfare: our combat forces must be able to fight and survive better than their adversaries. MOUT is special because it is perhaps the most complex and resource intensive environment in which they will have to fight.

2. Operational Capability Elements

Urban centers increasingly are the sites of conflict throughout the world. MOUT is, and will continue to be, a major area of concern for U.S. forces. MOUT entails military actions that are planned for and conducted in terrain that features manmade infrastructure designed for habitation, cultural and recreational use, and economic activities by civilian population where tactical options might be complicated by the proximity of noncombatants. Actions involve small units, and the potential of incurring casualties is high. MOUT requires extensive use of Army and Marine light forces whose mission success tends to focus more on the operational effectiveness at lower echelons (e.g., battalion and below) than larger scale conflicts. The U.S. operational advantage—typically associated with long-range, high-technology weapon platforms that use mass and mobility—is significantly reduced in urban environments. Therefore, the weapon of choice for MOUT remains the individual combatant working within a small unit.

As for warfare in general, for MOUT the key operational capabilities are engagement, force protection, and maneuverability. Within these three broad areas, we have defined specific operational capability elements that, if achieved, will lead to a significant improvement in our capability to effectively operate in a MOUT environment.

Engagement. MOUT engagement will consist of a “system-of-systems” that enables our forces to locate the objective or target, provide responsive command and control, generate the desired effect, assess the level of success, and retain the flexibility to reengage with precision when required. The specific operational capability elements are listed below.

- *Situation awareness.* The key to success in offensive operations in urban terrain is knowledge—knowledge of ones own position(s) and intent, and of the position(s) and intent

of the enemy. That knowledge must be readily available at every level down to the individual combatant, regardless of whether he has line of sight to the source of the information.

- *Increased weapons effectiveness.* MOUT engagements require overmatching lethality in terms of direct and indirect firepower tailored to effectively engage targets commonly encountered in MOUT, using smart and precision-guided munitions. We must build on current U.S. advantages in delivery accuracy and all-weather and night capabilities. Moreover, we must foster the development of nonlethal technologies to provide selective response and the ability to minimize collateral damage.
- *Increased individual agility.* The individual combatant must be able to move quickly and precisely, unencumbered by heavy and bulky body armor, weapon systems, and communications packages. His mobility—the ability to move vertically as well as horizontally—must be increased to allow him to engage where least expected.

Force Protection. MOUT force protection will enable the effective employment of our forces while degrading opportunities for the enemy. We must protect our own forces from the very technologies we are exploiting. Specific operational capability elements are:

- *Situation awareness.* Situation awareness will be built on information superiority, which will provide multidimensional and all-environment awareness and assessment as well as positive identification of all forces in the battlespace.
- *Increased weapons effectiveness.* A key to surviving in any environment is the ability to engage the enemy accurately and effectively in all conditions before the enemy is able to engage you. A flexible response option such as nonlethal weapons will lessen the chance of indecision associated with noncombatants in the battlespace.
- *Individual protection.* If our combatants are to be successful in MOUT, they must survive. Individual systems that enhance survivability are essential to force protection.

Maneuverability. MOUT maneuverability is the ability to apply the multidimensional aspects of information superiority and the ability to insert forces where and when we want them to accomplish assigned tasks within the constraints of the urban environment.

- *Situation awareness.* The application of rapid, unpredictable yet precise insertion of the right forces at the right time without the knowledge of the enemy will enable the broader operational capability of maneuverability. Situation awareness is one critical enabling ingredient.
- *Precision insertion.* Not only must we know where the enemy is, but we must be able to approach him from where he least expects it and when he least expects it—at night and in inclement weather.

The goal is to enhance the operational capability elements mentioned above to increase the effectiveness of the individual combatant in the urban environment. Situation awareness is the major enabler that is essential to the effectiveness of each of these elements as shown in Figure IV.E-1.

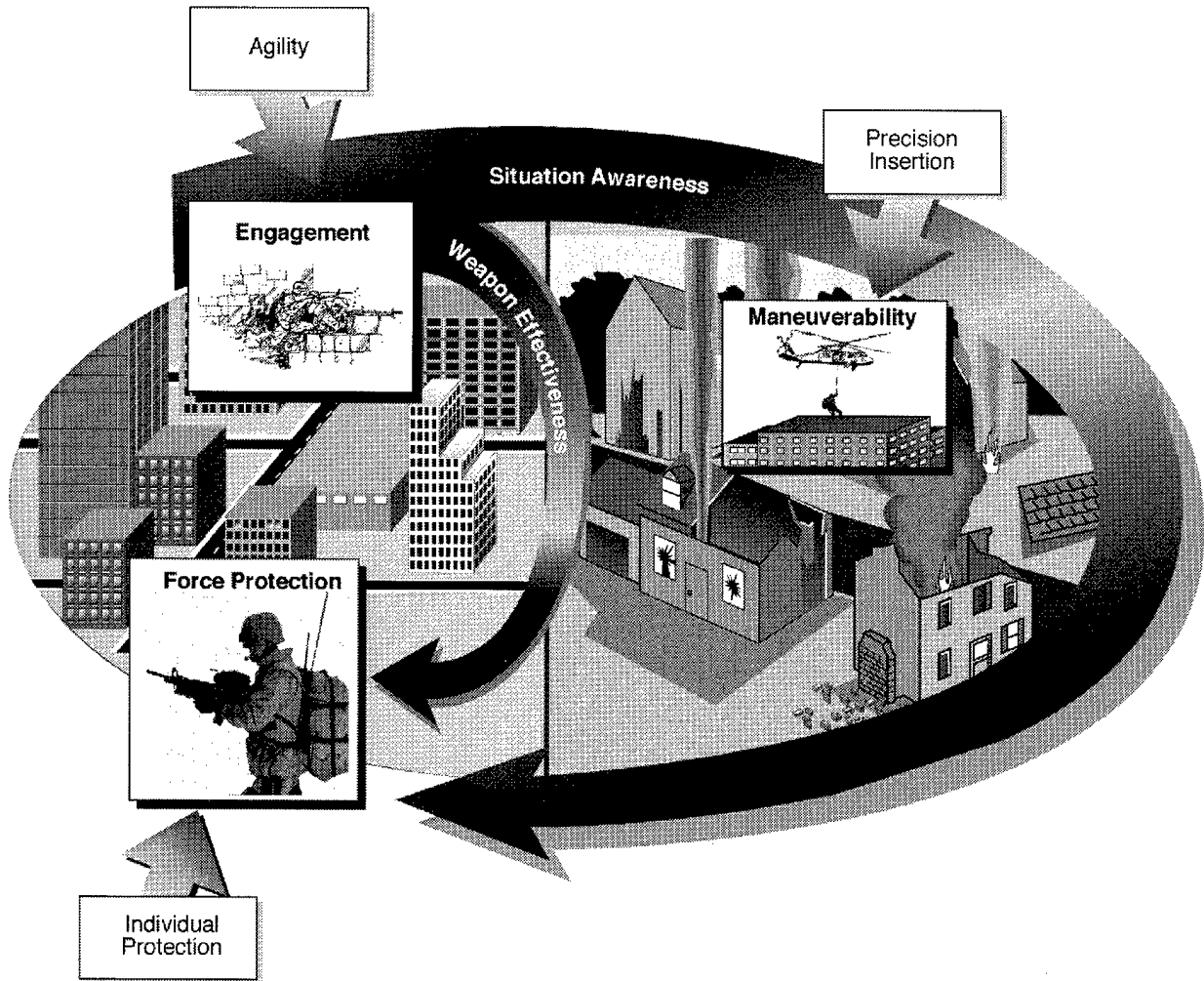


Figure IV.E-1. Concept—Military Operations in Urban Terrain

3. Functional Capabilities

The 1996 DSB Summer Study identified three technology areas that must be exploited if we are to be successful in urban operations: virtual line of sight; precise location of friends, innocents, and foes; and the need for minimum or no collateral damage. Virtual line of sight could be enabled with through-the-wall radar concepts, miniaturized unmanned airborne vehicles (UAVs) and unmanned ground vehicles (UGVs), or robots. Microbots could provide significant increases in functional capabilities for MOUT situation awareness. Robots could act as “point men” for force protection to precede our combatants and act in a sentry role to cover building exits. Non-lethals would help the small urban force deal with innocents and avoid any unnecessary collateral damage. The principal issue is identifying the “acceptable limits of effects.”

To achieve the needed operational capabilities and to create a greater U.S. military advantage, MOUT requires, at a minimum, the functional capabilities described below and shown in Table IV.E-1 as they relate to the eight operational capability elements.

Table IV.E-1. Functional Capabilities Needed—Military Operations in Urban Terrain

Functional Capabilities	Operational Capability Elements							
	Engagement			Force Protection			Maneuver	
	Situation Awareness	Weapons Effectiveness	Individual Agility	Situation Awareness	Weapons Effectiveness	Individual Protection	Situation Awareness	Precision Insertion
1. Accurately Place Self and Enemy With Complete Knowledge of Environment	●			●			●	
2. Flattened C ² I Structure Allowing Distribution of Essential Information to Every Level of Command Down to Individual Combatant	●			●			●	
3. Increased Individual Weapons Effectiveness Day/Night, All-Weather, Long Range With a Measured Response Capability		●			●			
4. Increased Crew Served Weapons Effectiveness Against Fortified, Defilade, Dug-In Targets		●			●			
5. Enhanced Target Acquisition Indirect Viewing and Through-Wall Sensing	○	●		○	●		○	
6. Decreased Sensor to Shooter Engagement Time		●			●			
7. Hands-Free Communication		○	●		○			
8. Lighter, Less Bulky Body Armor and Lighter Equipment and Compact Weapons Systems			●			●		
9. Enhancements for the Individual Combatant to Negotiate and Breach Obstacles			●			○		
10. Ability to Differentiate Friend From Foe in Reduced/No Visibility	●	○		●	○	●	●	
11. Increased Capability to Detect Mines and Explosives	●	●		●		●	●	
12. Increase Capability to Target Snipers and Mortars	●	○		●	○	●		
13. Reduction of Multispectral Signature of the Individual Combatant			○			●		○
14. Reduction of Susceptibility of the Individual Combatant to Small Arms, Fragmentation, and Environmental Hazards Such as Fire and Chemical Sources						●		
15. Ability to Monitor and Transmit the Physical Well-Being of Individual Combatant	○			○		●	○	
16. Precision, Survivable Covert Insertion of Combat Forces								●

● Strong Support

○ Moderate Support

Engagement. Improved individual and crew-served weapons with full-solution fire control, coupled with improved bunker-defeating weapon systems, will enhance target engagement capabilities against fortified, dug-in, or defilade targets. Multispectral sensors will provide enhanced target acquisition under all operational conditions. In addition, the sensor-to-shooter linkages will provide effective target handover to supporting standoff precision weapon systems. Irritants, barriers, and incapacitants will provide nonlethal capabilities to augment crowd control and deal effectively with the noncombatant population.

Force protection. Improved small-arms protective vests will stop 7.62-mm armor-piercing rounds. Multispectral signature-reducing materials and techniques will reduce detection by enemy sensors. Lightweight, multifunctional protective materials will allow survival in flame and fires and other environmental threats and hazards. Combat identification, indirect viewing/unexposed firing, mine detection, counter-sniper systems, and personnel status monitoring will also enhance survivability, as will overall improvements in situation awareness, particularly when digitally linked.

Maneuverability. Self-contained navigation technologies capable of better than 3-meter accuracy for GPS augmentation, urban databases and digital mapping (better than 1-meter resolution), and simulations fed by the rapid generation of terrain, feature, and building data, will provide increased command tempo, control, intelligence, and mission planning and rehearsal, while enhancing maneuverability of individuals and the force. Precision covert personnel aerial delivery technologies capable of providing 25-meter circular error probable accuracy will heighten soldier mobility and survivability.

Revolutionary advances in command, control, communications, computers, and intelligence (C⁴I) capabilities will be required across each of the operational capability elements if we are to achieve the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010*. Near-real-time vertical and horizontal C² from the battalion down to the individual combatant will enhance situation awareness at all levels. This will be accomplished through hands-free, robust communications; high-data-rate communications for rapid voice, data, and video transmissions; and video capture. Fusing, filtering, and disseminating technologies will ensure that essential information is distributed to the appropriate small units. Near-real-time sensor-to-shooter linkages are needed to facilitate the processing and dissemination of data. Improved multispectral sensors and optics, combat identification systems, topographical systems, counter-sniper systems, unmanned ground and aerial vehicles (UGVs, UAVs), and other emerging systems will be necessary to accommodate these near-real-time sensor-to-shooter linkages.

4. Current Capabilities, Deficiencies, and Barriers

The operational capabilities required to be effective in the urban environment are identical to those for land warfare in general. They are just harder to achieve. The current U.S. military capability was developed to conduct large-scale, rural war in central Europe (Reference 14). Many current systems are not fully suited to the MOUT mission and environment. Heretofore, the U.S. military strategy and doctrine called for avoiding urban areas and controlling them from without. Our currently fielded capabilities are optimized for this wide-open land battle and do not adequately support warfare in the much more difficult urban environment. Table IV.E-2 details the limitations and solutions for each of the operational capability elements.

Our combatants are unable to communicate through walls and other obstacles. They cannot determine their exact positions accurately enough, nor are they able to pinpoint targets for supporting arms. Urban databases do not exist from which they can draw to increase situation awareness. Combatants cannot determine the position of an enemy who chooses to remain covered. Individual equipment is bulky and heavy, and it degrades mobility in the often cramped urban environment. In addition, there is no capability to choose the type and degree of force to use, which puts innocent noncombatants at risk and might inhibit the use of any force.

Table IV.E-2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain

Goal	Functional Capabilities	Limitations	Key Technologies
Engagement			
Operational Capability Element: Situation Awareness			
Provide a system of systems that will enable our forces to locate the objective or target, provide responsive command and control, generate the desired effect, assess the level of success, and retain the flexibility to reengage with precision when required.	The ability to accurately place self and enemy with complete knowledge of environment Flattened C²I structure allowing distribution of essential information to every level of command down to individual combatant	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems See-through flat panel displays have limited resolution Uncooled thermal sensors have limited resolution No available shared aperture IR/radar sensor No available "smart ground station" processing capability Limitation presented at Figure IV.A-2 (Information Superiority) apply	Multichannel RF links Wireless networking Data compression technologies Real-time video Lightweight power technologies Electronics packaging Low-power electronics Microelectromechanical systems (MEMS) Advanced, lightweight multispectral sensors Lightweight, down-range wind sensing Advanced man/machine interfaces Automated artificial intelligence assisted sensor/data fusion Systems miniaturization technologies High bandwidth datalinks Smart remote/ground station processing with ATR Technologies listed in Figure IV.A-2 (Information Superiority) apply
Operational Capability Element: Weapons Effectiveness			
	Increased individual weapons effectiveness; day/night/all-weather long range with a measured response capability Increased crew-served weapons effectiveness against fortified, defilade, dug-in targets Enhanced target acquisition capability—indirect viewing and through-wall sensing Decreased sensor-to-shooter engagement time	Uniform fragmentation distribution Stability of lightweight individual weapons platforms Accurate laser range finding in all environments Boresighting weapon mounted sensors Cost, weight, and power for individual combatant acquisition, data processing, display, and weapons systems No tunable (lethality selectable) non-lethal weapons/munitions exist Limited bioeffects database on personnel effects of nonlethal technologies	Multichannel RF links Electronics packaging Low-power electronics Systems miniaturization technologies High bandwidth datalinks Lightweight, high-power density batteries/power cells Advanced materials Efficient recoil mitigation Accurate all-environment laser ranging techniques Lightweight optoelectronics Directed air-burst mechanisms Integrated range feedback with selectable lethality (nonlethal to lethal) munitions on a single weapons platforms Variable velocity weapon mechanisms Proximity fusing for antipersonnel use

Table IV.E-2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Engagement (continued)			
Operational Capability Element: Individual Agility			
	Hands-free communications Lighter less bulky body armor and equipment and compact weapons systems Enhancements for the urban warrior to negotiate and breach obstacles	Helmet weight Current sensor technology requires full time MITL teleoperation of UGVs Current sensor technology not size/weight/cost optimized for UGV applications Inability to capture and effectively user 100% of the body's energy expenditure Power sources are heavy and short lived	Advanced man/machine interfaces Voice controlled communication Advanced materials Miniaturized propulsion Biomechanics and robotics Lightweight, long-life power sources
Force Protection			
Operational Capability Element: Situation Awareness			
Provide the necessary systems to significantly increase personnel warfighter survivability in urban terrain	The ability to accurately place self and enemy with complete knowledge of environment Flattened C²I structure allowing distribution of essential information to every level of command down to individual combatant Ability to differentiate friend from foe in reduced/no visibility Increased capability to detect mines and explosives Increased capability to target snipers and mortars	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems See-through flat panel displays have limited resolution Uncooled thermal sensors have limited resolution No available shared aperture IR/radar sensor No available "smart ground station" processing capability Limitation presented at Figure IV.A-2 (Information Superiority) apply Current sensors have insufficient sensitivity and resolution to detect or track small arms projectiles Automated mine detection capabilities limited	Low cost millimeter wave radar Projectile detection/tracking algorithms processing Laser propagation RF antenna design/construction RF spread spectrum signal transmission and processing

Table IV.E-2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Force Protection (continued)			
Operational Capability Element: Weapons Effectiveness			
	Increased individual weapons effectiveness; day/night/all-weather long range with a measured response capability Increased crew-served weapons effectiveness against fortified, defilade, dug-in targets Enhanced target acquisition capability—indirect viewing and through-wall sensing Decreased sensor-to-shooter engagement time	Uniform fragmentation distribution Stability of lightweight individual weapons platforms Accurate laser range finding in all environments Boresighting weapon mounted sensors Cost, weight, and power for individual combatant acquisition, data processing, display, and weapons systems No tunable (lethality selectable) non-lethal weapons/munitions exist Limited bioeffects database on personnel effects of nonlethal technologies	Multichannel RF links Electronics packaging Low-power electronics Systems miniaturization technologies High bandwidth datalinks Advanced materials Efficient recoil mitigation Accurate all-environment laser ranging techniques Lightweight optoelectronics Directed air-burst mechanisms Integrated range feedback with selectable lethality (nonlethal to lethal) munitions on a single weapons platforms Proximity fusing for antipersonnel use
Operational Capability Element: Individual Protection			
	Reduction of multispectral signature of the individual combatant Reduction of susceptibility of the individual combatant to small arms fire, fragmentation, and environmental hazards such as fire and chemical sources The ability to monitor and transmit the physical well-being of the individual combatant	Lack of affordable, lightweight, flexible small arms materials Limited understanding of fundamental penetration mechanisms Independent component approach—not integrated The integration of thermal camouflage technology into a textile material Site-specific camouflage Electronics miniaturization and integration Lack of knowledge of appropriate essential elements of information Lack of personal medical sensors No automatic transmission of medical information	Electronics packaging Low-power electronics Advanced man/machine interfaces Automated artificial intelligence assisted sensor/data fusion Advanced materials Enhanced numerical modeling to understand fundamental penetration Increased strength and low density materials Improved specific toughness, high modulus polymers Lightweight, flexible, multispectral textile materials Accurate medical sensors on individual

Table IV.E-2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Maneuverability			
Operational Capability Element: Situation Awareness			
The multidimensional application of information, engagement, and mobility capabilities to position and employ widely dispersed joint air, land, sea, and space forces to accomplish the assigned operational tasks	The ability to accurately place self and enemy with complete knowledge of environment Flattened C²I structure allowing distribution of essential information to every level of command down to individual combatant	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems See-through flat panel displays have limited resolution Uncooled thermal sensors have limited resolution No available shared aperture IR/radar sensor No available "smart ground station" processing capability Limitation presented at Figure IV.A-2 (Information Superiority) apply	Multichannel RF links Wireless networking Data compression technologies Real-time video Lightweight power technologies Electronics packaging Low-power electronics Microelectromechanical systems (MEMS) Advanced, lightweight multispectral sensors Lightweight, down-range wind sensing Advanced man/machine interfaces Automated artificial intelligence assisted sensor/data fusion Systems miniaturization technologies High bandwidth datalinks Smart remote/ground station processing with ATR Technologies listed in Figure IV.A-2 (Information Superiority) apply
Operational Capability Element: Precision Insertion			
Precision covert insertion of airborne combat forces	Precision, survivable covert insertion of combat forces	Accurate characterization of decelerator aerodynamic coefficients of performance Maneuvering around urban obstacles at night Gliding characteristics of parafoil	Multichannel RF links Computational fluid dynamics applications for decelerator characterizations

For the most part, technologies necessary to achieve the operational capabilities of MOUT engagement, force protection, and maneuverability already exist either on the shelf or as short-term defense technology objectives in other JWSTP or DTAP technology areas. The challenge is to integrate these technologies into coherent systems optimized for MOUT.

There are technological barriers that we will have to surmount. For MOUT, these occur primarily in C⁴I, an area that is key to situation awareness. The greatest concern is the limiting effects of urban environments on small unit communications, reliability, and range. The technology does not currently exist, nor does a breakthrough appear imminent, that will allow the non-line-of-sight transmission (through obstacles) of the large bandwidths needed to carry necessary information to the individual combatant. Research will center on innovative new signal routing techniques and exploitation of low-frequency technology.

5. Technology Plan

Figure IV.E-2 depicts the integration of supporting technologies to achieve operational capabilities. Table IV.E-3 lists the key Defense Technology Objectives for MOUT, and Table IV.E-4 shows the demonstrations supporting MOUT Joint Warfighter Capability Objectives.

The U.S. warfighter currently has basic capabilities for conducting the full spectrum of operational missions in most environments; however, there are significant deficiencies associated with MOUT. The intent of the MOUT technology plan is to provide a path for resolving those deficiencies and advancing critical technologies needed for MOUT. The group of functional capabilities identified here must be developed to ensure that the United States can overmatch any adversary in a conflict set in urban terrain. The roadmap for the development and demonstration of the MOUT system-of-systems is shown in Figure IV.E-3.

The technologies required to achieve the functional and operational capability elements that are critical for MOUT are at varying levels of maturity. They will be demonstrated at the component and subsystem level primarily through the completion of the Defense Technology Area Plan (DTAP) Defense Technology Objectives (DTOs) (see Table IV.E-3). The full suite of products and functionality that evolves from these technologies is required for seamless operation in a MOUT environment. To maximize our warfighting edge, these technologies must be integrated into a MOUT system-of-systems.

One of the greatest technical challenges for MOUT is the integration of a wide range of equipment, which will operate effectively and reliably given the particular challenges of the urban environment. In addition, integration of much of this equipment onto the human platform—with all its peculiarities, variations, and individual preferences—is critical, given that most MOUT operations focus on the individual combatant and small units. Experience has shown that a systems approach must be aggressively pursued, as opposed to a “stovepipe” development of each technology component.

As seen in Figure IV.E-3, various projects feed into these objective areas. Service and Defense Advanced Research Projects Agency (DARPA) advanced technology demonstrations (ATDs) and technology demonstrations (TDs) will develop the new technologies, and most of the efforts provide for demonstration of those technologies. The primary focus of a few key programs (e.g., DARPA Small Unit Operations (SUO), Army/Marine Corps Force XXI Land Warrior (FXXILW)) is on integrating subsystems, systems, and functionality for the warfighter. These programs are the “cement” that will form the cornerstone of the MOUT system-of-systems.

While not a functional capability directly contributing to any of the operational capability elements, modeling and simulation (M&S) will contribute to the assessment of advanced technologies as well as contributing to MOUT mission rehearsal. M&S will complement hardware and system development via an instrumented MOUT testbed. Coupled with upgraded models and simulations, this capability will be used to assess and evaluate hardware and software performance. M&S will also augment the development and assessment of advanced operational concepts and tactics, techniques, and procedures for MOUT operations, in addition to providing a mission rehearsal capability. In aggregate, the M&S effort will allow full operational exploitation of the technological advances.

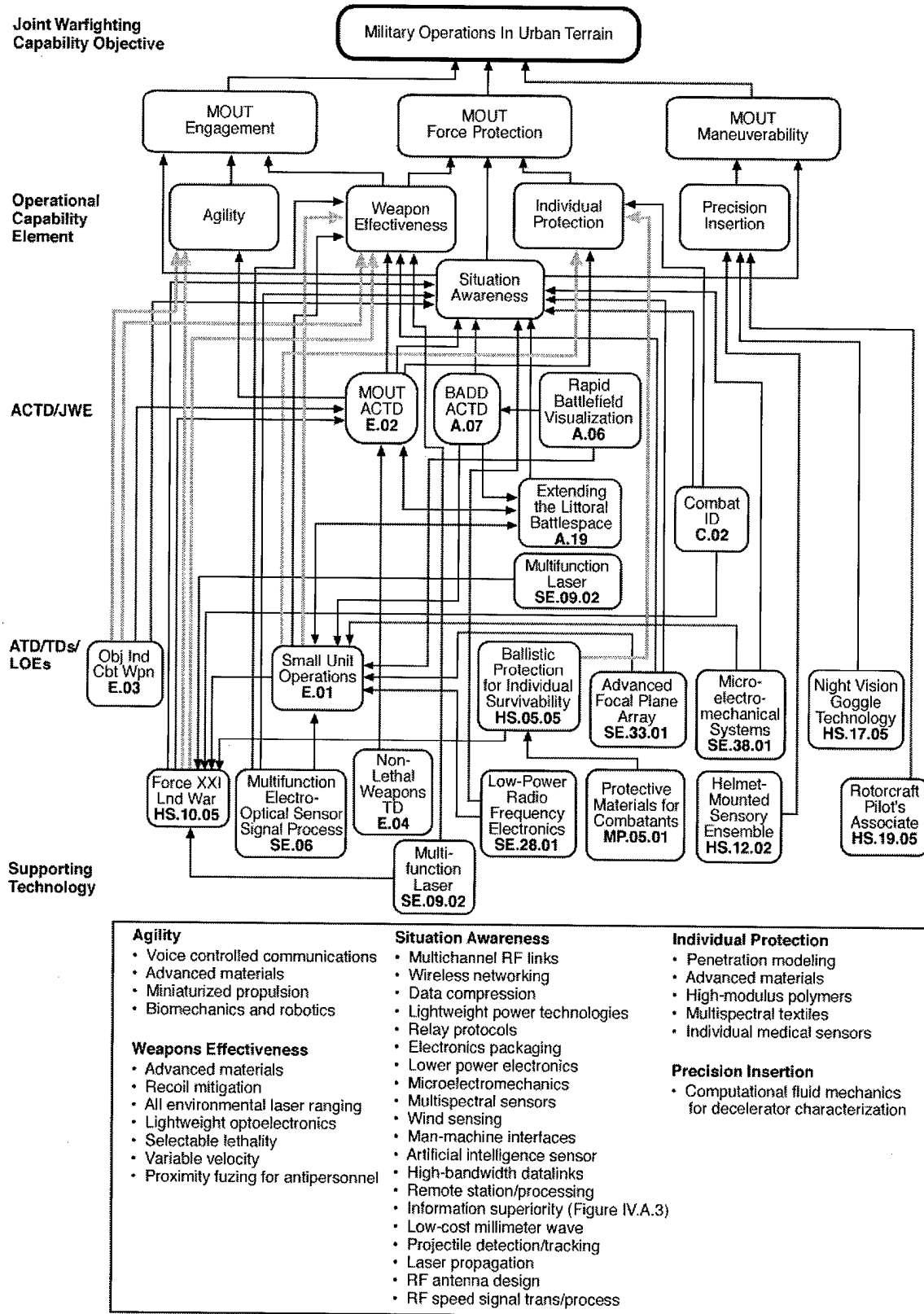


Figure IV.E-2. Technology to Capability—Military Operations in Urban Terrain

**Table IV.E-3. Defense Technology Objectives—
Military Operations in Urban Terrain**

DTO No.	Title
E.01	Small Unit Operations TD
E.02	Military Operations in Urban Terrain ACTD
E.03	Objective Individual Combat Weapon ATD
E.04	Non-Lethal Joint Limited Objective Experiment
A.06	Rapid Battlefield Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.19	Extending the Littoral Battlespace (Sea Dragon) ACTD
C.02	Combat Identification ACTD
HS.05.05	Ballistic Protection for Individual Survivability
HS.10.05	Force XXI Land Warrior
HS.12.02	Helmet-Mounted Sensory Ensemble
HS.17.05	Night Vision Goggle Technology
HS.19.05	Rotorcraft Pilot's Associate
MP.05.01	Protective Materials for Combatant and Combat Systems Against Conventional Weapons
SE.06.01	Multifunction Electro-Optical Sensor Signal Processing
SE.09.02	Multifunction Laser
SE.28.01	Low-Power Electronics
SE.33.01	Advanced Focal Plane Array
SE.38.01	Microelectromechanical Systems

Table IV.E-4. Demonstration Support—Military Operations in Urban Terrain

Demonstration	Operational Capability Elements								Service/ Agency	Type of Demonstration				
	Engagement			Force Protection			Maneuver	DTO		ACTD	ATD	TD	LOE	
	Situation Awareness	Weapons Effectiveness	Individual Agility	Situation Awareness	Weapons Effectiveness	Individual Protection	Situation Awareness							Precision Insertion
Small Unit Operations*	●			●			●		DARPA	E.01			X	
Military Operations in Urban Terrain*	●	●	●	●	●	●	●		Joint	E.02	X			
Objective Individual Combat Weapon*	○	●	○	○	●				Joint	E.03		X		
Non-Lethal Joint Limited Objective Experiment*		●			●				USMC, Army	E.04				X

*Strong support for counterterrorist operations

● Strong Support

○ Moderate Support

Table IV.E-4. Demonstration Support—Military Operations in Urban Terrain (continued)

Demonstration	Operational Capability Elements								Service/Agency	Type of Demonstration				
	Engagement			Force Protection			Maneuver			DTO	ACTD	ATD	TD	LOE
	Situation Awareness	Weapons Effectiveness	Individual Agility	Situation Awareness	Weapons Effectiveness	Individual Protection	Situation Awareness	Precision Insertion						
Rapid Battlefield Visualization*	●			●			●		Joint	A.06	X			
Battlefield Awareness and Data Dissemination (BADD)	●			●			●		DARPA	A.07	X			
Extending the Littoral Battle-space (Sea Dragon)	●	●		●			●		DARPA	A.19	X			
Combat Identification	●			●		●	●		All	C.02	X			
Ballistics Protection for Individual Survivability			●			●			USMC	HS.05.05			X	
Force XXI Land Warrior*	●	●	●	●	●	●	●		USMC, Army	HS.10.05			X	
Helmet-Mounted Sensory Ensemble			●					●	Air Force, Navy	HS.12.02			X	
Night Vision Goggle Technology			●					●	Air Force, Navy	HS.17.05			X	
Rotorcraft Pilot's Associate								●	Army	HS.19.05		X		
Protective Materials for Combatant and Combat Systems Against Conventional Weapons			●			●			Army, Navy	MP.05.01			X	
Multifunction Electro-Optical Sensor Signal Processing	●			●		●	●		Army, Air Force	SE.06.01			X	
Multifunction Laser	○	●	○	○	●		○		Joint	SE.09.02			X	
Low-Power Electronics	●		○	●			●		Air Force	SE.28.01			X	
Advanced Focal Plane Array	●	●		●	●		●		Army, Navy	SE.33.01			X	
Microelectromechanical Systems	●			●			●		Army, Air Force	SE.38.01			X	

*Strong support for counterterrorist operations

● Strong Support

○ Moderate Support

Each component will be ready for demonstration at a different point along the roadmap. The MOUT Advanced Concept Technology Demonstration (ACTD) provides the first opportunity to demonstrate a MOUT system-of-systems in the FY 1999–2000 timeframe. The MOUT ACTD will demonstrate available technology items (i.e., NDI/COTS/GOTS) during FY97/98. This initiative cuts across the services and will capture the efforts of the Army, DARPA, Marine Corps, and U.S. Special Operations Command (USSOCOM). It will focus primarily on the integration, linkage, and interoperability of MOUT system components, and will include demonstrations in joint field exercises. (See DTO E.02.)

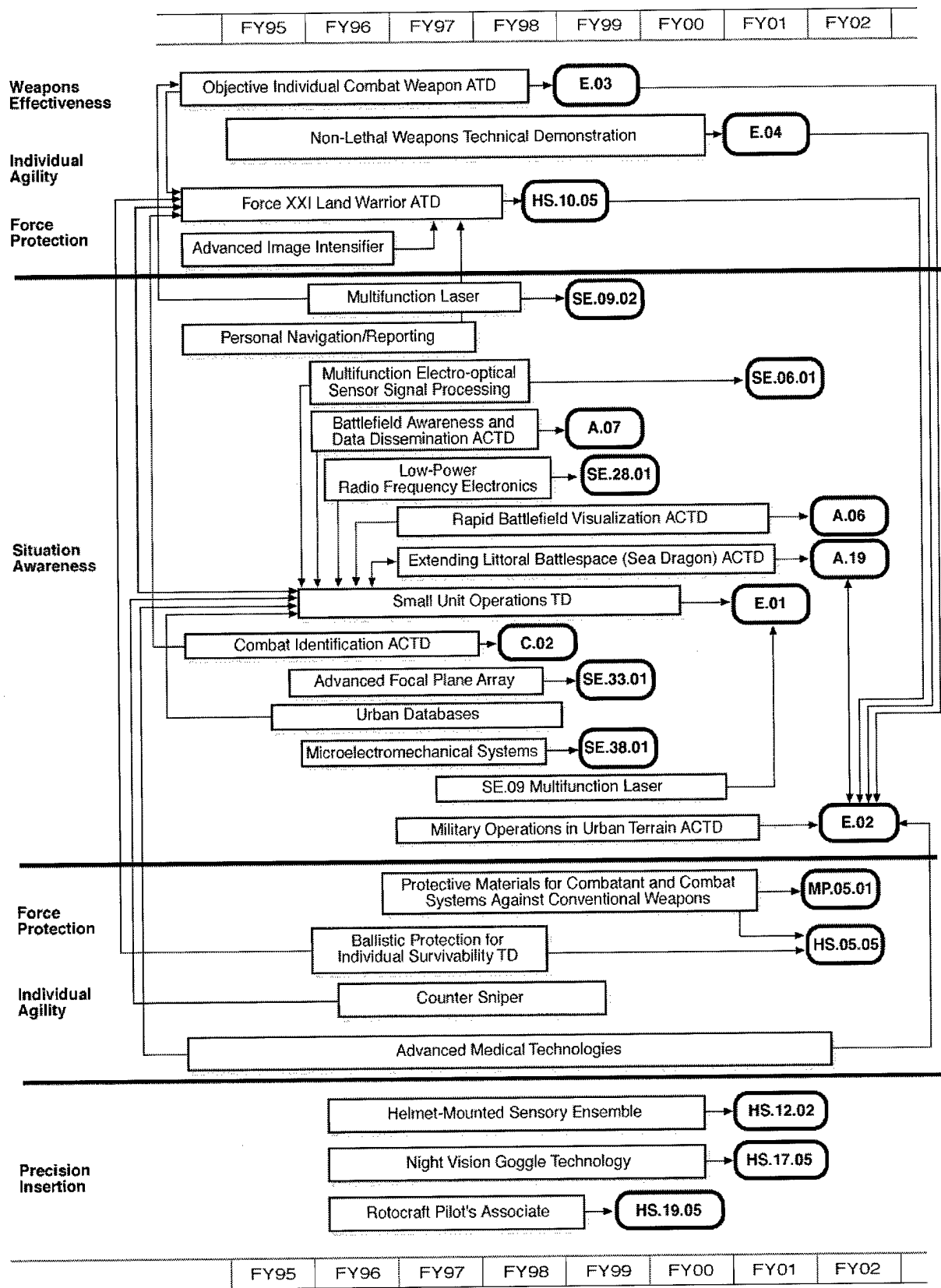


Figure IV.E-3. Roadmap—Military Operations in Urban Terrain

6. Summary

Accomplishment of the objectives delineated in each of the MOUT DTOs reflects the integration of capabilities within a given operational area. These DTOs are, in effect, waypoints on the path to achieving a full spectrum of enhanced operational capability elements in MOUT. Each DTO represents a complement of interim capabilities within that specific area. The MOUT ACTD will complete the integration, interoperability, and linkage across the operational areas to achieve the full-spectrum, seamless MOUT capability, as illustrated in Figure IV.E-4. The successful implementation of this technology plan will result in substantial improvements in the ability of U.S. forces to effectively and efficiently accomplish missions, including general war, contingency operations, counterinsurgency, and peace and humanitarian operations in built-up areas.

Measures of success will serve as quantitative goals for the MOUT ACTD. Although not defined for all potential technologies, the overall measures of success are defined in terms of percent improvements over the base, MOUT capabilities, and applicable doctrinal and technical publications. Specific measures of effectiveness (MOE) for technology components will be developed and refined using the model-test-model methodology. The base case will be modeled using CAST-FOREM, incorporating the anticipated field experiment, terrain, and scenario. Based on runs of the base case and the ACTD case, specific data on MOEs and performance can be predicted with defensible analytical underpinnings.

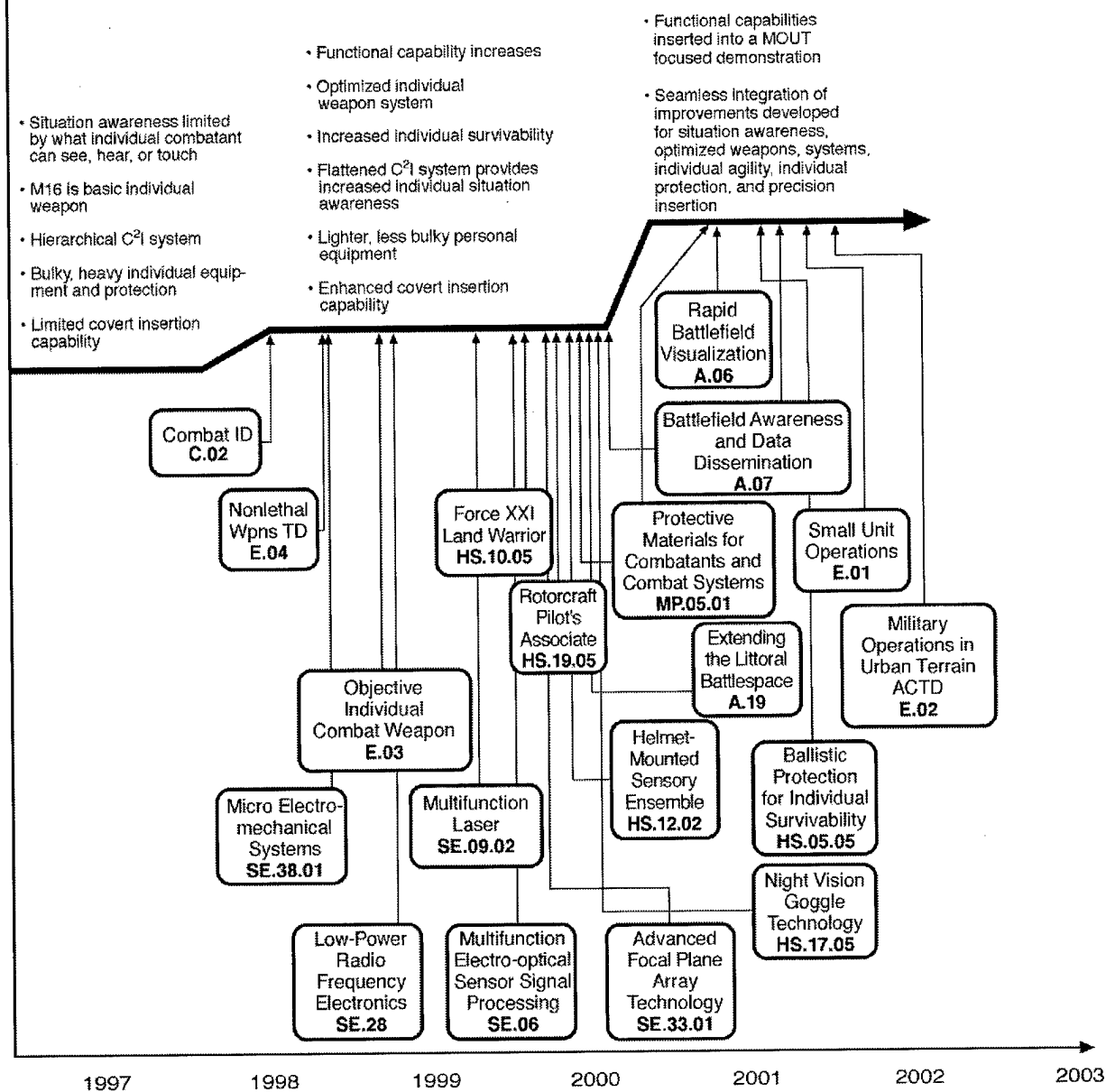


Figure IV.E-4. Progress—Military Operations in Urban Terrain

F. JOINT READINESS AND LOGISTICS

1. Definition

Joint Readiness and Logistics is the capability to enhance readiness and logistics for joint and combined operations. It includes capabilities for enhanced simulation for training; improved and affordable operations and maintenance (O&M) and life cycle costs; mobility and sustainability (i.e., transportation support technologies, speed of delivery); and near-real-time visibility of people, units, equipment, and supplies that are in storage, in process, in transit, or in theater, linked with the ability to act on this information. The CJCS-approved Universal Joint Task List (UJTL) identifies the readiness tasks that must be accomplished within the Joint Warfighting arena. The UJTL is broken down into operational and functional capabilities that are the CINC's domain. If a Combatant Command has the means to accomplish all of the joint mission-essential tasks derived from the UJTL, then by definition the assigned forces have achieved a high state of readiness.

Figure IV.F-1 depicts the technology areas within which advances will lead to increased functional capabilities. Technological enhancements in these functional areas will improve performance in the operational capabilities that define Joint Readiness and Logistics. Some of the operational capability elements affecting joint readiness and logistics are discussed in the technology objectives contained in the Information Superiority (IS) portion of this plan. To avoid duplication, the Joint Readiness portion of this chapter narrows its focus to capabilities not covered specifically in the IS area, namely the broad areas of assessment of force readiness; collaborative planning for the deployment and sustainment of these forces; and joint and combined training in CONUS and deployment abroad. The key to readiness is the capability to have near-real-time visibility and the ability to assess the status of people, units, equipment, and sustainment that are in theater, in transit, in storage, or in process anywhere; to have the training and equipment needed to effectively plan their joint utilization in support of assigned missions; and to rapidly deploy units and distribute sustainment supplies to the most useful destinations from factory to the front. In addition, ensuring long life and low cost for equipment and the logistics infrastructure is a key requirement across the entire spectrum of capabilities.

The following metrics will be used to determine success:

- Readiness of primary weapon systems will be increased by a minimum of 10 percent with a goal of 20 percent.
- Confidence in the logistics pipeline will be demonstrated by a decrease in redundant requisitions and reorders to no more than 5 percent with a goal of zero.
- The speed with which logistics courses of action (COA) can be generated will increase to a minimum of one COA in 4 hours with a goal of one in 1 hour.
- The dollar value and volume of DoD-owned supply inventories will be reduced—a minimum of 20 percent with a goal of 32 percent reduction in dollar value, and a minimum of 30 percent with a goal of 40 percent reduction in volume (cubic feet).
- The cost per operation will be reduced by a minimum of 10 percent with a goal of 25 percent.
- The logistics pipeline throughput capacity will be increased by a minimum of 100 percent with a goal of 200 percent.

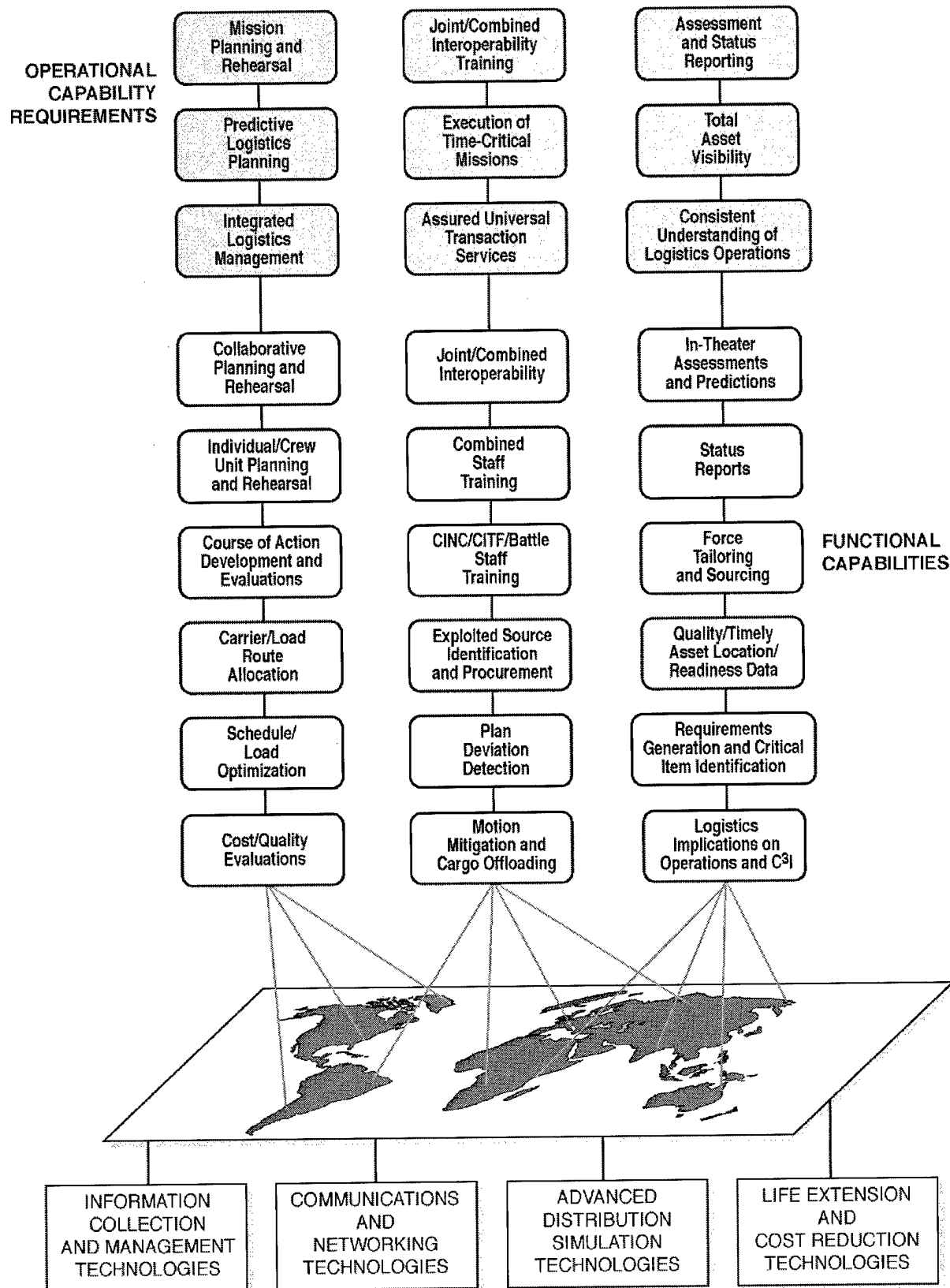


Figure IV.F-1. Concept—Joint Readiness and Logistics

- “Leading indicator” data will be automatically captured and forwarded for use in predictive failure estimation and advanced logistics planning and support—a minimum of 25 percent of data captured and forwarded in 1 to 3 hours with a goal of 75 percent.

2. Operational Capability Elements

National military strategy has changed from one of a forward-deployed ground-force presence to one of CONUS-based forces that must respond rapidly to joint combined operations anywhere in the world. As a result, it is important not only to demonstrate multiorganization interoperability for deployment of forces on specific missions to any place in the world, but also to demonstrate that those forces, their backup, and needed sustainment can be delivered to the right place at the right time to support or sustain missions. To do this, it is necessary to improve our ability to know in near-real time the location of each person, unit, piece of equipment, and item of supply. It is also important to know its state of readiness, its physical health, its completeness, its manufacturing or training status, or the fact that it was recently consumed in the course of its mission. This requires improved, large-scale accounting for inventory; status monitors on people, equipment, and cargo shipments; and near-real-time accessibility of this massive information data network for deployment and sustainment decisions. The technical objectives affecting the operational capabilities of joint, combined, and interoperability training; mission planning and rehearsal; and the readiness assessment and status reporting deal primarily with the ability of the CINC and Commander Joint Task Force (CJTF) to train their respective staffs, assess the readiness of assigned forces from both active and reserve components stationed in CONUS and deployed abroad, and evaluate possible courses of action.

The future concept of operations is envisioned as an interoperable environment in which the operators (J3), the logisticians (J4), and the planners (J5) at all echelon levels coordinate their activities across organizational boundaries. This tightly knit environment will enable the impact of logistics to bear directly on the decision-making process during course-of-action development and evaluations. The key element of this coordinated process will be the ability to plan in sufficient detail to allow execution directly from the plan. The mission plan and the logistics plan are thus developed in consonance with explicit common assumptions and expectations. Deviations from the plan can be detected through the creation of trigger processes or *plan sentinels* placed at key nodes or links in the logistics pipeline. These plan sentinels provide the necessary closed-loop feedback to maintain control and support the oversight process. To ensure that all this happens, extensive joint combined training is required in the use of interoperable processing and communication assets and in integrated rehearsals on cost-effective simulations.

In addition to seamless interoperability, logistics requires that information processing and communication technologies be applied to the monitoring, planning, execution, and tracking of forces and sustainment ranging from acquisition, storage, maintenance, and repair, through the transportation pipeline to the field. This requirement is critical to prolong the life of the personnel, equipment, and facilities used to support deployment and sustainment operations and to reduce impact of personnel casualties through medical support and rapid evacuation. Areas to be addressed include airfields dealing with much heavier wheel loads on pavements made from often low-quality local materials; storage, personnel, fueling, and other facilities that are exposed to extremes of wind, dust, rain, and humidity; and littoral docking and fuel transfer facilities that have to deal with variable tides, high sea states, and fouling of facilities and equipment exposed to the sea. Reducing the

logistics burden either by ensuring longer invulnerability or by providing lower costs per required useful lifetime is critical for readiness in many theater environments.

3. Functional Capabilities

To enhance operational capability elements for Joint Readiness and Logistics, a number of specific functional capabilities need to be improved.

Joint Readiness. As portrayed in Figure IV.F-1, enhanced Joint Readiness operational capability elements are impacted by (1) CINC/CJTF/Battle Staff training, combined staff training, and interoperability of forces; (2) individual/crew/unit planning and rehearsal of missions, and COA development; and (3) status reporting, assessments, and force tailoring. The functional capabilities needed to enhance the operational capability elements for Joint Readiness are shown in Table IV.F-1. Advancements in the key technology areas of advanced distributed simulations (e.g., common technical framework, authoritative environmental representations, and human systems interfaces) will lead to more effective joint, combined, and interoperability training. Modeling and simulation (M&S) improvements, advances in communications technologies (e.g., bandwidth management techniques, multilevel security), and information management (e.g., rapid database preparation, high-performance computing, data standardization) will yield faster collaborative planning, dynamic retasking, and more realistic mission rehearsal. Additional research is needed in the area of performance assessment at the individual and collective levels. Specifically, measures of performance must be developed and incorporated into models and simulations, and methodologies must be developed to support automated assessment and reporting.

Real-Time Focused Logistics. The functional capabilities needed to enhance the operational capability elements for Real-Time Focused Logistics are shown in Table IV.F-2. The most important functional requirements needing enhancement include:

- Readiness status reporting on all force and sustainment supplies in theater, in transit, in process, and in storage; assessments of the timed availability of these resources; generation of logistics requirements; and identification of critical items and predictive force tailoring.
- Collaborative operations and logistics planning; simulated rehearsals of individual, unit, weapon, equipment, and supply deployments; development of operations and logistics COAs.
- Sourcing/ordering and quality/cost assessments; mode/carrier/route allocation; scheduling and load optimization; and the detection and mitigation of deviations.
- The interoperability of operations and logistics planning and execution equipment and software; joint and combined staff training; and cost-effective distributed simulations for operations and logistics rehearsal.
- Airfield improvements for heavier wheel loading and use of local materials, land-based structures, and equipment improvements to survive extremes of local environments; littoral-based structures and interfaces improvements to survive fouling and adverse sea states; and transportation equipment improvements to ensure delivery.

Table IV.F-1. Functional Capabilities Needed—Joint Readiness

Functional Capabilities	Operational Capability Elements						
	Train			Plan		Assess	
	Joint	Combined	Interoperability	Mission Planning	Mission Rehearsal	Status Reporting	Predictive Assessment
1. Joint/Combined Interoperability	●	●	●		○		
2. Combined Staff Training		●	●				
3. CINC/CJTF/Battle Staff Training	●	○					
4. Individual/Crew/Unit Planning and Rehearsal	○	○	○	●	●		
5. Collaborative Planning and Rehearsal	○		○	●	●		
6. Course of Action (Staff) Development	○		○	●			○
7. Status Reports						●	○
8. In-Theater Assessments						○	●
9. Force Tailoring				○		○	●

● Strong Support ○ Moderate Support

Table IV.F-2. Functional Capabilities Needed—Real-Time Focused Logistics

Functional Capabilities	Operational Capability Elements							
	Effective Employment			Logistics Awareness		The Grid		
	Predictive Planning and Preemption	Integrated Logistics Management	Execution of Time-Critical Missions	Total Asset Visibility	Consistent Understanding of Logistics OPs	Universal Transaction Services	Distributed Environmental Services	Assurance of Services
1. Quality and Timely Data	●	○	●	●	○	●	●	●
2. Visibility Into the Logistics Pipeline	●	○	●	●	●	○	○	●
3. Logistics Implications of OPs	●	○	○		●			
4. Real-Time Logistics/OPs C ³ I	○	○	●	○		●	○	●
5. Strategic Assessment of Supply Requirements	●	○	○	●	●	○		○
6. Logistics Requirements Generation	●		○	○	○	○		●
7. Critical-Item Identification	●		●	●	○	○		○
8. Course-of-Action Logistics Evaluations	●						●	●
9. Carrier/Load/Route Allocation	●	○	●	○	○		●	●
10. Optimal Scheduling	●	○	●	○			●	●

● Strong Support ○ Moderate Support

Table IV.F-2. Functional Capabilities Needed—Real-Time Focused Logistics (continued)

Functional Capabilities	Operational Capability Elements						
	Effective Employment			Logistics Awareness		The Grid	
	Predictive Planning and Preemption	Integrated Logistics Management	Execution of Time-Critical Missions	Total Asset Visibility	Consistent Understanding of Logistics OPs	Universal Transaction Services	Distributed Environmental Services
11. Plan Deviation Detection	○		○	○			
12. Adaptive Replanning and Rescheduling	●	○	●		○		○
13. Deviation Mitigation and Cargo Offloading	○	○	●	○			
14. Support Force Sourcing	○	○	●	○			●
15. Rapid Supply Source Identification (Military and Commercial)	○	○	●	○		○	○
16. Flexible Item Descriptions	○	○	●	○		●	
17. Expedited Procurement	○	○	●			●	●
18. Cost/Quality Evaluations	●	○	●		○		
19. Rehearsal/Training Simulation	○	●	●			●	○
20. Reduced Burden of Logistics Infrastructure	○	●	○	○	○		

● Strong Support

○ Moderate Support

The key technology areas needing improvement are information collection and management; communications and networking; advanced distributed training simulations; materials, processes, and human systems for life extension; and cost reduction to reduce the logistics burden. Research is needed in establishing a common technical framework for distributed logistics simulations with authoritative environmental representations, timed logistics inputs, automated assessment and reporting, and appropriate human system interfaces. In addition, wideband communication management, multilevel security, rapid database preparation and access, high-performance computing, and data standardization is needed to yield faster collaborative planning, dynamic retasking, and more realistic mission rehearsal. To provide performance assessments at the individual and collective levels, measures of performance must be developed and incorporated into the models and simulations, and methodologies must be developed to support automated assessment and reporting.

To track people, equipment, vehicles, facilities, and supplies from origin to destination, item-level detail must be reflected in the logistics plan along with automated access to these detailed databases to seek out and merge prescribed information and provide real-time feedback on asset status, transportation movements, and the operational status of the logistics infrastructure. Replanning action can be triggered by plan sentinels inserted in the data stream that provide early warning of potential problems so they can be mitigated by corrective actions based on reasonable predictive analysis. To reduce planning time from days to hours and replanning from hours to minutes, COA evaluation tools must be developed that translate logistics capability into meaningful decision aids.

All movements and loading must be optimized as closely as possible. Existing stocks and commercial sources must be evaluated against each requirement, and requisitions, purchase orders, and contracts must be autonomously negotiated and executed. The key is to incorporate, in advance, the ability to understand the impacts of alternative logistics decisions on battlefield and in-theater mission planning and execution.

4. Current Capabilities, Deficiencies, and Barriers

Joint Readiness. The performance goals within each functional capability, current limitations to achieving these goals, and the technologies required to overcome these limitations are identified for Joint Readiness in Table IV.F-3. In-theater readiness assessment and status reporting is currently limited to manual recording, relatively simple mathematical formulations, and educated estimates. The Status of Resources and Training System (SORTS) provides an estimate of current unit or force readiness based on a compilation of readiness evaluations from its component units. There is no effective predictive means for determining future personnel, equipment, or unit readiness based on ongoing operations and resourcing decisions. For example, if a unit is supporting a peacekeeping mission and not training to conduct sustained combat operations, it is difficult for a CINC to estimate with any reliability what the unit's proficiency will be to accomplish its wartime mission if it had to respond to a Major Regional Conflict (MRC) at some future date. Advances in performance assessment methods and the development of predictive tools will lead to more robust and objective assessments of readiness from individual units to joint force levels. Additional work is needed in providing performance feedback to trainers and trainees and in aggregating and synthesizing readiness data for high-level reporting needs.

Collaborative mission planning is currently limited to the passing of independently generated portions of mission plans from one service or unit to another. No real-time collaborative planning tools are currently fielded that enable disparate mission planning systems to share information. Mission rehearsal tools are limited to selected weapon systems, mission preview systems, and simulators—virtually all of which are in the aviation community. Realism, or human immersion, in the simulators is limited by the lack of authoritative representations of other systems, human and group behaviors, and the natural environment. Deficiencies and barriers to mission planning and mission rehearsal include disparate architectures among current planning systems, thus precluding interoperability; a lack of shared standards and protocols; and nonstandard databases.

The capability to conduct distributed joint, combined, and interoperability training is currently limited. Most often, live simulator-supported exercises are conducted at single locations. Not only does this involve high travel costs, but the simulation itself is most often limited to the use of artificial systems rather than real-world C⁴I and weapon systems and controls. Today's computer simulations are often time and labor intensive to plan, set up, and run, and frequently require large support staffs. The principal barriers to more effective joint and combined staff training include the lack of interoperability among service and allied training simulations and models and the lack of tools and methods for assessment and feedback. Another barrier is the absence of an embedded training capability in C⁴I and weapon systems. A common technical framework for modeling and simulation—based on a high-level architecture, data standardization, and a common understanding of actions and interactions—will help overcome the interoperability shortfalls and allow for a seamless, distributed simulation. Planning for interoperating with simulations from the requirements definition stage of new weapons and C⁴I systems acquisition will allow for more realistic training.

Table IV.F-3. Goals, Limitations, and Technologies—Joint Readiness

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Joint, Combined, and Interoperability Training			
Provide home station, real-world equipment training for distributed forces (active and reserve). Ensure cross-simulation validity of representation and interactions.	Joint/combined/interoperability Combined staff training CINC/CJTF/battle staff training	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C⁴I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Bandwidth limitations of present communications nets (limited support for large block data transfers or simultaneous flow of data, voice, graphics, and video) Multilevel security cannot interactively support a mix of classified and unclassified information Long lead time for development of environmental databases Lack of cross platform commonality of terrain databases	Easily deployable, evolvable, scalable, interoperable, plug and play architecture for C⁴, intelligence, and M&S systems for "train as we fight" capability Virtually resident database capable of self update and automatic reconstruction and redistribution Advanced M&S tools Multilevel security Secure, high rate, high bandwidth communications Information fusion Tailored, natural language, information search and retrieval capability Embedded, deployable, distributed fault tolerant M&S for mission planning, rehearsal, and training Distributed, synchronized databases Object-oriented, distributed automated, dynamic scenario generation and exercise planning
Operational Capability Element: Mission Planning and Rehearsal			
Provide rapid response to planning and rehearsal requirements for contingency operations. Real-time mission planning. Dynamic mission retasking.	Individual/crew planning and rehearsal Collaborative planning and rehearsal Course of action development	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C⁴I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Bandwidth limitations of present communications nets (limited support for large block data transfers or simultaneous flow of data, voice, graphics, and video) Multilevel security cannot interactively support a mix of classified and unclassified information Long lead time for development of environmental databases Lack of cross platform commonality of terrain databases	Easily deployable, evolvable, scalable, interoperable, plug and play architecture for C⁴, intelligence, and M&S systems for "train as we fight" capability Virtually resident database capable of self update and automatic reconstruction and redistribution Advanced M&S tools Multilevel security Secure, high rate, high bandwidth communications Information fusion Tailored, natural language, information search and retrieval capability Embedded, deployable, distributed fault tolerant M&S for mission planning, rehearsal, and training Distributed, synchronized databases Object-oriented, distributed automated, dynamic scenario generation and exercise planning Advanced collaboration planning capability

Table IV.F-3. Goals, Limitations, and Technologies—Joint Readiness (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Assessment and Status Reporting			
Provide near-real-time information on unit readiness; for example relevant details on each person (education, training, health, etc.) and equipment (numbers, condition, status) for assigned forces. Tailor force packages based on near-real-time readiness status update to modifying or reconfiguring forces due to changes in situation, mission, or combat capability. Provide the capability of predict near- and mid-term impacts of operational and resource decisions on unit and joint readiness.	Status reporting Force tailoring Predictive assessment	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C⁴I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Delay in data reporting. No common metrics for operational picture/readiness reporting, especially coalition readiness Lack of accredited algorithms to forecast readiness impacts Lack of performance measures embedded in models and simulations Lack of tools to assess collective and joint readiness and provide feedback to trainers, trainees, and commanders Lack of tools and capabilities to synthesize and report readiness	Advanced M&S tools Secure, high rate, high bandwidth communications Information fusion Intelligent agents to retrieve, filter, sterilize, sanitize, and deconflict information and data Object-oriented, distributed, automated, dynamic planning tools Effective methods for embedding performance measures in M&S systems Capabilities to synthesize and report readiness data After-action review tools Unit performance measures in readiness reporting

Real-Time Focused Logistics. The performance goals within each functional capability, current limitations to achieving these goals, and the technologies required to overcome these limitations for Real-Time Focused Logistics are identified in Table IV.F-4. To accurately assess or determine future readiness posture, it is also important to consider our capability to sustain the force and to maintain visibility across the entire logistics pipeline and across all logistics functional areas (maintenance, supply, services, medical, personnel, engineering, etc.). The current logistics spectrum is compartmentalized into functional disciplines with little or no data sharing capability. Efforts are currently under way in the Joint Total Asset Visibility (JTAV) Program, under the sponsorship of the Deputy Undersecretary of Defense for Logistics, to link these numerous stovepipe logistics asset databases. Improvements are needed in source data capture to provide accurate and timely logistics, operational, and infrastructure data. Assured advanced communications support is also required to transfer these data along the entire logistics pipeline from point of origin to ultimate destination. Combining these data with advanced methods to monitor logistics execution will introduce the possibility of a real-time logistics system to manage the in-storage, in-process, in-transit, and in-theater pipeline, as illustrated in Figure IV.F-2.

Visibility over assets and resources has continued to be a very high priority. Some of the efforts listed in Table IV.F-4 have provided inroads into cargo and asset visibility, but cost, operating ranges, reliability, human interface, size, and power sources all need to be improved. The Joint

Table IV.F-4. Goals, Limitations, and Technologies—Real-Time Focused Logistics

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Effective Employment			
Collaboratively develop executable logistics plans at item-level detail, which can be globally or locally optimized through the use of course-of-action evaluations. Reduce the planning cycle from days to hours. Develop integrated logistics management systems which train joint/combined staff interoperatively using advanced rehearsal simulations to spur rapid awareness of and reaction to deviations to ensure supply. Reduce the reaction time for deviation from days to hours and in some cases minutes. Create automated execution systems to track sourcing options, expedite negotiation and ordering within realistic cost/quality criteria, optimize allocation and scheduling, and react to deviations within minutes. Improve the life expectancy and lower the cost of the infrastructure needed to move and store forces and supplies under the wide variety of local environments anticipated.	Quality and timely data Visibility in to the logistics pipeline Logistics implications of operations Real-time logistics/operations C³I Strategic assessment of supply requirements Logistics requirements generation Critical-item identification Course-of-action logistics evaluations Carrier/load/route allocation Optimal scheduling Plan deviation detection Adaptive planning and rescheduling Deviation mitigation and cargo offloading Support force sourcing Rapid supply source identification (military and commercial) Flexible item descriptions Expedited procurement Cost/quality evaluations Distributed rehearsal/training simulations Reduced burden of logistics infrastructure	No infrastructure investments/alternative planning Planning systems only run with summary-level data No aggregation and deaggregation processing available Logistics and transportation systems are not linked to conduct movement feasibility in the "sourcing" process No cost evaluation done No automated access into logistics databases by intelligent software agents Limited movement optimization or scheduling within same platform Limited collaboration tools No mapping tools to assess infrastructure in theater Details for execution not linked to the plan Deviation detection during execution not possible No optimization process in use for asset allocation and scheduling No access to commercial databases Requires "pushed" data Semantics difficulties No visible requisition process—no receipt to fill No autonomous negotiation and purchase No rapid replanning capability exist No method to initiate replanning and rescheduling based upon input from monitoring and deviation detection sentinels No method to replan with optimization to fix local or global problems Limited collaboration tools	Semiautonomous search and retrieval EDI extensions Advanced optimization Active databases and data mining Shared ontology Interoperable modeling High-fidelity simulations Adaptive work flow Intelligent agent mediator processing Advanced human/computer interface Desktop videoteleconferencing Shared whiteboards Advanced scheduling technology Motion mitigation control research Automated identification technology Object-oriented plan representation

Table IV.F-4. Goals, Limitations, and Technologies—Real-Time Focused Logistics (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Logistics Awareness			
Provide real-time visibility of the total logistics pipeline, from factory to foxhole, including personnel, units, equipment, and items of supply in process, in storage, or in transit. Satisfactorily respond to customer queries in near-real time. Provide man-friendly access for every active and proposed area of operation. Provide real-time, common view of the entire logistics pipeline from the ultimate point of origin, through all critical nodes into the theater of operations. Provide rapid response end-to-end model of the entire logistics pipeline for use as a training/wargaming tools for preemptive mission planning.	Quality and timely data Visibility in to the logistics pipeline Logistics implications of operations Real-time logistics/operations C³I Strategic assessment of supply requirements Logistics requirements generation Critical-item identification Plan deviation detection Distributed rehearsal/training simulations Reduced burden of logistics infrastructure	Human interaction with creating source data No real-time feedback on the status of logistics operations Only nodal reporting within ITV process No infrastructure capability feedback No automated source data capture No real-time monitoring feedback from transportation movements, and operational status of the infrastructure that supports the logistics framework No logistics visualization techniques No method to detect deviations that occur and signal the need for replanning No mapping tools to assess infrastructure in theater No access to commercial databases Logistics and transportation systems not linked No assured communications supports	Deviation detection from monitoring systems In-theater measurement monitors Infrastructure monitors Dependency-driven notification of deviation from plan Next-generation AIT research Embedded software agents (sentinels)
Operational Capability Element: The Grid			
Tie the logistics system to the Universal Transaction Services so that all force and supply sourcing, carrier, route, storage, and in-field positioning options are available in real time for rapid planning and execution.	Quality and timely data Real-time logistics/operations C³I Carrier/load/route allocation Optimal scheduling Expedited procurement Distributed rehearsal/training simulations	No automated access into logistics databases by intelligent software agents Deviation detection during execution not possible No access to commercial databases No real-time feedback on the status of logistics operations No infrastructure capability feedback No automated source data capture No real-time monitoring feedback from transportation movements, and operational status of the infrastructure that supports the logistics framework No method to automatically notify all players of replan action	Covered in Information Superiority

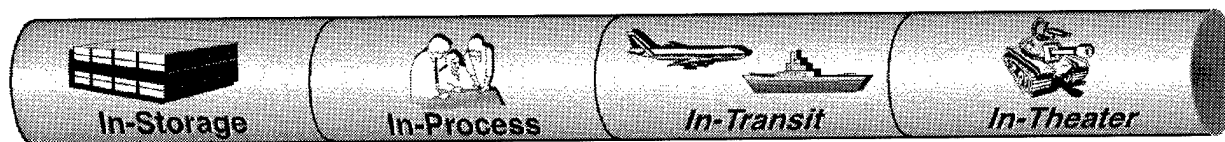


Figure IV.F-2. Logistics Pipeline

Logistic ACTD, supported by the Army's Total Distribution ATD and the DARPA Advanced Logistics Program, will take the first steps in providing the needed near-real-time asset visibility and control of the logistics pipeline.

Logistics planning is presently only loosely bonded to operations planning. The warfighting commander delineates the overall mission and concept of operation. The operations staff (J3) outlines the alternative COAs and the requirements necessary to accomplish the mission with little input from logistics planners on their ability to support the concept of operations. The summary level of their logistics portion of the plan does not usually reflect what will eventually move. There is very little real-time feedback to commanders to tell them whether they are deviating from the plan. As unforeseen events begin to affect the actual movement, operators and planners cannot predict the magnitude of the breakdowns or their location. The planning and execution processes suffer greatly from compartmentalized systems that lack the detail necessary to make timely and accurate decisions.

It is also important to reduce the burden on the logistics systems by extending useful life and lowering infrastructure and facility costs. The present transportation infrastructure is not a totally integrated intermodal system and reacts slowly when stressed by massive transportation movement requirements. During logistics over the shore, bare beach, or austere port operations, the transfer of cargo and fuel from sea to shore is not reliable. Wave motion compensation and near-shore soil assessment techniques are inadequate. On-site fabrication of cargo causeway systems in the sea surface environment is unreliable and unwieldy. Continuous-flow pipelines, on the surface or under the water, have proven unreliable, especially across extended ship-to-shore distances, which can be up to 25 nautical miles. Given the large amount of fuel in a 25-nautical-mile pipeline, if a break occurs, adverse environmental and operational impacts are sure to result. Batch systems have potential, but much more information is needed about reliable manufacture of composite bladders, shelf life, fatigue, sea chemistry effects, and abrasion resistance in the sea environment. The littoral environment differs enough throughout the world that fouling of facilities and operational areas has become a problem. Road, bridge, and airfield construction overseas, using local materials, is unreliable due to the often poor quality of the materials and poor ability to assess the ground mobility properties of the local terrain. Wheel and tread loadings for aircraft and ground vehicles continue to increase. Methods for providing rapid design, construction, and maintenance have not been put in place for the variety of environments anticipated, especially in cold areas. Portable, lightweight, self-erecting composite shelters with low signatures are needed, together with lightweight power generators, heat pumps, and waste disposal systems. Firefighting is hampered by a poor ability to detect fires and to see into a fire to detect problems and focus points. The firefighters themselves are often inadequately protected from the chemicals and heat, especially where hazardous wastes are involved. Many fire suppression agents are toxic and need to be replaced with new materials. Present fire rescue vehicles are inadequate to deal with crashes involving modern aircraft and need radical improvement.

5. Technology Plan

Joint Readiness. The currently programmed DTOs on the critical path to supporting joint readiness are listed in Table IV.F-5. An indication of the areas of operational capability most impacted by these technologies is provided in Table IV.F-6. Figure IV.F-3 illustrates how these technology developments support overall joint readiness. Note that these tables and the figure show that many DTOs from other sections are crucial to achieving joint readiness. These are primarily a series of battlefield visualization and assessment tasks in Joint Warfighting from Information Superiority (Section IV.A) and from Military Operations in Urban Terrain (Section IV.E). Several additional tasks from Information Systems and Technology (IS&T) (Chapter III of the DTAP) also critically support modeling and simulation needs for rehearsal and training simulations.

Technology Advances are needed to effectively link live, virtual, and constructive simulations. The Synthetic Theater of War (STOW) ACTD is intended to develop and demonstrate modeling and simulation technology for the next generation of training tools needed by the Combatant Command, Commander Joint Task Force, and the Joint Task Force Component Commanders and their staffs. This Joint Simulation System (JSIMS) will be the first training capability to fully utilize the data collection, assessment, management, and display technology advances envisioned in this plan. Several IS&T DTOs are on the critical path to enhance joint readiness capability. The most important are Simulation Interconnection (IS.10.01); Simulation Information Technologies (IS.11.01); Simulation Representation (IS.12.01); Simulation Interfaces (IS.13.01); Forecasting, Planning, and Resource Allocation (IS.02.01); and Assured Communications (IS.21.01). In combination, these technology focuses will demonstrate the use of a common technical framework (CTF) that facilitates unprecedented interoperability among simulations and C⁴I systems. The CTF framework will be used by STOW, JSIMS, Joint Warfare Simulation (JWARS), and all the other

Table IV.F-5. Defense Technology Objectives—Joint Readiness

DTO No.	Title
F.01	Synthetic Theater of War ACTD
F.02	Advanced Joint Planning ACTD
F.04	Joint Training Readiness
A.06	Rapid Battlefield Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.12	Information Security ATD
E.02	Military Operations in Urban Terrain ACTD
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.10.01	Simulation Interconnection
IS.11.01	Simulation Information Technologies
IS.12.01	Simulation Representation
IS.13.01	Simulation Interfaces
IS.21.01	Assured Communications
IS.40.01	Individual Combatant and Small Unit Operations Simulation

Table IV.F-6. Demonstration Support—Joint Readiness

Demonstration	Operational Capability Elements			Service/Agency	Type of Demonstration		
	Joint, Combined Training for Interoperability	Mission Planning and Rehearsal	Status Reporting and Predictive Assessment		DTO	ACTD	ATD
Synthetic Theater of War ACTD			●	DARPA	F.01	X	
Advanced Joint Planning ACTD	○	●	○	DARPA	F.02	X	
Joint Training Readiness	●	○	○	DUSD, Services	F.04		
Rapid Battlefield Visualization ACTD	●	●	●	Army	A.06	X	
Battlefield Awareness and Data Dissemination ACTD	●	●	●	DARPA	A.07	X	
Information Security ATD			●	Joint	A.12		X
Military Operations in Urban Terrain ACTD			●	DARPA	E.02	X	
Forecasting, Planning, and Resource Allocation	○	●	●	Joint	IS.02.01		
Simulation Interconnection	●	●		DMSO	IS.10.01		
Simulation Information Technologies	●	●	●	DMSO, DARPA	IS.11.01		
Simulation Representation	●	●	●	DMSO, DARPA	IS.12.01		
Simulation Interfaces	○	●	○	DMSO	IS.13.01		
Assured Communications	○	●	●	Army, Air Force	IS.21.01		
Individual Combatant and Small Unit Operations Simulation	○	●	○	Army	IS.40.01		

● Strong Support

○ Moderate Support

simulation developments. The collective goal of these efforts is to reduce exercise planning and setup time by 70 percent, reduce the exercise support cadre by 50 percent, and reduce travel in support of command post and computer-aided exercises by 60 percent. The DoD Modeling and Simulation Master Plan (DoD 5000.59.P) provides a more detailed discussion of objectives in this area.

This CTF and seamless interfacing enables real-time dynamic collaborative planning using automated mission planning and rehearsal across all service and mission areas. The Advanced Joint Planning ACTD will leverage the advances in distributed modeling and simulation to demonstrate C⁴I systems integration for distributed collaborative planning capability and common perception of the battlespace. This will result in an 80 percent reduction in CINC planning cycles for emerging crisis response and a 60 percent reduction in planning time for major deployments. This aspect of joint readiness is also supported by the Logistics Anchor Desk, which is to demonstrate a common logistics terminal; the Joint Logistics ACTD Phases II and III, which are to demonstrate collaborative logistics planning; and the Advanced Logistics Program, which is developing the advanced software and hardware tools for logistics planning, execution, monitoring, and replanning capabilities that are to be phased into the demonstrations over time.

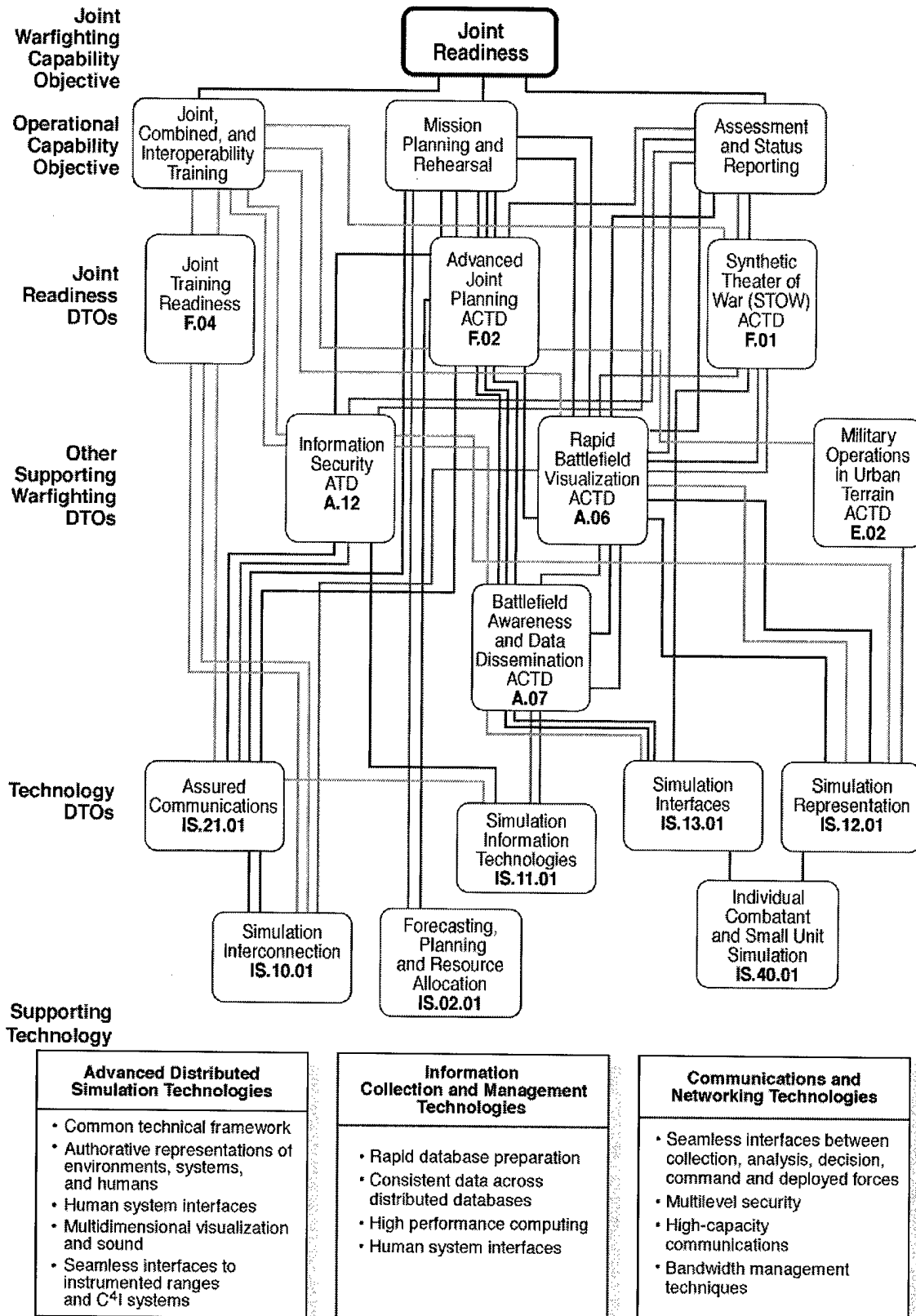


Figure IV.F-3. Technology to Capability—Joint Readiness

In addition, other IS&T DTOs support Joint Readiness. The Forecasting, Planning, and Resource Allocation DTO (IS.02.01) addresses the development of a proactive planning process to avoid direct conflict or to react quickly if conflict becomes inevitable. The Assured Communications DTO (IS.21.01) provides the secure guards and firewalls needed at the B3 level of service and develops new communication waveforms with less susceptibility to jamming. The Individual Combatant and Small Unit Operations Simulation DTO (IS.40.0) is to develop the real-time, multisensory, virtual-reality simulation of the battlefield that puts individual combatants in three-dimensional geographic space to provide more realistic training and COA evaluations.

Information Superiority technology feeds into these demonstrations by developing specific tools for sensing in-theater forces, reporting their readiness, processing and transferring the data, fusing the information content into decision-useful displays, and assessing and planning force and mission responses. The Rapid Battlefield Visualization ACTD (DTO A.06) will merge digital imagery with terrain data to rapidly develop databases that can provide realistic depiction of areas of operation for training and real-world contingencies. These databases must be highly accurate for each specific application in terms of surface resolution, guidance precision, friend and foe signatures, etc. The IS&T DTAP DTO, Simulation Representation (IS.12.01), will demonstrate the capability to reduce the time necessary to develop terrain databases by 75 percent or more to meet the needs of the Special Operations community for delivery within 96 hours to support mission planning and rehearsal. The Sensors, Electronics, and Battlespace Environment DTAP DTO, Forecast of Littoral Currents and Waves (SE.45.01), supports the objectives of the Simulations Representation DTO above, as well as exploits accurate forecasts for use in operational planning and execution.

Battlefield Awareness and Data Dissemination (BADD) ACTD (DTO A.07) will allow commanders to design their own information systems to deliver accurate, timely, and consistent pictures of the joint/coalition battlefield. Vital to these capabilities is a marked improvement in networking, multilevel security, and communication technologies, such as those produced by the improved Information Security ATD (DTO A.12) and the Assured Communications DTO (IS.21.01). Individual and small-unit performance in complex urban environments will be addressed separately in the Military Operations in Urban Terrain (MOUT) ACTD (DTO E.02) with a goal of increasing situational awareness at all levels by 50 percent and increasing force survivability by 20 percent.

Feedback tools for training and joint force assessment methodologies will be demonstrated in the Joint Training Readiness (JTR) DTO. Investments in synthetic environments and distributed simulations can be leveraged to develop tools for linking performance in joint exercises to estimates of joint training readiness. Performance and assessment data can then be linked to cost-effectiveness evaluations and tradeoff decisions to guide joint training policy and resources. This effort is expected to result in a 30 percent reduction in time required to achieve training readiness and a 50 percent increase in the number of warfighting tasks demonstrated effectively during exercises.

Figure IV.F-4 is the roadmap for developing and demonstrating the technologies required to support the advancements in functional and operational capabilities that affect joint readiness. This roadmap shows how advances in advanced distributed simulation, communication technologies, and information management will provide significant improvements in the ability to conduct distributed joint, combined, interoperability, and staff training of various scales.

IV-F-17

Real-Time Focused Logistics. The mission and supporting logistics planning must be accomplished in consonance if the overall campaign plan is to be successfully executed. It is critical to ensuring that the right capability, the right resources, and the right quantity of sustainment supplies are at the right place at the right time. Accurate and accessible information is the foundation on which the logistics systems must be built. This means automated capture of accurate data at the source; some form of automated sensing of the status of people, weapons, facilities, and sustainment supplies; autonomous connection of heterogeneous and distributed databases; semiautonomous search and retrieval; and intelligent query for information. The current DTOs supporting logistics are listed Table IV.F-7. An indication of the assessment, planning, and training functions that they support is provided in Table IV.F-8. The interactive flow between the various DTOs is shown in Figure IV.F-5 along with a listing of some of the key supporting technologies expected to impact their utility.

Table IV.F-7. Defense Technology Objectives—Real-Time Focused Logistics

DTO No.	Title
F.14	Joint Decision Support Tools (Joint Logistics (JL) ACTD, Phase II)
F.15	Real-Time Focused Logistics (JL ACTD, Phase III)
F.16	Logistics Technologies for Flexible Contingency Deployments and Operations
F.17	Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD
F.18	Joint Advanced Health and Usage Monitoring (JAHUM) ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.12	Information Security ATD
IS.01.01	Consistent Battlefield Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.10.01	Simulation Interconnection
IS.13.01	Simulation Interfaces
IS.20.01	Universal Transaction Communications
IS.21.01	Assured Communications
IS.46	Advanced Logistics Program
MP.07.06	Affordable Sustainment of Aging Aircraft Systems
MP.12.11	Higher Sea State Logistics Support for Expeditionary Forces
MP.13.11	D-Day Fuel Support for Expeditionary Forces
MP.14.11	Wartime Contingencies and Bare Airbase Operations
MP.16.06	Firefighting Capabilities for the Protection of Weapon Systems
MP.17.11	Airfields and Pavements To Support Force Projection
MP.18.11	Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure
MP.23.06	Affordable, Short-Lead-Time Parts Production and Repair

Table IV.F-8. Demonstration Support—Real-Time Focused Logistics

Demonstration	Operational Capability Elements			Service/Agency	Type of Demonstration		
	Effective Employment	Logistics Awareness	The Grid		DTO	ACTD	ATD
Joint Decision Support Tools (Joint Logistics (JL) ACTD, Phase II)	●	●	○	Joint	F.14	X	
Real-Time Focused Logistics (JL ACTD, Phase III)	●	●	○	Joint	F.15	X	
Logistics Technologies for Flexible Contingency Deployments and Operations		●		Air Force, Navy	F.16		
Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD	●	○		Marine Corps, Navy	F.17		X
Joint Advanced Health and Usage Monitoring ACTD	●	●	○	Navy, Army	F.18	X	
Battlefield Awareness and Data Dissemination ACTD	●	●		DARPA	A.07	X	
Information Security ATD	●	●	●	Joint	A.12		X
Consistent Battlefield Understanding	●	●		Army, Navy	IS.01.01		
Forecasting, Planning, and Resource Allocation	●	●	○	Army, Air Force, Navy	IS.02.01		
Integrated Force and Execution Management	●	●	○	Army, Air Force, Navy	IS.03.01		
Simulation Interconnection	●	●	○	DMSO	IS.10.01		
Simulation Interfaces	●	●	○	DMSO	IS.13.01		
Universal Transaction Communications	○	●	●	Army, Navy	IS.20.01		
Assured Communications	●	●	●	Joint	IS.21.01		
Advanced Logistics Program	●	●	●	DARPA, DLA	IS.46		
Affordable Sustainment of Aging Aircraft Systems	●			Army, Air Force, Navy	MP.07.06		
Higher Sea State Logistics Support for Expeditionary Forces	●			Navy	MP.12.11		
D-Day Fuel Support for Expeditionary Forces	●			Navy	MP.13.11		
Wartime Contingencies and Bare Airbase Operations	●			Air Force	MP.14.11		
Firefighting Capabilities for the Protection of Weapon Systems	●			Air Force, Navy, Army	MP.16.06		
Airfields and Pavements To Support Force Protection	●			Army, Air Force, Navy	MP.17.11		
Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure	●			Navy	MP.18.11		
Affordable, Short-Lead-Time Parts Production and Repair	●			Air Force	MP.23.06		

● Strong Support

○ Moderate Support

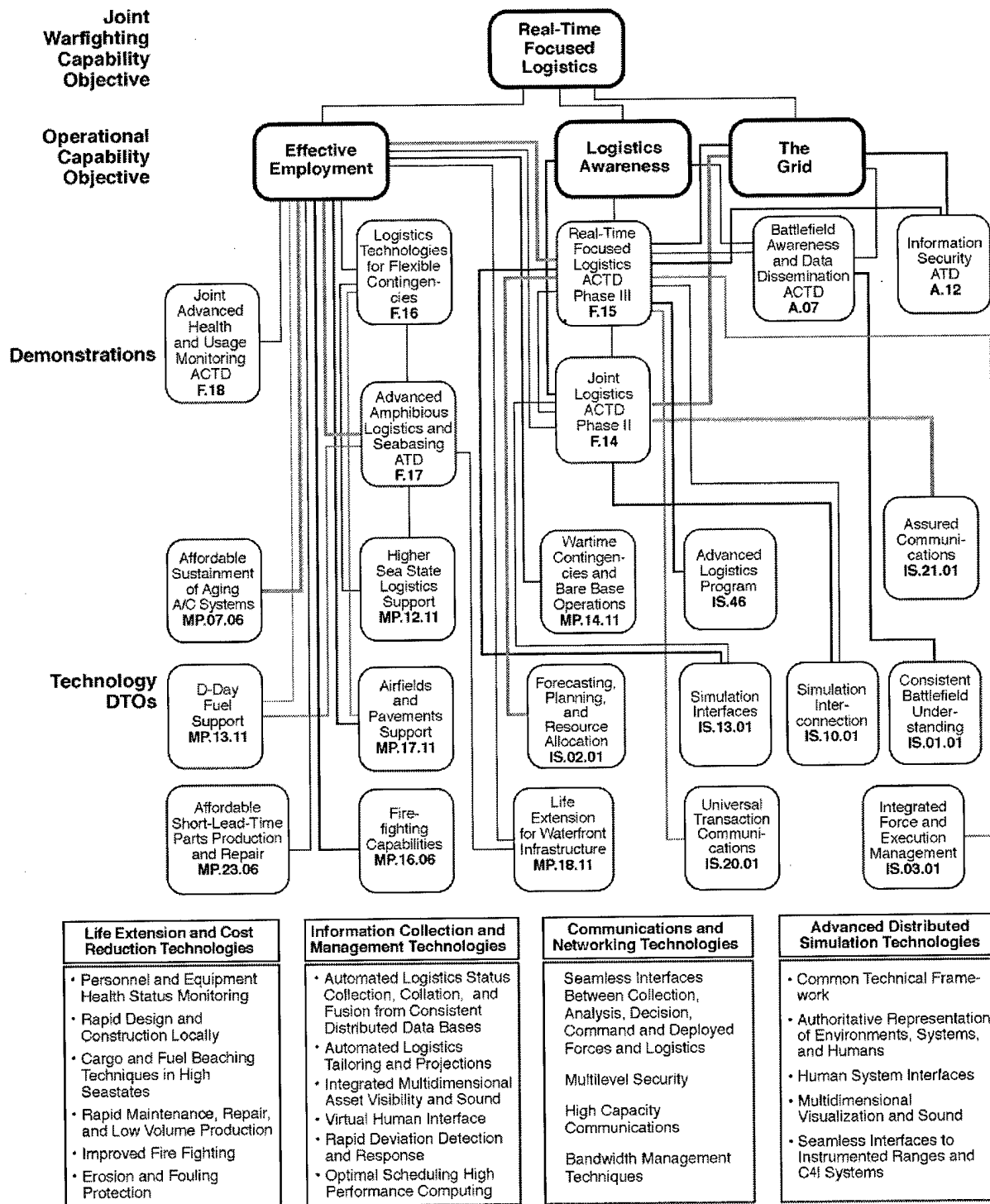


Figure IV.F-5. Technology to Capability—Real-Time Focused Logistics

The Army's Total Distribution ATD continues development of the Logistics Anchor Desk (LAD) first initiated under JL ACTD Phase I and integrates it with logistics data sources. LAD displays logistics data in real time, thus allowing planners access to equipment and personnel densities, support requirements for mission-critical units or items, projections and summaries of sustainment issues, secondary-item density forecasts, ongoing logistics system and unit performance, and the status of ongoing deployment actions with an emphasis on critical items. Each anchor desk can share the work of other desks immediately by electronic data transfer, including integrated virtual conferencing. This integrated view of sustainment allows distributed collaborative logistics planning across services and echelons. The LAD workstation thus provides logistics decision work tools for transition to the Future Joint Logistics Workstation in the Joint Decision Support Tools (Joint Logistics ACTD Phase II) (DTO F.14).

The Advanced Logistics Program (DTO IS.46) is developing and demonstrating the planning, execution, monitoring, replanning, assessment, projection, ordering, loading, scheduling, and modeling and simulation tools needed to control the logistics pipeline. A key aspect is to reduce reliance on large government-held inventories while still ensuring that the right material is delivered to the right place at the right time. At present the major focus is on improving the visibility of the logistics pipeline, making better use and tracking of transportation assets, improving the distribution of sustainment supplies to provide faster and more flexible acquisition of supplies, improving tools for force sustainment planning and sourcing, and improving tools that allow the logistics COA planning to be linked to the mission plan.

The Real-Time Focused Logistics (Joint Logistics ACTD, Phase III) (DTO F.15) links and consolidates relevant logistics data sources, models, and simulations to provide a unique situation awareness capability to support real-time logistics management. Integrated planning technology and reliable broadband communications are expected to migrate from the Advanced Joint Planning ACTD (F.02) and the Information Superiority ACTD on Battlefield Awareness and Data Dissemination (A.07), on Rapid Battlefield Visualization (A.06), and on Information Security (A.12). Many of the tools for Real-Time Focused Logistics will be developed under Information Sciences in DTOs for Consistent Battlefield Understanding (IS.01.01); Forecasting, Planning, and Resource Allocation (IS.02.01); Integrated Force and Execution Management (IS.03.01); Simulation Interconnection (IS.10.01); Simulation Interfaces (IS.13.01); Universal Transaction Communications (IS.20.01); and Assured Communications (IS.21.01). Consistent Battlefield Understanding puts complex tactical information in geospatial coordinates into situational assessment tools and smart presentations. Forecasting, Planning, and Resource Allocation provides automated real-time mission planning tools to analyze and select courses of action, construct and analyze forecasts, and prioritize critical objectives to establish the base point for logistics. Integrated Force and Execution Management provides real-time multi-echelon monitoring tools that detect and display deviations from plans and provide automated recommendations for mitigation. Universal Transaction Communications and Assured Communications provide information exchange that is transparent to actual interfaces and connectivity and protect it with secure guards and firewalls and with new communications bandwidths with lower susceptibility to jamming. Simulation Interconnections and Simulation Interfaces provide the basis for logistics Training and Rehearsal Simulation interoperability through common modeling and simulation infrastructure and seamless interfaces. These capabilities will continue to be demonstrated in CINC-level exercises with ACTDs embedded in Joint Warfighting

Exercises and migrate into the emerging Global Combat Support System. The warfighter's objective for focused logistics will be met through this DTO.

A supporting part of Real-Time Focused Logistics is ensuring that a resilient, low-cost logistics infrastructure is in place to support deployment and sustainment of forces without major interruptions. This is not just consumable items such as rations and ammunition. It includes the survivability of key transportation nodes and networks such as airfields; seaports, and pier facilities; roads, bridges, and railroad lines; communications complexes necessary to deploy forces and distribute supporting material and supplies; lightweight shelters to billet and support personnel; lightweight power, heat, and waste disposal units; kitchen facilities; fuel storage equipment; maintenance and repair facilities; medical support units; and communications and electronics facilities. Bridges, piers, and roadway surfaces must be rapidly designed, built, or modified to accommodate heavier vehicle weights, environmental erosion, and corrosion. In addition to being lighter, shelters also must be more survivable to withstand a greater variety and more lethal array of conventional small-arms fire, while still having a low profile to make them less observable and impervious to chemical and biological agents, fiber and dust clouds, and terrorist attacks. The other logistics DTOs (F.16, F.17, and F.18) and the Materials and Processes DTOs address these problems specifically.

The intended roadmap for developing and demonstrating the technologies required to support the advancements in functional and operational capabilities for Real-Time Focused Logistics is shown in Figure IV.F-6. The roadmap shows how total visibility of all warfighting resources can be achieved with advances in information collection and management, broadband communications, and distributed simulations. This visibility allows predictive planning and preemption, integrated logistics management, and time-critical execution of missions. These integrated tools enable faster acquisition of material; total visibility of the logistics pipeline; optimal scheduling of lift assets; more meaningful and less costly training, modeling and simulation; and collaborative planning, execution monitoring, and dynamic replanning. In parallel, Information Superiority (Section IV.A) will be developing the sensing, fusion and visualization technologies needed to supply reliable inputs to this entire process; while Materials/Processes (DTAP, Chapter V) and Human Systems (DTAP, Chapter IX) will be developing the time-responsive and long-life infrastructure that make real-time focused logistics effective and affordable.

6. Summary

Joint Readiness. Joint Readiness and Logistics is directly affected by many of the other JWCOS in this JWSTP and by many of the technology DTOs in the DTAP. However, the operational capabilities of training, planning, and assessment are essential elements that must be specifically addressed. Developments in technology promise advancements in these capabilities in the near, mid, and long term, as illustrated in Figure IV.F-7.

Real-Time Focused Logistics. The current logistics environment consists of disparate databases, compartmentalized by functional disciplines—material acquisition, supply and storage, maintenance, transportation, and traffic management; medical support and evacuation; and more. Future operations will demand that logistics planning be conducted concurrently with warfighting planning and development of the warfighting concept of operations so that total visibility into the entire logistics pipeline can be maintained. Only by applying and advancing information systems technology can these capabilities be met. Real-time focused logistics is at the heart of our ability to

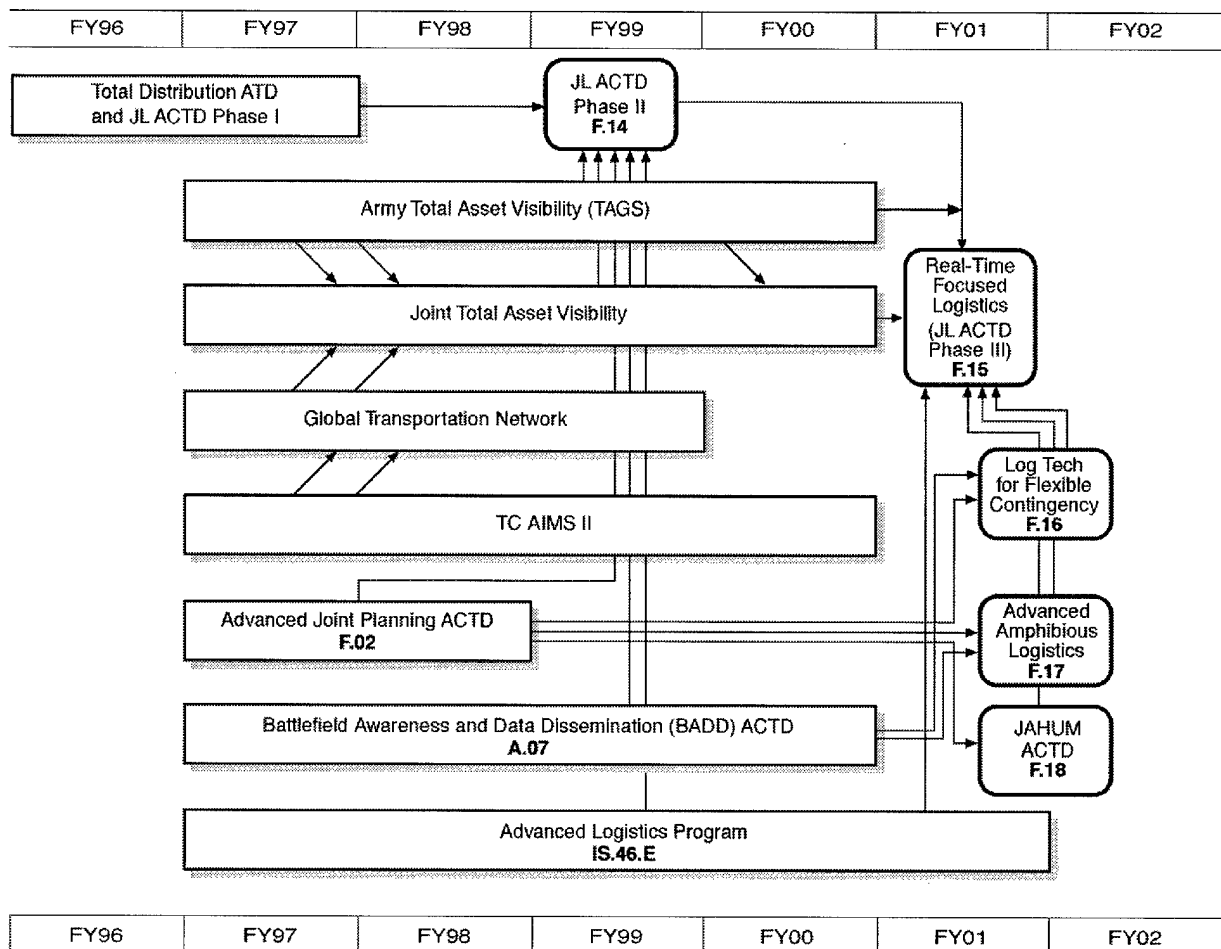


Figure IV.F-6. Roadmap—Real-Time Focused Logistics

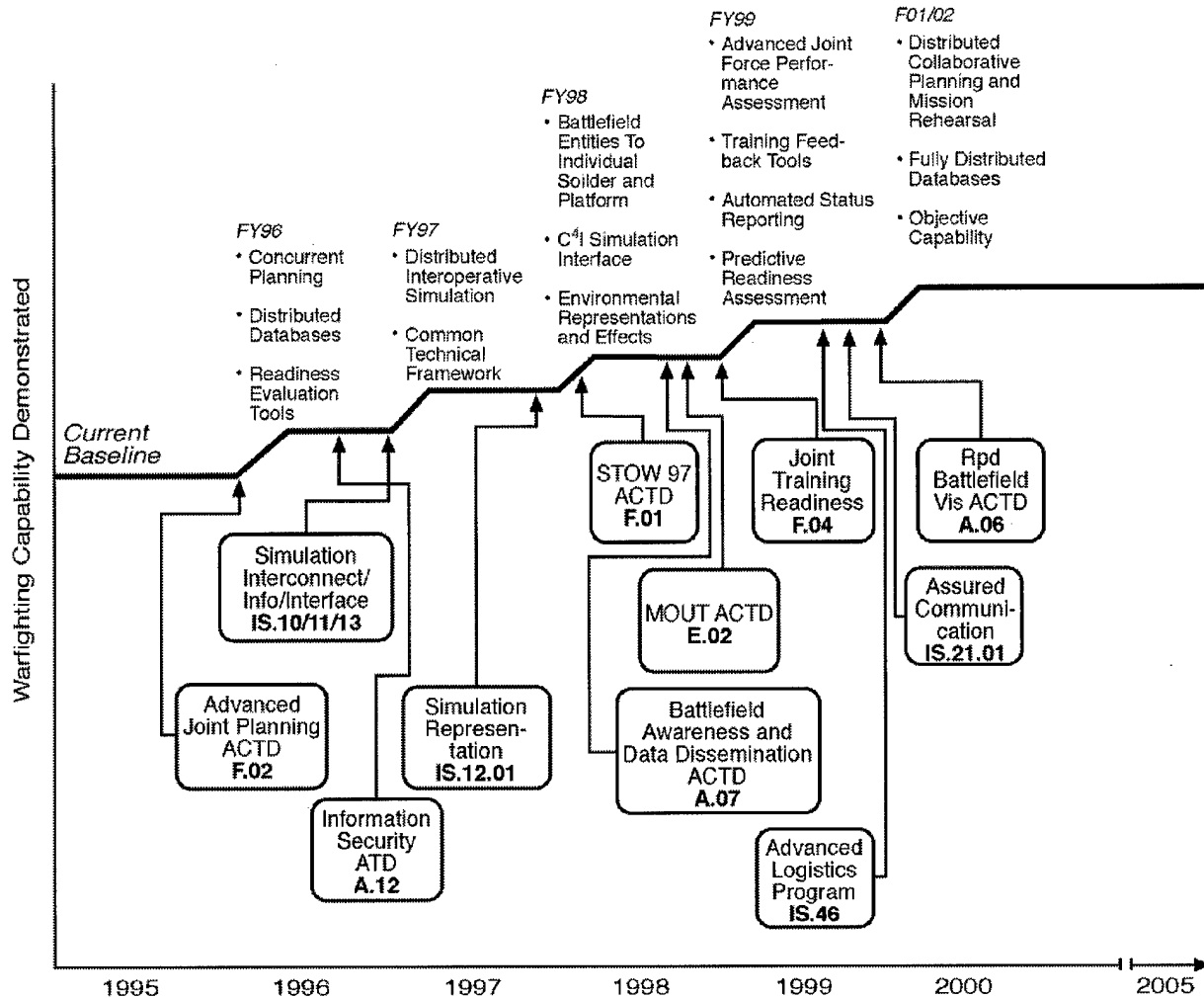


Figure IV.F-7. Progress—Joint Readiness

generate and support overwhelming combat power. It is the national capability that will deliver and sustain combat operation wherever and whenever needed. Real-time focused logistics welds the logistics disciplines into a seamless interoperable process, using the information processing technologies outlined in Figure IV.F-8, to create operational capabilities for planning, execution monitoring, and replanning. Logistics planning will be conducted concurrently with warfighting operational planning and will influence future battlefield decisions. Future logistics systems must exploit state-of-the-art distributed systems architectures, current state measurements from automated identification and other technologies, and heterogeneous database access and maintenance techniques. These must be supported by an assured, reliable, robust logistics communications infrastructure for continuous visibility of the logistics pipeline. It is only through the complex linkage of operational and logistics planning, execution monitoring, dynamic replanning, and end-to-end system visibility that success can be ensured in future operations.

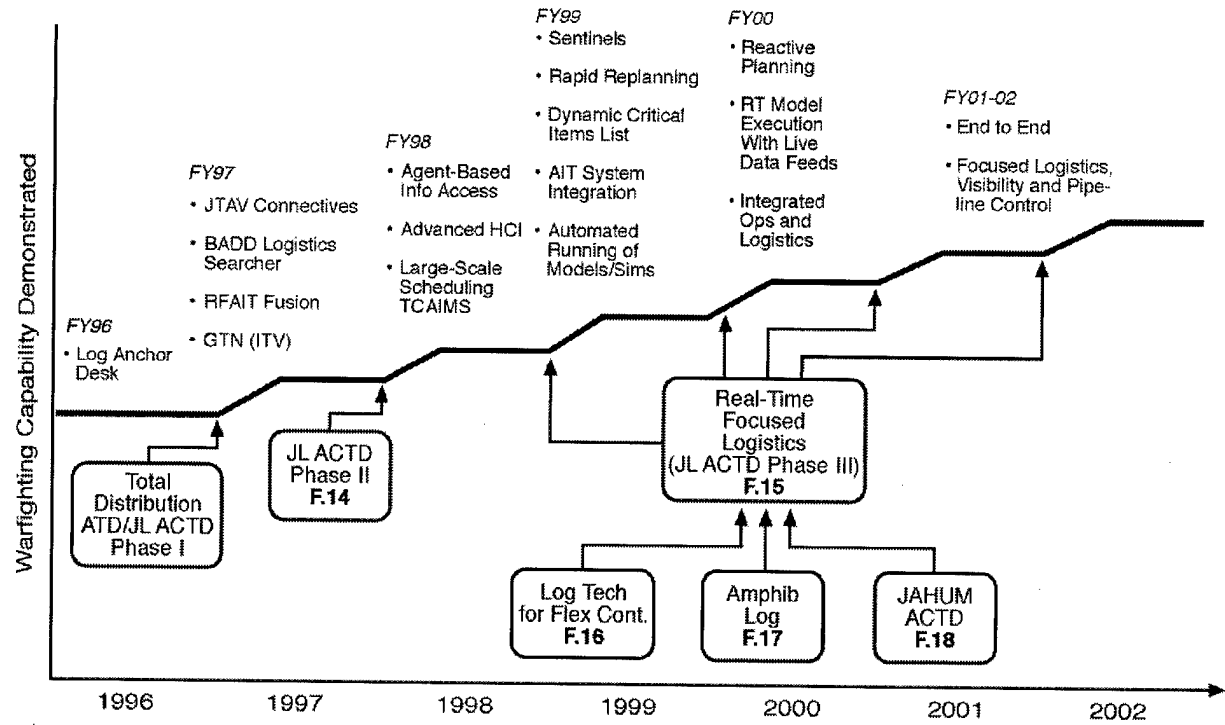


Figure IV.F-8. Progress—Real-Time Focused Logistics

G. JOINT COUNTERMINE

1. Definition

Joint Countermine provides the capability for assured and rapid surveillance, reconnaissance, detection, and neutralization of mines to enable forced entry by expeditionary forces. It includes the capability to control the sea and the ability to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, anti-invasion, and land mines. For land forces, dominance means the ability to conduct in-stride tempo operations in the face of severe land mine threats.

2. Operational Capability Elements

The ability to shape and maintain dominance of the battlespace is critical to maneuver warfare. The threat posed by mines has the potential to significantly limit battlespace dominance, thus inhibiting or deterring a U.S. force's ability to execute our nation's tasking. To achieve battlespace dominance, U.S. forces must have a credible capability to counter the mine threat in all environments. For naval forces, this necessitates unencumbered passage through strategic lines of communication in support of joint strategic mobility, freedom of maneuver in operating areas in support of joint strike warfare, and rapid movement in amphibious operating areas in support of joint littoral warfare. For land-based forces, this means control of the land to enable rapid maneuver in joint littoral and land warfare as well as in joint regional engagement/presence missions such as peacekeeping.

Joint Countermine is one of the essential keys to unlocking control of the battlespace. Historically, countermine operations, both at sea and on land, have been considered in terms of a number of elements, individually and separately applied to various mine search and neutralization tasks in different environments. The objective of Joint Countermine is to address the complex countermine problem through a "system-of-systems" approach. This approach will integrate all equipment and operations into a seamless capability to conduct joint land and littoral warfare, including amphibious or land/airborne missions into hostile territory with minimal disruption and losses due to minefields. This seamless countermine capability will also significantly enhance the capability to safely maneuver forces in regional engagement/presence missions.

The diverse service countermine elements will be integrated through a common communication architecture that will provide commanders full visibility, status, and control of countermine operations. The Joint Countermine Operational Simulation (JCOS) will permit realistic staff training, mission rehearsal, and, ultimately, operational support at all operational unit echelons.

U.S. forces must be able to engage regional forces promptly and decisively on a global basis. In the post-cold war era, the United States and its coalition partners must be prepared to bring the battle to the enemy in expeditionary operations. In nearly all JWCA mission areas, mines (sea, coastal, and land) offer a potential adversary a low-cost means of holding our forces at bay or restricting their maneuver, particularly in view of America's low tolerance for combat losses. The best way to counter mines is to detect their presence and avoid them. However, even with "perfect" real-time intelligence, this may not always be feasible. Minefields are generally employed to shape the battlespace, channeling the opposition's forces in the direction that the enemy desires. In such a situation, circumventing a minefield may be playing into the enemy's hands. Consequently, breaching may

become necessary to sustain maneuver. Regardless, the decision as to where, how, and when to enter a combat area must be made with the maximum confidence in our knowledge of the location and nature of the mine threat.

The first essential step in the Joint Countermine Joint Warfighting Capability Objective is broad, clandestine, and low-observable surveillance using all available sources, including national technical means (NTM) and human intelligence (HUMINT), to characterize battlespace and to narrow maneuver options. This initial surveillance phase is followed by tactical clandestine reconnaissance using a wide variety of sensors and platforms, including unmanned aerial and underwater vehicles (UAVs/UUVs), for detailed investigation of potential avenues of approach in the presence of mines, obstacles, and other defenses. The commander selects the actual assault path based on the latest intelligence and, once overt operations commence, seeks to establish a beachhead or lodgment within 2 to 6 hours of committing forces. Even in areas deemed to contain few or no mines, some breaching operations must be anticipated, since mines could be emplaced at the last minute or scattered into the area by aircraft, missiles, and artillery.

Figure IV.G-1 shows an integrated operational concept that relies on highly effective surveillance, reconnaissance, detection, characterization, and breaching or clearance of mine and obstacle fields to ensure force mobility in hostile areas. The individual systems used to implement this concept must provide the high confidence necessary to make reliable judgments concerning the likelihood of success and potential losses associated with various maneuver alternatives. The objective of countermine S&T programs is to have, by the year 2001, an initial limited capability to counter the most serious current countermine deficiencies and, by 2006, a demonstrated technical capability to address all currently known threats.

Vision: Seamless countermine operational capability element for surveillance, reconnaissance, detection, characterization, breaching, and clearing of mines and minefields

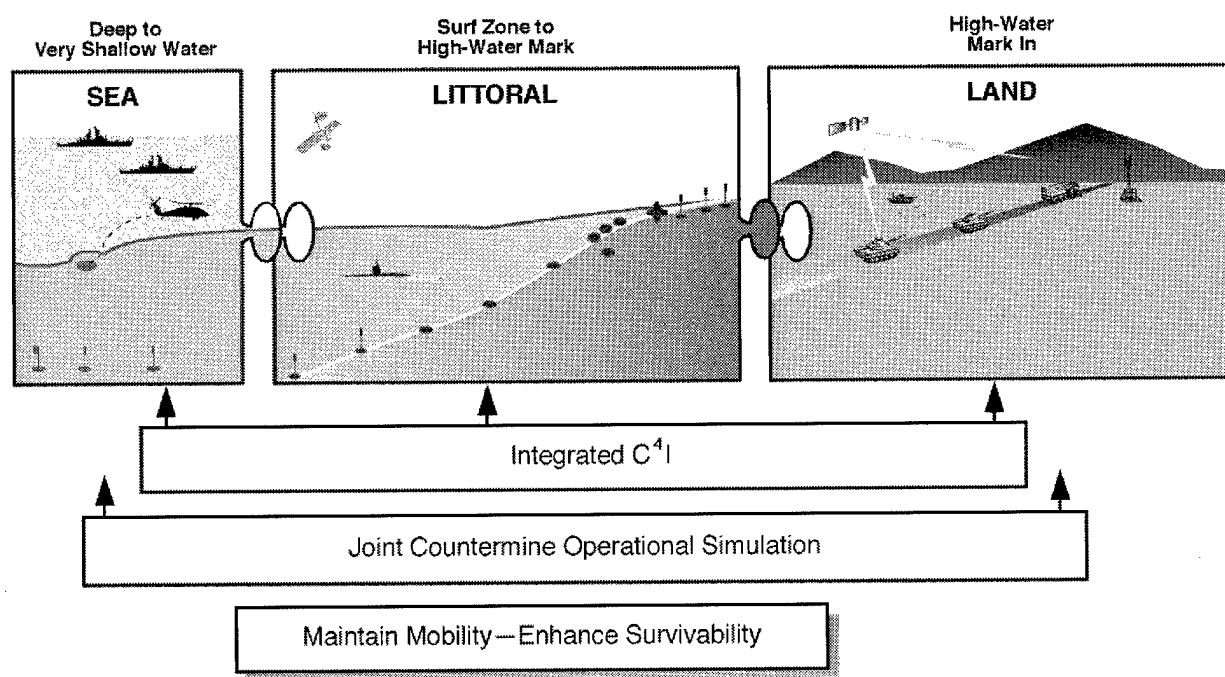


Figure IV.G-1. Concept—Joint Countermine

The initial 5-year capability will be achieved through a combination of countermine systems integrated into a common joint command and control structure. Data collected by NTM will be made available in near-real time to tactical commanders. Individual elements of the S&T program are developing a variety of multispectral sensor systems for employment on remotely controlled UAVs and UUVs to detect minefields at sea, in the surf zone, on the beach, and on land. Several DTAP DTOs complement these S&T elements: SE.33.01, Advanced Focal Plane Array Technology; SE.28.01, Low-Power Radio Frequency Electronics; and SE.29.01, Design Technology for Radio Frequency Front Ends. These sensors for mine/minefield detection include multibeam sonars for high-rate underwater search; ultrasensitive magnetic sensors and synthetic aperture sonars for buried sea mine detection; ground-penetrating radar for nonmetallic targets; and multispectral, hyper-spectral, forward-looking radar and infrared imaging for detection of mines and minefields in the surf zone, on the beach, and on land. Through the use of these sensors, the program will demonstrate the detection of volume and bottom sea mines, buried land and sea mines, and roadbed antipersonnel mines, including plastic mines, at greater than 95 percent probability of detection and acceptable false alarm rates. Breaching and clearing of surf, beach, and land areas will be accomplished by advanced mechanical and explosive systems currently in development.

Longer term (10-year) capabilities depend on advanced technologies now emerging from basic and applied research. These will form the basis for joint countermine forces to keep pace with the anticipated expansion of the sea and land mine threat well into the 21st century. Promising longer term technologies being pursued include directed-energy and underwater focused-pressure shock waves for mine destruction; hypersonic, water-piercing projectiles for standoff sea mine clearance; undersea acoustic local area networks and chemical sensing for underwater mine detection; and improved laser imaging and advanced synthetic aperture radar for clandestine reconnaissance and detection.

3. Functional Capabilities

Table IV.G-1 illustrates the joint countermine functions required to produce the operational capability elements.

4. Current Capabilities, Deficiencies, and Barriers

Table IV.G-2 presents the technologies needed to breach the limitations on achieving the joint countermine objective.

Current operational countermine surveillance capabilities are extremely limited. With the exception of mine reconnaissance by Special Operations Forces, very few dedicated collection systems exist. Exploitation of NTM for countermine intelligence is limited by the absence of tailored countermine products and less than adequate C⁴I capabilities and procedures for information distribution to operational commanders and forces. Mine-related databases are sparsely populated, and prediction/forecasting models are often not validated. Services now rely on overt tactical techniques to acquire and detect mines.

The Navy's mine detection capabilities are limited to dedicated mine countermeasures (MCM) ships and aircraft equipped with systems designed primarily for deep water or friendly port breakout missions. These systems have limited capabilities in the very shallow waters of the littoral, and the specialized platforms can require long lead times to reach a crisis response area. Organic

Table IV.G-1. Functional Capabilities Needed—Joint Countermine

Functional Capabilities	Operational Capability Elements									
	Surveillance, Reconnaissance, and Detection			Breaching and Neutralization		Battlespace Management				
	Continuous Surveillance	High Rate Area Reconnaissance/Detection	Precision Mine Location	Route Clearance, Sweeping, and Breaching	Area Clearance	Avoidance	Marking	Reporting	Recording	Dissemination
1. All-Source Intelligence Fusion	●	●	○	○	○			○	○	○
2. Environmental Characterization	●	●	●	○	○					
3. Minefield Detection	●	●	○	○	○					
4. Individual Mine Detection			●	○	○					
5. Mine Classification			●	○	○					
6. Mine Identification			●	○	○					
7. Low Cost Robotics	○	●	●	●	●					
8. Signal Processing and Sensor Fusion		●	●							
9. Mine Removal/Destruction				●	●					
10. Obstacle Removal				●	●					
11. Common C ⁴ I Environment						●	●	●	●	●
12. High Data Rate Communications						●	●	●	●	●
13. Signature Reduction						●				
14. Vulnerability Reduction						●				

● Strong Support

○ Moderate Support

mine reconnaissance systems for use by non-MCM surface ships and submarines have not yet been fielded. Detection of mines in very shallow water and in the surf zone is slow and limited to Navy SEALs using handheld equipment or marine mammals (not surf zone capable).

Likewise, land forces rely on fragmentary intelligence for the locations of mine and minefields. A primary source continues to be HUMINT via interviews with the local populace and the use of scouts and patrols to conduct visual reconnaissance missions. The detection of individual mines by land forces is still conducted much as it was during World War II using handheld magnetic detectors or probes.

Significant technological barriers exist in the detection of mines. The wide variety in mine designs (metallic/nonmetallic, contact/influence fuzed) and the different environments in which mines are employed (sea, surf, beach, land) preclude a single solution approach to the detection problem. Ultimately, the challenge is to detect and identify mines and minefields in high background clutter with a low false alarm rate. Several mine designs and environments provide unique challenges. In both the maritime and land environment, buried nonmetallic mines are difficult to detect. Optical, magnetic, and acoustic sensors are of limited effectiveness in the high ambient noise of the surf zone. Surf and tides quickly erase mine burial scars on the beach—limiting the effectiveness of electro-optical systems. The land environment offers similar challenges for magnetic sensors,

ground-penetrating radar, and passive infrared sensors. These challenges include soil type, moisture content, diurnal cycle, and natural and manmade ground clutter.

Mine breaching and neutralization is currently slow, tedious, and often dangerous. Sea mines are cleared either by influence or mechanical sweeping or through one-on-one neutralization charges. Mechanical sweeping of naval mines is conducted by dedicated MCM ships or aircraft and is only effective against moored mines in relatively deep water. Once swept, moored mines become "floaters" and are still dangerous. No rapid method for neutralizing these floaters exists, and they must be engaged one-on-one using small-arms fire or small explosive charges placed next to the mines by a tethered robotic mine neutralization system (MNS) or by explosive ordnance demolition

Table IV.G-2. Goals, Limitations, and Technologies—Joint Countermine

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Surveillance, Reconnaissance, and Detection			
Collect, correlate, and report prehostility mining operation; after mines are laid, provide commanders and individual units and soldiers the ability to detect and avoid mines/minefields from a safe distance at maneuver speed.	All-source intelligence fusion	Information from various national, theater, and tactical sensors is not fully compatible No ability to provide continuous countermine surveillance Limited access to intelligence databases at the tactical level	Exploitation of NTM for countermine purposes GCCS compatible tactical decision aids and mission planning tools Automated sensor/processor C ⁴ I interfaces
	Environmental characterization	Limited high search rate capabilities	Autonomous ocean sampling for littoral marine environment
	Minefield detection	Limited ability to determine precise minefield boundaries Limited ability to distinguish minefields from background clutter Limited sensor ranges and high false alarm rates Limited clandestine sensors for very shallow water, surf zone, and land	Autonomous/remotely operated air vehicles Multispectral/hyperspectral imaging Enhanced IR sensitivity and resolution Multispectral image processing Automatic target pattern recognition IR polarization Multisensor fusion Multibeam volume search sonar Synthetic aperture radar and sonar
	Individual mine detection	Limited endurance of autonomous vehicles	Autonomous/remotely operated vehicles
	Mine classification	Limited capability to detect buried mines in high clutter background	Forward looking radar/IR Low cost robotic platforms
	Mine identification	Limited capability to identify mines in very shallow water, the surf zone, and on land	Efficient power generation Superconducting magnetic gradiometers Ground penetrating radar/IR High repetition rate laser imaging technologies
	Signal processing and sensor fusion	Limited capability to coregister multiple dissimilar sensor inputs	ATR algorithm enhancements Enhanced signal processing algorithms for coregistration

Table IV.G-2. Goals, Limitations, and Technologies—Joint Countermine (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Breaching and Neutralization			
From the sea to land combat—dispose of mines in deep, shallow, and very shallow water through the craft landing zone into the land with minimal casualties to men and equipment.	Mine removal/destruction Obstacle removal	Mine neutralization is slow, dangerous, and labor intensive Limited ability to breach and clear minefields in a timely and safe manner No capability to sweep pressure influence sea mines Limited capability to neutralize mines on land, in surf, and in shallow water	Robotic breaching, neutralization, and removal systems Enhance efficiency of power generation and reduced weight for magnetic and seismic influenced sweeping sources Focused pressure shock waves Enhanced explosive materials Increased standoff explosive neutralization techniques Hypervelocity projectiles Kinetic energy neutralization RF signal neutralization Chemical neutralization
Operational Capability Element: Countermines Battlespace Management			
Provide synchronized countermines command and control in support of joint operations.	Common C ⁴ I environment High data rate communications Signature reduction Vulnerability reduction	Information from various national, theater, and tactical sensors is not fully compatible Limited access to intelligence databases at the tactical level Common countermines operational picture is not available Models and data do not support optimum mission planning and equipment design C ⁴ I systems and computer models supporting countermines are not fully compatible Limited ability for automated marking of mines/minefield data to situation displays Communication data rates limit the capabilities of autonomous/remotely operated systems Magnetic signatures of naval vessels/ground vehicles make them vulnerable to influence mines	Interactive distributed simulation models Data compression, bandwidth optimization, and high data rate acoustic modems Closed loop degaussing and active magnetic field suppression

(EOD) personnel. Bottom magnetic or seismic influence mines are swept using influence sweeping devices deployed from MCM ships or helicopters. The United States has no capability to sweep pressure influence mines; the only method for neutralizing these mines is to first locate and then disable them using an explosive charge placed by the MNS or by EOD safe rendering procedures.

Current surf zone, beach zone, and land mine clearance is limited to M-58 and M-59 line charges deployed from autonomous armored vehicles (AAVs) or trailers accompanied by the Track Width Mine Plow (TWMP) for proofing. Explosive line charges generate overpressure onto a minefield. Current mechanical neutralization and breaching techniques simply push mines into the

plowed spoil. In both cases, there is no standoff capability. The overall effectiveness of these systems is further hampered by technological enhancements to mine fuses and the environmental limitations imposed on each of the neutralization techniques.

Reliable neutralization of mines presents several unique challenges. Improved targeting systems and in-depth ballistic/hydroballistic analysis and testing are needed to make directed fire an effective neutralization tool against subsurface or buried mines. A technology breakthrough is required to solve the naval pressure minesweeping problem. To reduce human vulnerability, neutralization techniques like signature duplication must be light enough to be deployed from small remotely controlled vessels and ground systems and be highly durable to operate in the high shock/vibration conditions of the surf and land battlefield environments. The problem with any breaching operation is that it is usually complicated by the fact that mines and obstacles are often deployed together. Effectiveness of explosive line charges and Track Width Mine Plows/Track Width Mine Rollers (TWMP/TWMR) are significantly degraded when obstacles are factored into the counter-mine task.

To provide a true in-stride breaching capability, improved fire control systems must be developed to permit the firing of breaching charges from amphibious landing craft operations in breaking surf and from vehicles on the run. Improved breaching charges must be developed to provide a high kill probability against all types of fuzed mines including those buried by surf and tidal action on the beach. Additionally, for a holistic breaching capability, efforts are needed in the area of obstacle removal.

Another new challenge to land warfare is off-route mines. This emerging threat can lay in wait at standoffs up to 100 meters, and it is capable of targeting and killing mechanized forces without being detected. Systems must be developed for in-stride clearance of these mines from the shoulders of the intended route as well as from barrier minefields.

Area clearance in support of a military mission is a challenge that has been overlooked. This task requires the clearing of large areas infested with mines or unexploded ordnance (UXO). Such an action is paramount to the conduct of logistics over the shore and the establishment of rear-area Combat Service Support (CSS) functions. CSS elements must be capable of operating in a mined environment. Currently these units rely on many of the same personnel and equipment resources that support the maneuver force. Clearance resources available to the CSS as well as to the general forces are limited and labor intense. Efforts are needed to provide mechanical, electronic, robotics, and low-order neutralization technologies that will allow for the systematic removal of mines and UXO by organic resources. Dissemination of intelligence relative to the locations of previous combat and fire support operations is required. This intelligence will allow CSS units operating in post-combat areas to be aware of the risk, and it will support planning for required clearance missions.

Battlespace management for countermine warfare must be improved. To be effective, the operational commander requires fused mine warfare intelligence in a timely manner within his overall maneuver battle plan. Currently, for both land and amphibious operations, the electronic dissemination of information regarding suspected minefields, actual mine locations, and cleared routes or areas is often inaccurate and unreliable. In shallow water, in surf zones, and on beaches, no capability exists to rapidly mark these areas cleared for follow-on maneuver. Mine warfare environmental sampling, databases, and modeling efforts must be improved if they are to contribute to the development of sensors and systems as well as real-time support for field commanders in the form of tactical

decision aids (TDAs). Data collection tools for mine/minefield reports are needed to provide accurate, consistent mine data inputs. Software tools are needed to collect, store, format, display, and disseminate countermine data. The goal of this effort is to provide a comprehensive countermine picture to all required operational units. Reduction in the vulnerability of watercraft, land vehicles, and personnel to mines is a critical technical challenge involving blast deflection/absorption, signature duplication and projection, acoustic and magnetic signature reduction, and other techniques.

5. Technology Plan

Figure IV.G-2 presents the technologies needed to breach the limitations to functional capabilities required to achieve the joint countermine objective. These technologies offer the potential for a significant increase in today's capability. Their need is underscored by experience in the Persian Gulf War, Somalia, and Bosnia.

Table IV.G-3 identifies the Joint Countermine DTOs. Table IV.G-4 presents the DTOs that, when attained, will enable the operational capability elements. Each DTO is plotted in the technology roadmap, Figure IV.G-3.

The roadmap for developing and demonstrating the technologies required to support the JCM JWCO is shown in Figure IV.G-3. This diagram shows the demonstrations that result from three serial processes: phenomenology, technology, and integration. Phenomenology addresses the understanding of the physical effects that influence mine detection, detonation, and negation. These effects include a better understanding of hydrographic phenomena in shallow and littoral waters and the surf zone, acoustic and electromagnetic mine and minefield signatures, and the reaction of explosives to chemical and energetic perturbation (pressure, directed energy, etc.). Technology enables the design of various sensing and neutralization systems, including algorithms for the detection and identification of minefields and for the exploitation of all available data (tactical sensors, intelligence sensors, and threat databases). This effort is supported by DTAP DTO SE.19.03, Affordable ATR via Rapid Design, Evaluation, and Simulation. Integration represents the effort required to put technologies on a militarily significant platform for demonstration. Integration also addresses the critical need to provide a comprehensive C⁴I capability, which includes near-real-time, high-confidence situational awareness of the mine threat, the location and availability of friendly forces and their countermine capabilities, and coordination among service and coalition forces to optimize countermine effectiveness.

The technology efforts include several projects in the Army, Navy, and Marine Corps S&T programs. Following is a list by DTOs:

- **G.01 *Land Mine Neutralization*.** The Mine Hunter Killer (MH/K) ATD provides a capability to neutralize individual mines and other UXOs from a mounted platform at maneuver speeds by integrating advanced mine detection and mine neutralization technologies with automated targeting and fire control mechanisms. This capability increases operational tempo by avoiding time delays due to mines and enhances force survivability by avoiding direct- and indirect-fire kills resulting from minefield delays. This DTO focuses on the neutralization component of the MH/K ATD. Specifically, the neutralization goal of the MH/K ATD is 98 percent probability of kill (P_k) of metallic and nonmetallic mines, both surface laid and buried, from a platform traveling at speeds up to 20 mph and standoff ranges up to 75 meters.

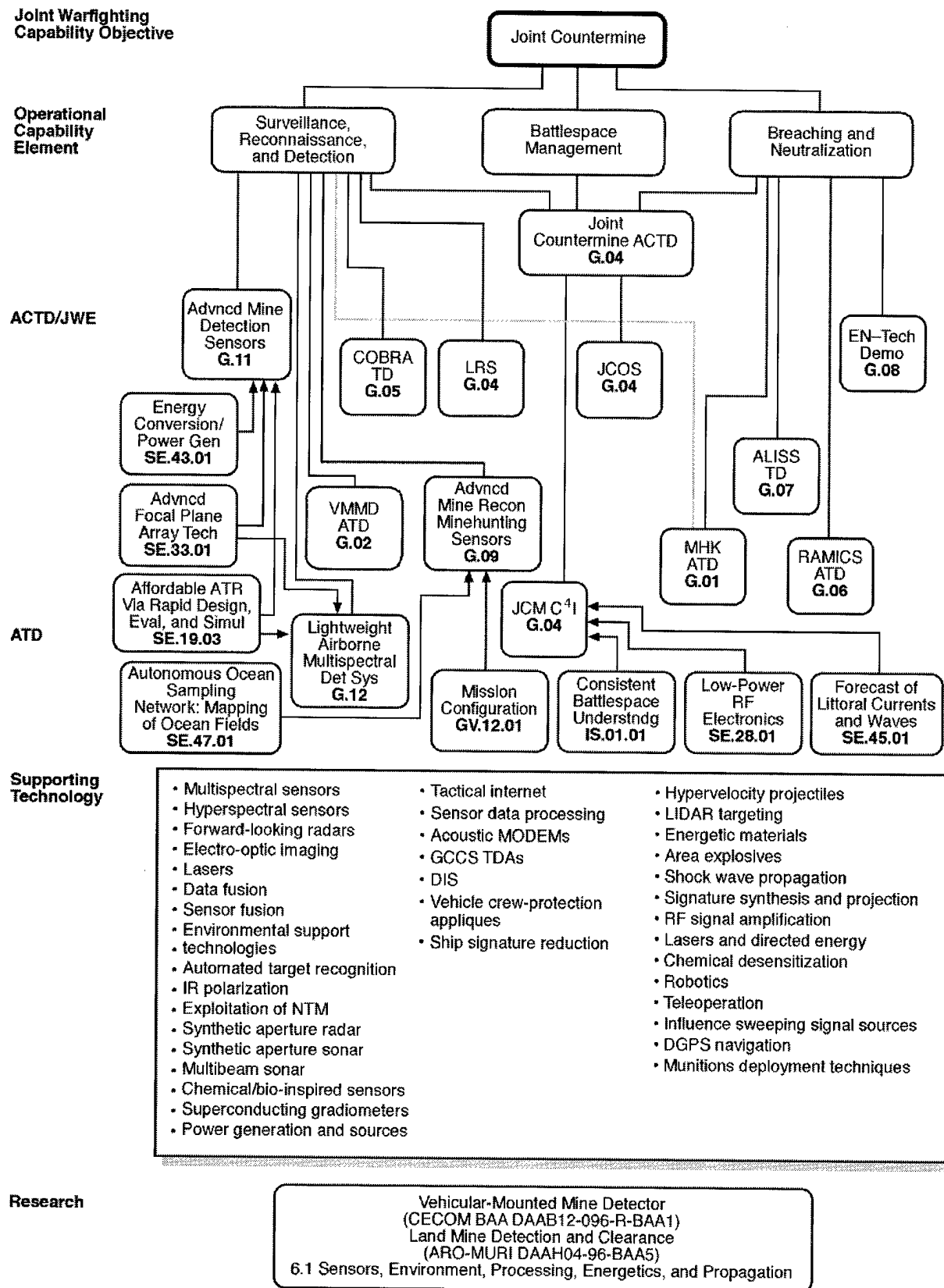


Figure IV.G-2. Technology to Capability—Joint Countermine

Table IV.G-3. Defense Technology Objectives—Joint Countermine

DTO No.	Title
G.01	Land Mine Neutralization
G.02	Land Mine Detection
G.04	Joint Countermine ACTD
G.05	Rapid Battlefield Mine Reconnaissance
G.06	Rapid Sea Mine Neutralization
G.07	Autonomous Shallow Water Influence Sweeping
G.08	In-Stride Amphibious Breaching
G.09	Advanced Mine Reconnaissance/Minehunting Sensors
G.11	Advanced Mine Detection Sensors
G.12	Lightweight Airborne Multispectral Countermining Detection System
GV.12.01	Mission Reconfigurable Unmanned Undersea Vehicle
IS.01.01	Consistent Battlespace Understanding
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.28.01	Low-Power Radio Frequency Electronics
SE.29.01	Design Technology for RF Front Ends
SE.33.01	Advanced Focal Plane Array Technology
SE.43.01	Energy Conversion/Power Generation
SE.45.01	Forecast of Littoral Currents and Waves
SE.47.01	Autonomous Ocean Sampling Network: Mapping of Ocean Fields

- G.02 Land Mine Detection.** The Vehicle-Mounted Mine Detector (VMMD) provides the capability to detect surface-laid and buried mines and other UXO from a vehicle-mounted system through (SE.19.01, Affordable ATR via Rapid Design, Evaluation, and Simulation) the development of new sensors and integration with sensor fusion and automatic mine recognition techniques. This capability increases operational tempo by providing mine on/off-route locations and locations of the leading edges of minefields to operational users prior to encounter, thereby avoiding delays and losses caused by unexpected mine threats. This DTO includes the VMMD ATD and the detection component of the MH/K ATD. A robust mine detection capability is essential for the success of the MH/K ATD (see G.01), which relies on mine detection technologies for target acquisition. Specifically, the goals for the VMMD are 2–5 mph detection speed, 80–90 percent probability of detection (P_d), and 0.15–0.04 false alarm rate (FAR) per meter of advance.
- G.04 Joint Countermining ACTD.** This DTO will demonstrate selected clandestine reconnaissance and detection technologies and in-stride neutralization and clearance technologies, together with currently fielded capabilities, to improve the task force commander's ability to conduct seamless countermining operations from the sea, through the surf zone, and on land. Specific demonstrated capabilities to achieve the Joint Countermining (JCM) ACTD goals include demonstration of standoff reconnaissance and detection of

Table IV.G-4. Demonstration Support—Joint Countermine

Demonstration	Operational Capability Elements										Service/ Agency	Type of Demonstration		
	Surveillance, Reconnaissance, and Detection			Breaching and Neu- tralization		Battlespace Management						DTO	ACTD	ATD
	Continuous Surveillance	High Rate Area Recon- naissance/Detection	Precision Mine Location	Route Clearance, Sweeping, and Breaching	Area Clearance	Avoidance	Marking	Reporting	Recording	Dissemination				
Land Mine Neutralization				●		○					Army	G.01	X	X
Land Mine Detection			●	●	○	●	○	○			Army	G.02		X
Joint Countermine ACTD	●	●	●	●	●	●	●	●	●	●	Army, Navy	G.04	X	
Rapid Battlefield Mine Reconnaissance		●		○	○	○	○	○			Marine Corps	G.05	X	X
Rapid Sea Mine Neutraliza- tion			○	●	●						Navy	G.06		X
Autonomous Shallow Water Influence Sweeping				●	●						Navy	G.07	X	X
In-Stride Amphibious Breaching				●							Navy	G.08	X	X
Advanced Mine Reconnaissance/ Minehunting Sensors		○	●			●					Navy	G.09	X	
Advanced Mine Detection Sensors			●								Army	G.11		X
Lightweight Airborne Multi- spectral Countermine Detection System		●		○	○	○	○	○			Army	G.12	X	(C)
Mission Reconfigurable Un- manned Undersea Vehicle	●	●	○	○							Navy	GV.12.01		
Consistent Battlespace Understanding								●	●	●	Air Force, Navy, DARPA	IS.01.01		
Affordable ATR via Rapid Design, Evaluation, and Simulation			●	○		○					Army, Air Force	SE.19.01		
Low-Power Radio Fre- quency Electronics	●	●	●			●	○	○	○		Air Force, DARPA	SE.28.01		
Design Technology for RF Front Ends	●	●	●			●	○	○	○		Air Force, DARPA	SE.29.01		
Advanced Focal Plane Array Technology	●	●	●			●	●	○	○		Air Force, Navy, DARPA	SE.33.01		

● Strong Support

○ Moderate Support

(C) 6.3 Core Demo

Table IV.G-4. Demonstration Support—Joint Countermine (continued)

Demonstration	Operational Capability Elements										Service/ Agency	Type of Demonstration		
	Surveillance, Reconnais- sance, and Detection			Breaching and Neu- tralization		Battlespace Management						DTO	ACTD	ATD
	Continuous Surveillance	High Rate Area Recon- naissance/Detection	Precision Mine Location	Route Clearance, Sweeping, and Breaching	Area Clearance	Avoidance	Marking	Reporting	Recording	Dissemination				
Energy Conversion/Power Generation	○	○	○	○	○						Navy, Air Force, DARPA	SE.43.01		
Forecast of Littoral Currents and Waves						○	●	●	●	●	Navy, Army	SE.45.01		
Autonomous Ocean Sam- pling Network	●	○	●			●	●	●	●		Navy, Army	SE.47.01		

● Strong Support

○ Moderate Support

(C) 6.3 Core Demo

mines and minefields in an Amphibious Operating Area, very shallow water, the surf zone, on the beach, and on land (Advanced Underwater Sensors, Littoral Remote Sensing, ASTAMIDS, Magic Lantern (Adaptation), COBRA, and CIMMD); the in-stride movement through the surf zone, beach, and land using standoff neutralization (ALISS, EN ATD, JAMC, and ORSMC); and countermine battlespace awareness through use of the Joint Countermine Operational Simulation (JCOS) and unique Countermine C⁴I applications.

- **G.05 Rapid Battlefield Mine Reconnaissance.** Coastal Battlefield Reconnaissance and Analysis (COBRA) ATD incorporates advanced multispectral sensors into a UAV to provide daylight coastal reconnaissance of beach areas and craft landing zones. Enhanced COBRA optics are being developed under the 6.2 Joint Mine Detection Program. COBRA addresses the limitation in high-search-rate reconnaissance capabilities of minefields and obstacles on the beach and improves the capabilities of forces to determine precise minefield boundaries.
- **G.06 Rapid Sea Mine Neutralization.** The Rapid Airborne Mine Clearance System (RAMICS) ATD will employ a LASER system to target hypervelocity, super-cavitating projectiles fired from a conventional 20-mm gun mounted on a helicopter. The system will provide a capability to rapidly neutralize near-surface moored mines within 20 feet of the sea surface. RAMICS addresses a shortfall in the ability of Airborne Mine Countermine (AMCM) forces to rapidly neutralize mines once they are identified. Current capability requires mines to be marked and subsequently neutralized by EOD divers or surface MCM vehicles.

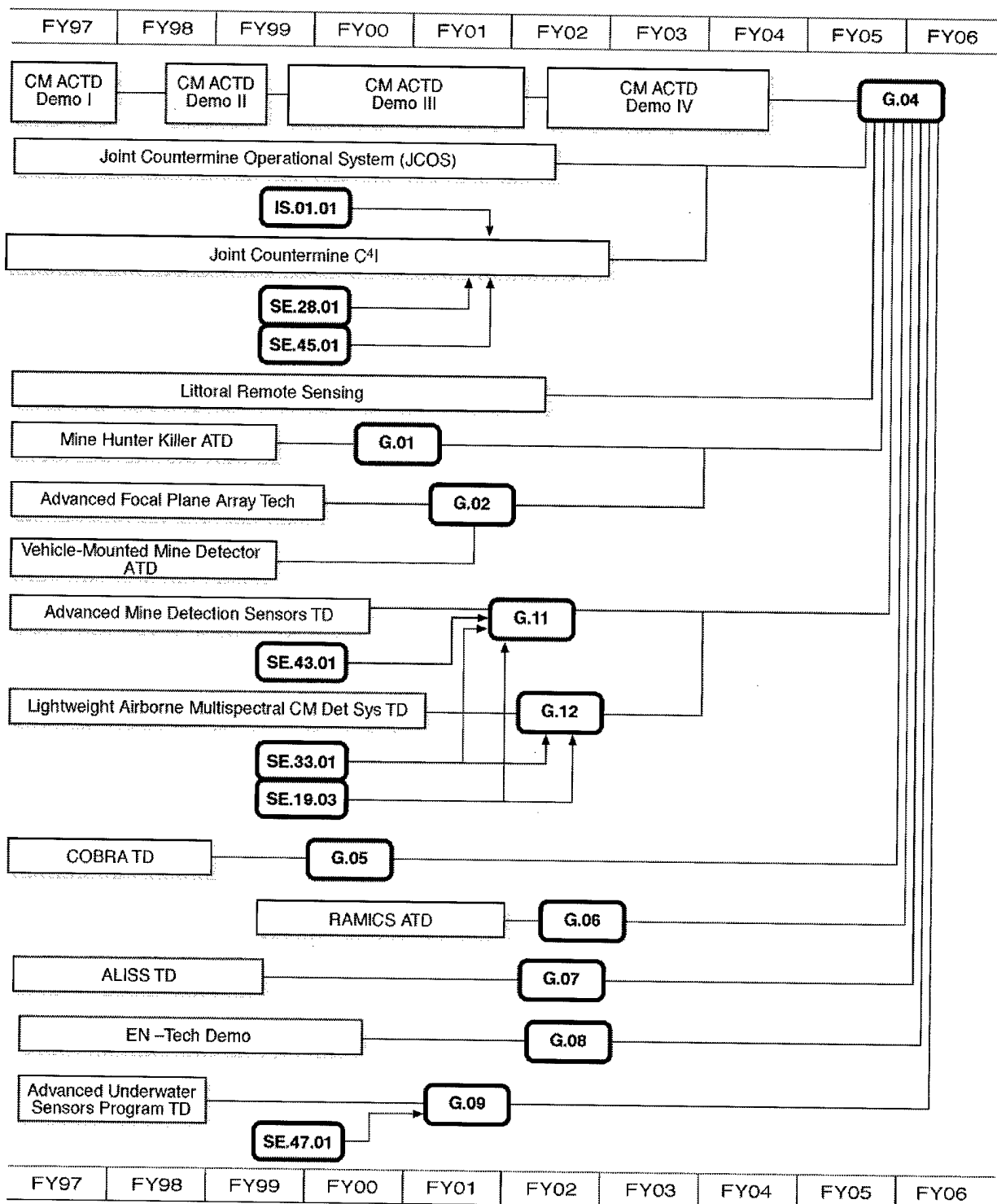


Figure IV.G-3. Roadmap—Joint Countermine

- **G.07 *Autonomous Shallow-Water Influence Sweeping.*** The Advanced Lightweight Influence Sweep System (ALISS) will use superconducting magnet and plasma-discharge pulse power technology to provide lightweight acoustic and magnetic signature emulation sweeping. ALISS may be deployed from a variety of platforms, including high-speed boats, Landing Craft Air Cushions (LCACs), or traditional MCM ships. ALISS fills a shortfall in the ability to rapidly sweep amphibious craft landing lanes in shallow water and provides a rapid-response capability for organic mine clearance.
- **G.08 *In-Stride Amphibious Breaching.*** The Explosive Neutralization Technology Demonstration (EN-Tech Demo) will demonstrate in-stride mine and light obstacle breaching from the sea using improved explosive line charges and distributed explosive arrays deployed from an LCAC. An improved fire control system and longer range rocket motors will allow the LCAC to hover outside the surf zone in conditions up to Sea State 3 while launching explosive charges. The Magic Carpet concept enables the deployment of explosive beach zone arrays by an unmanned glider launched by a cargo aircraft flying offshore. The EN-Tech Demo significantly reduces the shortfalls in the joint force's ability to conduct successful in-stride breaching in support of amphibious operations.
- **G.09 *Advanced Mine Reconnaissance/Minehunting Sensors.*** The Advanced Underwater Sensors Program is developing a family of acoustic and nonacoustic sensors for rapid, reliable underwater mine/minefield reconnaissance. The effort features computer-aided detection/classification, long-range sonar for the detection of mines in the water volume, high-resolution sonar for the reliable detection and classification of buried and partially buried mines, highly sensitive cryogenic magnetic gradiometers for mine classification and detection of buried mines, and electro-optic laser line scan sensors for mine identification. The sensors will be available for incorporation into a variety of UUVs, including autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), and towed bodies. Advanced Underwater Sensors address shortfalls in the ability to conduct high-confidence, rapid, clandestine underwater reconnaissance of the complex littoral environment and to identify safe operating areas and lanes for the maneuver of forces. This JWSTP DTO is complemented by DTAP DTO SE 47.01, Autonomous Ocean Sampling Networks (AOSN), and SE.45.01, Forecast of Littoral Currents and Waves. AOSN provides advances in oceanographic and UUV technology of significance to the Advanced Underwater Sensors Program.
- **G.11 *The Advanced Mine Detection Sensors*** provides enhanced mine detection capability through the fusion of multiple sensor output. Sensor fusion will overcome the natural and manmade clutter challenges experienced by current mine detection systems. The goals of this DTO are to provide a single ground-based detection system with a P_d for antitank and antipersonnel mines of 98 percent, a false alarm rate of <2 per meter of forward progress, and an ability to operate in all weather. Fusing the outputs of advanced forward-looking IR, forward-looking radar, and side-looking radar will initiate this DTO. The mine detection contribution of seismic, acoustic, and bio-inspired sensors will be incorporated as these technologies mature. This JWSTP DTO is supported by DTAP DTOs SE.28.01, Low-Power Radio Frequency Electronics, and SE.29.01, Design Technology for Radio Frequency Front Ends.

- **G.12** *The Lightweight Airborne Multispectral Countermine Detection System* provides innovative concepts and technologies to support a new, lightweight, airborne standoff mine detection sensor for integration into the tactical UAV. This DTO focuses on new IR focal plan array technologies, multi/hyperspectral imaging, passive polarization, active sources, and electronic stabilization. The goals of the DTO are to reduce the weight and volume of the mine detection sensor package to allow direct interface with the tactical UAV, and enhance detection performance over the current Airborne Standoff Minefield Detection System (ASTAMIDS). This JWSTP DTO is supported by DTAP DTOs SE.57.01, Analog-to-Digital Converter, and SE.33.01, Advanced Focal Plane Array Technology.

The primary mechanism for consolidating these projects into an integrated system-of-systems is the joint countermine Advanced Concept Technology Demonstration (ACTD) (DTO G.04), sponsored and executed by USACOM and developed and managed by a Navy/Marine Corps/Army Joint Program Office. The two key integration activities in this ACTD are the C⁴I effort and the Joint Countermine Operational Simulation (JCOS) project. Under the C⁴I effort, the Joint Task Force Commander will be provided a complete, up-to-date situation awareness of the countermine intelligence and status along with direct connectivity to all maneuver units via existing or planned communications links. Global Command and Control System (GCCS)-compatible countermine warfighting evaluation tools and tactical decision aids (TDAs) will support all aspects of the littoral countermine effort, including minefield and obstacle surveillance and reconnaissance, mine and obstacle detection and avoidance, mine classification, and mine and obstacle clearance. The JCOS links existing modeling and simulation tools along with representatives of all countermine platforms and units in a distributed interactive simulation (DIS) framework consistent with the JCM/C⁴I net to provide a comprehensive planning, training, rehearsal, and operational evaluation tool for joint countermine operations.

Additionally, individual service 6.2 and 6.3 core programs in various areas—including environment, sensors, explosives, and countermine—contribute significantly to the joint countermine effort. Several other related efforts also have the potential to help countermine efforts. The Army Environmental Center recently completed a range clean-up technology program at the Jefferson Proving Ground. DOE and EPA requirements for test range and dump site redemption have led to the joint DoD/DOE Mobile Underwater Debris Survey System (MUDSS) project. Sandia National Laboratory is exploring foam bridges for minefield breaching and chemical sensing devices for mine reconnaissance. DARPA has an ongoing mine hunting UUV program and is developing a synthetic aperture sonar for underwater mine reconnaissance. DARPA is also investing in low-cost robotic technology for use in very shallow water, surf zone, and beach zone mine and obstacle clearance. Under DTO GV.14.07, Advanced Ship Degaussing, efforts are underway to significantly reduce steel-hulled ships' magnetic and induced field strengths.

6. Summary

FY96 highlighted the accomplishment of a number of key milestones. During FY96, the Close-in Man-Portable Mine Detector (CIMMD) and the Off-Route Smart Mine Countermeasure (ORSMC) completed their ATDs. The Coastal Battlefield Reconnaissance and Analysis (COBRA), Joint Amphibious Mine Countermeasure (JAMC), and the fire control of the Explosive EN-TD successfully underwent technology demonstrations. Components of the JAMC, LRS/Radiant Clear,

and Advanced Underwater Sensor programs participated in USACOM Purple Star exercise (May 1996). CIMMD and ORSMC participated in the TRADOC-sponsored Lightfighter Countermining Experiment (September 1996). These live exercises serve as preparation for the Joint Countermining ACTD Demonstration I in August 1997. Numerous virtual experiments were also conducted during this year. These experiments provided insight to the impact that emerging technologies have on countermining tactics, techniques, and procedures.

Between 1997 and 2005, DoD will continue to enhance the warfighting capability of the services. The collective capabilities demonstrated for each DTO scheduled between 1997 and 2005 shows a stepped improvement over the previous demonstration. The capabilities and their schedule of availability are depicted in Figure IV.G-4. Through combined joint countermining capabilities and user awareness of the growing mine threat, the overall joint countermining objective of providing seamless mine and minefield detection and neutralization in a force projection from sea to inland targets will be realized.

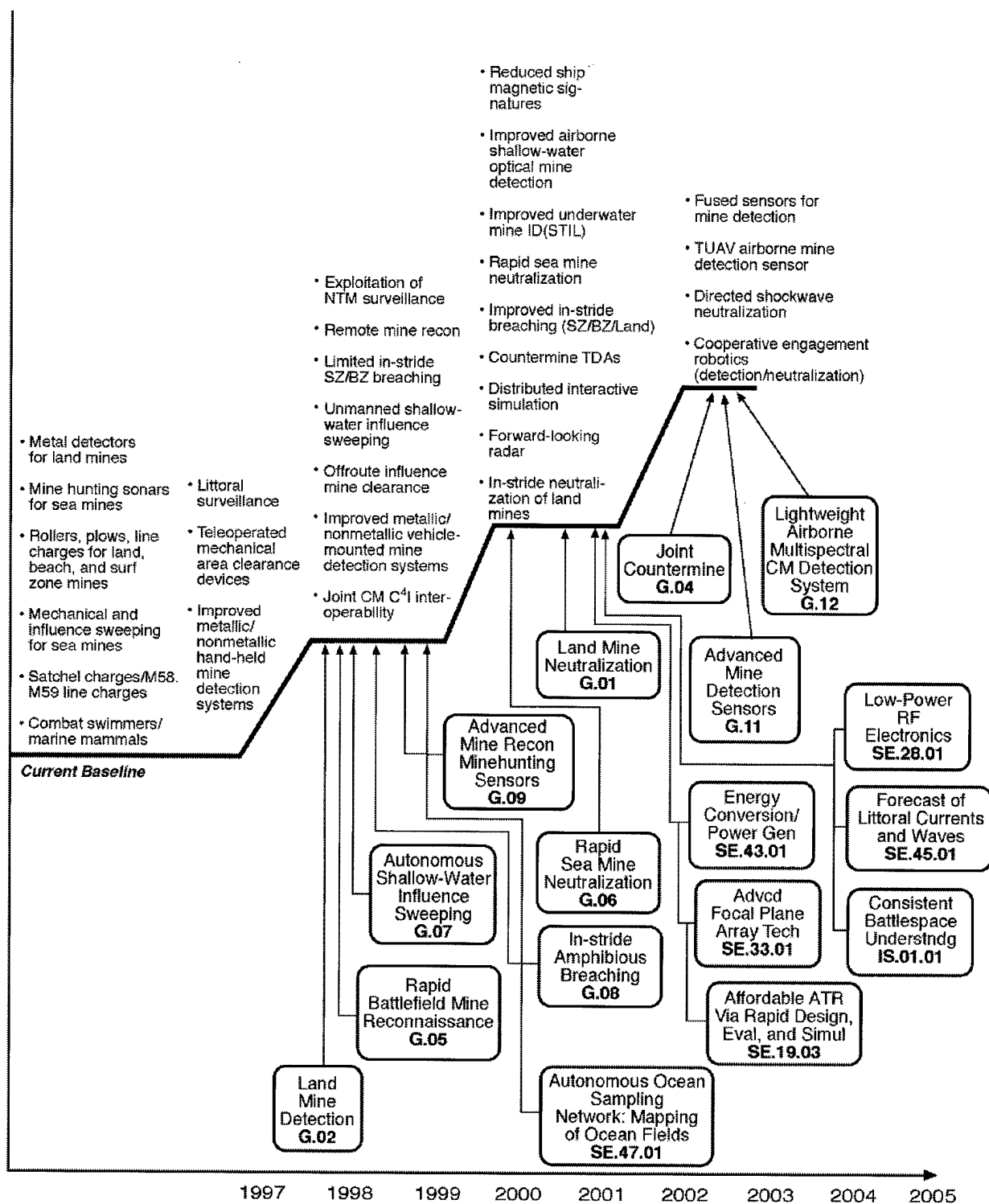


Figure IV.G-4. Progress—Joint Countermine

H. ELECTRONIC COMBAT

1. Definition

Electronic Combat (EC) encompasses the capability to disrupt or degrade an enemy's defenses throughout the areas and times—and across the entire electronic, infrared (IR), and visual spectrums—required to permit the deployment and employment of U.S. and allied combat systems. EC (also known as electronic warfare, or EW) includes capabilities for deceiving, disrupting, or destroying enemy surveillance, command and control (C²), and weapon systems/sensors (e.g., early warning, acquisition, and targeting functions) associated with the enemy's integrated air/area defense network. EC also includes the critical capabilities of recognizing attempts by hostile systems to track or engage U.S. or friendly forces, automatically initiating the appropriate countermeasures or defensive response, and protecting friendly systems through redundancy and hardening.

2. Operational Capability Elements

The strategic goal of EC is to control and exploit the electromagnetic spectrum for maximum effectiveness of U.S. military operations—that is, to deny, disrupt, degrade, deceive, or exploit enemy use of the full electromagnetic spectrum while ensuring its use by friendly or joint forces. Successful attainment of this goal necessarily confers a superior capability on U.S. military and friendly forces to survive in their execution of all required combat/conflict operations/missions. EC has three principal and integral operational capability elements: electronic attack, electronic protection, and electronic support. Each element provides a range of benefits to participants in joint organizations and operations. Figure IV.H-1 depicts these principal elements as they contribute to joint operations.

Electronic attack (EA) involves the defensive or offensive protection of U.S. forces and platforms against hostile weapon, sensor, and C³ systems. In its traditional form (“self-protection”), EA consists of a warning receiver to warn of impending weapon attack (“attack warning”), expendable countermeasures, and a jamming system working in concert to prevent sensor-guided weapons from hitting their target. More recent technology further expands the boundaries of electronic attack by engaging sophisticated, long-range target acquisition sensors—such as airborne and space-based surveillance/synthetic aperture radars, and the increasingly modern communications supporting all phases of the enemy attack or defense—thereby becoming a key, integral element of battlespace dominance. Therefore, EC/EW and its EA element plays a prominent, vital role in the new, “leveraged” concept of Full Dimensional Protection, as described in the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010*.

One critical aspect of electronic attack is the ability to deny an opponent the reliable use of their own command, control, communications, and computer/intelligence, surveillance, and reconnaissance (C⁴ISR) systems—thereby permitting U.S. platforms and forces to operate freely throughout the battlespace with minimal loss to hostile weapons. Such freedom is gained due to confusion, analysis, and decision delays induced and propagated within the enemy's C⁴ISR infrastructure regarding the location(s), structure, and intent of joint forces. This EA strategy is an enabling capability for operations requiring penetration of hostile territory (e.g., suppression of enemy air defenses (SEAD), close air support (CAS), counter-C³, and precision attack on any fixed or mobile target). Thus, again, electronic attack plays a prominent role in the *Joint Vision 2010* concept of

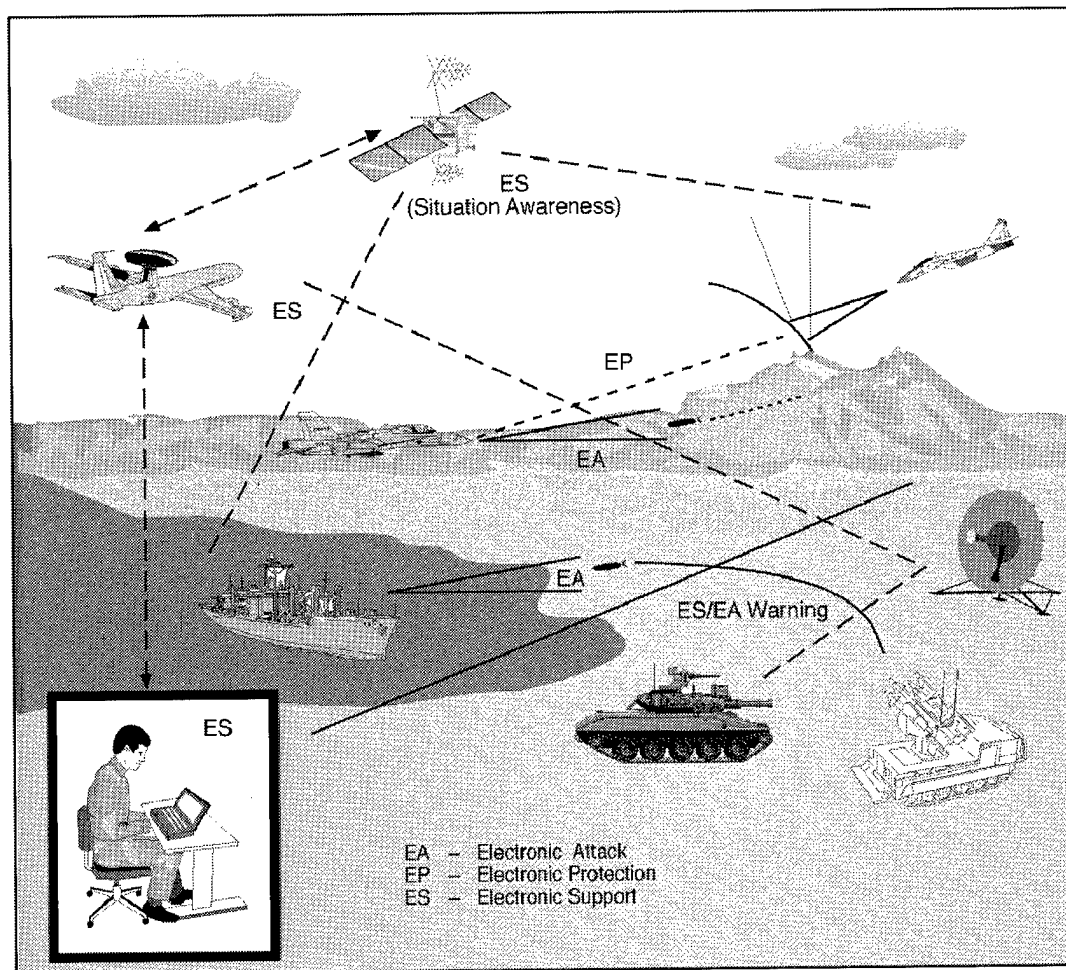


Figure IV.H-1. Concept—Electronic Combat

Dominant Maneuver by virtue of aiding the control of operational tempo, and EA is synergistic with the Joint Warfighting Capability Objective (JWCO) of Information Superiority.

Electronic protection (EP) supports the development of design features and employment techniques that allow U.S. forces to enjoy the benefits of accurate electronic sensors and systems, both offense and defensive—despite an environment that includes hostile jamming, deception activity, and enemy weapon targeting that, itself, depends on detecting, recognizing, and determining the location of U.S. emitters. EP allows operational users to initiate and prosecute a mission without degradation from opposing EW or from conventional or directed-energy weapons cued or targeted by hostile sensors. Successes in EP techniques translate into effective targeting by joint combatants and reliable communications, surveillance, and electronic support sensors—corresponding to the JWCOs of Precision Force and Information Superiority.

Electronic support (ES) is the EC element that gathers, consolidates, and employs information from hostile or potentially hostile electronic sensors and C³ systems. ES is critical to developing a comprehensive picture of the battlespace and a reliable indication of hostile force movement and intentions. ES allows force avoidance, efficient engagement, and electronic deception—EA—of enemy sensors, weapons, and communications systems. The classic definition of electronic support recognizes its functionality from the joint operational commander level down to the “single-seat”

cockpit combatant. With increasingly sophisticated, worldwide, modern weapon systems, the pressures for ever-increasing ES fidelity are blurring the older distinctions between the classic radar warning receiver (attack warning) and the longer range electronic support measures (ESM) systems. Therefore, in the future, all joint combatants/platforms can be integrated into the battlespace picture via the contributions of their ES systems. ES enables a wide range of operational options that contribute to virtually every combat and peacekeeping mission. Hence, ES is strongly synergistic with the JWCOs of Precision Force, Combat Identification, and Information Superiority and the associated *Joint Vision 2010* concept of Precision Engagement.

3. Functional Capabilities

Table IV.H-1 depicts the relationships between operational capability elements and functional capabilities for the EA and ES components of EC. Because electronic protection capabilities are generally specific to a sensor or C³ system, the EP component is not addressed further in this section.¹ From a basic technology perspective, refer to the *Defense Technology Area Plan* (DTAP), Chapter VII, Sensors, Electronics, and Battlespace Environment; and Chapter X, Weapons (EW Mission Support).

Table IV.H-1. Functional Capabilities Needed—Electronic Combat

Functional Capabilities	Operational Capability Elements									
	Electronic Attack						Electronic Protection	Electronic Support		
	Attack Warning	A/C Protection	Ship Protection	Land Combat Vehicle Protection	C ² Attack	Lethal SEAD		Signal Collection	Emitter ID/Location	Battlespace Awareness
1. Real-Time Threat Detection, ID, and Geolocation	●	●	●	●	●	●	Specific to Sensor or C ³ Systems Under Development—Not Addressed in This Chapter. Refer to Sensors, Weapons (EW) DTAP Chapters.	●	●	●
2. Missile Approach Warning	●	●	●	●						●
3. Modular, Programmable EW Receiver/Processor	●	○	○	○	●	●		●	●	●
4. Sensor/Data Fusion, Electronic Intelligence	●	●	●	●	●	○		●	●	●
5. Decoy Terminal Threat Weapons		●	●	●		●				
6. UAV EW Employment	○	●	●	●	●	●		●	●	●
7. Robust, Multispectral EA of Simultaneous Threats		●	●	●		●				
8. Broadband, Coherent, Surgical RF Countermeasures		●	●	●	●	○				
9. Second-Generation Directed IRCM		●	●	●						
10. Laser-Based IRCM		●	●	●						
11. Counter IADS Surveillance, Acquisition, and C ²		●	●	●	●	○		○	○	○

● Strong Support

○ Moderate Support

¹ For example, protecting operational usage of GPS is dealt with, in part, by the Navigation Warfare ACTD.

4. Current Capabilities, Deficiencies, and Barriers

Current EC/EW capabilities are generally the result of extensive, detailed concentration on the capabilities of the former Soviet Union; a coherent "successor" threat has not yet been established. However, it is clear that generic trends exist in global military technology that allow identification of the most prominent deficiencies and barriers to joint EW operations. Table IV.H-2 provides a top-level summary of capabilities, limitations, and key technologies to overcome current limitations and to provide those capabilities.

The threat of passively guided weapons has increased dramatically over the past decade. Today, infrared-guided weapons pose a serious and growing threat to U.S. forces and platforms in the air, on land, and at sea. Inexpensive, portable missiles can be launched with ease and effectiveness against all airborne combatants. The threat of longer range infrared guided antiship missiles is equally great, and formidable in both at-sea and littoral scenarios. Land combat vehicles are similarly threatened by frontal and top-attack munitions guided by infrared and multispectral seekers. *Protection against infrared guided weapons is the highest priority need in electronic attack* and is an important deficiency that constrains the efficient execution of joint operations.

The technology barriers to resolutions of these EA deficiencies include inadequate detection range and angular resolution on attack warning systems to eject decoys or initiate jamming; insufficient power, low efficiency, and unacceptable size, weight, and cost of laser devices that could be used in countermeasure systems; and insufficient output power and excessive size, weight, and cost of high-power microwave systems for self-protection of platforms. Of particular concern in the high-power microwave arena is the integration of this weapons-level EC effect into operational concepts of Joint Forces—so as to avoid/mitigate the possible, self-inflicted, mission-degrading effects of electronics fratricide and platform "suicide." Each of these barriers is being addressed with ongoing technology demonstration programs.

As a second area of high EA priority, the rapid development and adoption of new communications technology has created deficiencies in the ability of U.S. forces to exploit and selectively disrupt modern signals. Cellular and personal communications systems used by civilians and hostile forces, and high-capacity digital, multichannel networks associated with distributed information systems, pose particularly difficult technical challenges. The ability to detect, analyze, exploit, and disrupt these signals is fundamental to the conduct of joint operations against an opponent with modern communications equipment and sensors. In the context of EA, jamming transmitters and antennas used against C³ signals require improvements in precise modulation selection and modulator control, linearity, efficiency, output power, and directivity.

Electronic protection measures are generally specific to a sensor or C³ system. EP measures entail the tailoring of generic protection technology and techniques (again, as treated in the respective DTAP sections) to satisfy the electronic protection requirements of a specific system in order to ameliorate the effects of hostile jamming, deception, targeting, or directed-energy attack. Although included as an element of EC, these efforts are an integral part of the sensor or C³ development program (e.g., GPS). As stated previously and noted at the end of Table IV.H-2, further EP details are omitted from this section.

Table IV.H-2. Goals, Limitations, and Technologies—Electronic Combat

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Attack—Platform Protection			
>99 percent combined probability of no hostile weapon launches, and/or weapon miss.	Attack Warning Real-time RF threat detection, ID, and geolocation Missile approach warning Modular, programmable EW receiver/processor Sensor/data fusion, electronic intelligence	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Incomplete/uncorrelated apriori database information Unpredictable emitter mode changes, and tracking thereof	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors High sensitivity, multiband IR detectors/sensors Directional apertures Digital and channelized receivers Low false alarm, high sensitivity missile warning, with accurate "time to go" Real-time techniques for correlation/fusion of all-source information/data
	Expendable/Decoy Countermeasures Decoy terminal threat weapons UAV employment Robust, multispectral EA of simultaneous threats	Slow, inaccurate, and ambiguous threat ID and bearing resolution Unmatched/incoherent spectral content and output profile/signatures Tight packaging constraints High cost of integrating multispectral capability(s) Inaccurate ejection timing, leading to rapid stores depletion Unacceptably high false alarm rate	Advanced signal ID and detection algorithms High sensitivity, multiband detectors Digital and channelized receivers Low false alarm, high sensitivity missile warning, with accurate "time to go" Enhanced IR flare materials Kinematic/aerodynamic techniques Digital RF memories (DRFMs) VHSIC/application specific ICs (ASICs) MMIC/microwave power module (MPM) amplifier technologies Cooperative DIRCM/laser-based IRCM EA techniques Signature modification/control and location masking techniques (e.g., chaff, smoke, aerosols)

Table IV.H-2. Goals, Limitations, and Technologies—Electronic Combat (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Attack—Platform Protection (continued)			
	<i>Coherent Jamming</i> Robust, multispectral EA of simultaneous threats Broadband, coherent, surgical RFCM Second-generation directed IRCM (DIRCM) Laser-based IRCM Counter IADS surveillance, acquisition, and C ²	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Unpredictable emitter mode changes, and tracking thereof Unmatched/incoherent spectral content and output profile/signatures Tight packaging constraints High cost of integrating multispectral capability(s) High retrofit costs Nonintegrated approach to EA of multispectral/multimode threats	Advanced signal ID and detection algorithms High sensitivity, multiband detectors Directional apertures Digital and channelized receivers Digital RF memories (DRFMs) VHSIC/application specific ICs (ASICs) MMIC/microwave power module (MPM) amplifier technologies Cooperative DIRCM/laser-based IRCM EA techniques Signature modification/control and location masking techniques (e.g., chaff, smoke, aerosols) Affordable, compact laser (minimum 2W/20kHz, mid IR) Coherent, doppler, monopulse, and false target CM techniques
Operational Capability Element: Electronic Attack—C²W and SEAD			
Exploit, disrupt, deceive modern integrated defense system/network.	<i>Complex C² Signal Identification</i> Real-time RF threat detection, ID, and geolocation Modular, programmable EW receiver/processor Sensor/data fusion, electronic intelligence UAV employment	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Unpredictable emitter mode changes, and tracking thereof Tight packaging constraints High retrofit costs Insufficient low-noise signal intercept and decoding techniques Inability to track/jam in real time	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors Directional apertures Digital and channelized receivers Real-time techniques for correlation/fusion of all-source information/data VHSIC/application specific ICs (ASICs) Negative signal-to-noise (SNR) signal and code ID/tracking algorithms Parallel signal channel tracking and algorithm techniques Near-real-time code breaking techniques

Table IV.H-2. Goals, Limitations, and Technologies—Electronic Combat (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Attack—C²W and SEAD (continued)			
	<i>Nonfratricidal C² Jamming</i> UAV employment Broadband, coherent, surgical RFCM Counter IADS surveillance, acquisition, and C ²	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Unpredictable emitter mode changes, and tracking thereof Tight packaging constraints High retrofit costs Inability to track/jam in real time Nonlinear power amplification Imprecise coding/signal demodulation Poor beam/radiation control	Distributed/parallel COTS multiprocessors Digital and channelized receivers Digital RF memories (DRFMs) VHSIC/application specific ICs (ASICs) Negative signal-to-noise (SNR) signal and code ID/tracking algorithms Near-real-time code breaking techniques High efficiency, linear, solid-state amplifiers (HF, VHF, UHF) C ² frequency MPMs Efficient HF, VHF, UHF antenna designs (e.g., high temperature superconductivity, arrays)
	<i>Lethal SEAD</i> Real-time RF threat detection, ID, and geolocation Modular, programmable EW receiver/processor Sensor/data fusion, electronic intelligence Decoy terminal threat weapons UAV employment Robust, multispectral EA of simultaneous threats Broadband, coherent, surgical RFCM Counter IADS surveillance, acquisition, and C ²	Slow, inaccurate, and ambiguous threat ID and bearing resolution Simultaneous, overlapping signals Incomplete/unrelated a priori database information Unpredictable emitter mode changes, and tracking thereof Unmatched/incoherent spectral content and output profile/signatures Tight packaging constraints High cost of integrating multispectral capability(s) Affordability of UAV decoys Affordable, compact RF support jamming (stand-off/stand-in techniques)	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors Directional apertures Digital and channelized receivers Digital RF memories (DRFMs) VHSIC/application specific ICs (ASICs) MMIC/microwave power module (MPM) amplifier technologies Frequency/bandwidth aperture function control techniques (EA vs. ES) Large-extent phased arrays

Table IV.H-2. Goals, Limitations, and Technologies—Electronic Combat (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Support			
> 99 percent probability of signal intercept, detection, ID, and location across EM spectrum, mission, and battlespace.	<i>High Fidelity Signal Recognition and Tracking</i> Real-time RF threat detection, ID, and geolocation Missile approach warning* Modular, programmable EW receiver/processor	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Incomplete/uncorrelated apriori database information Unpredictable emitter mode changes, and tracking thereof High retrofit costs Insufficient low-noise signal intercept and decoding techniques Insufficient processing time and "power" Little interoperability between operational/service systems	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors High sensitivity, multiband detectors Directional apertures Digital and channelized receivers Low false alarm, high sensitivity missile warning, with accurate "time to go" Real-time techniques for correlation/fusion of all-source information/data VHSIC/application specific ICs (ASICs) Negative signal-to-noise (SNR) signal and code ID/tracking algorithms Parallel signal channel tracking and algorithm techniques Near-real-time code breaking techniques Sub 1° DF aperture/beamforming systems Rapid (e.g., GHz), high fidelity (e.g., 10-14 bit) analog-to-digital conversion (ADC) hardware/processing Software-reconfigurable/"open" architectures
	<i>All-Source Data Integration/Fusion</i> Sensor/data fusion, electronic intelligence	Slow, inaccurate, and ambiguous threat ID and bearing resolution Limited probability of intercept in dense, high signal, high clutter environment Simultaneous, overlapping signals Incomplete/uncorrelated apriori database information Unpredictable emitter mode changes, and tracking thereof Imprecise coding/signal demodulation Insufficient processing time and "power" Inability to deal with missing, incomplete, and corrupted data	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors Directional apertures Digital and channelized receivers Real-time techniques for correlation/fusion of all-source information/data Software-reconfigurable/"open" architectures Expert systems and algorithms (knowledge-based information representation and computer "reasoning" techniques that allow manipulation of sensor, text, and archival/library data in one process)

* In mission/platform context of MWS contributions to battlespace awareness/situation assessment

Table IV.H-2. Goals, Limitations, and Technologies—Electronic Combat (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Support (continued)			
	<i>Hostile Battlespace Signal Intercept/Collection</i> UAV employment Counter IADS surveillance, acquisition, and C ²	Vulnerability of conventional manned platforms	Advanced signal ID and detection algorithms Distributed/parallel COTS multiprocessors Digital and channelized receivers Real-time techniques for correlation/fusion of all-source information/data VHSIC/application specific ICs (ASICs) Near-real-time code breaking techniques Rapid (e.g., GHz), high fidelity (e.g., 10–14 bit) analog-to-digital conversion (ADC) hardware/processing Software-reconfigurable/"open" architectures UAV payloads Wideband datalink
Operational Capability Element: Electronic Protection			
Not considered in this document			

Electronic support is the activity that gathers timely information on hostile force composition, status, and intentions by intercepting and analyzing the signals from hostile electronic systems and integrating this information with that from our own forces and electronic systems—whether at the joint command, at-sea battlegroup, or single-seat cockpit/battlefield soldier level. The composition and characteristics of C³ systems are changing rapidly as low-cost, high-performance digital technology becomes universally available. The proliferation of this technology has also encouraged the widespread availability of cellular and personal communications devices that are highly mobile and resistant to conventional electronic attacks. Optical fiber networks, coupled with increasingly more powerful computers, constitute the basis for powerful information systems that support sophisticated military C³ functions as easily as civilian applications. These advances in processing and communications technology facilitate and encourage the acquisition of customized, unique C³ systems in the military forces of many small countries. This diversity and unpredictability constitutes a formidable challenge to ES organizations that must support operational users with services and products in any conceivable location and situation.

As advanced knowledge of threat system parameters—necessary for attack warning and countermeasure waveform development—becomes more difficult to obtain, EW receivers on tactical aircraft, ships, and land combatants will have to assume some of the burden formerly assigned to dedicated special signal collection receivers (i.e., the "blurring" regarding ES as discussed in Subsection 2, above). This will be necessary to accumulate detailed information on classes of emitters, as well as individual emitters, and to support the development of generic system recognition algorithms.

The ability to fuse different forms of information from multiple sources is an important capability in an environment of mixed-media signals. Algorithms that can analyze and consolidate information from different sensors and databases can produce a product that is more complete and informative than the sequential examination of the individual contributions. Algorithms using expert system techniques and artificial intelligence principles can represent and manipulate knowledge faster and more exhaustively than is possible with human analysts in time-critical situations.

The technology deficiencies in electronic combat include incomplete development of technologies suitable for unmanned aerial vehicles (UAVs) for signal collection/ES missions (and linkages/extrapolations of this technology to broadband RF support EA countermeasures from UAV platforms); inadequate processing subsystems and algorithms for detection, identification, and analysis of new communications waveforms; unacceptable performance in signal collection against mixed-media networks containing fiber optic and other transmission media; and inadequate performance and excessive cost to acquire and maintain warning and signal collection capabilities in tactical EW receivers. Finally, current capabilities in the representation of data, automated sensor product analyses, and machine reasoning capabilities are insufficient to perform timely and complete sensor product and data fusion.

Figure IV.H-2 illustrates how technology developments support technical demonstrations that contribute to operational capability elements in Electronic Combat. Table IV.H-3 lists planned DTOs for EC, the details of which can be found in the DTO volume for the JWSTP and the DTAP. Table IV.H-4 correlates the technical demonstrations with the operational capability elements they support.

5. Technology Plan

As emphasized above, a critical, coordinated tri-service plan to address vulnerability to IR missiles and weapons has been developed under Defense Reliance and is being executed. The program includes near to mid term measures to reduce vulnerabilities by using improved missile warning capabilities and advanced flares. Coupled with laser source work under the DTAP (DARPA and WE.43.08), conventional laser-based infrared countermeasures (IRCM) solutions are in progress—notably the current work under DTOs H.02 (for rotary-wing aircraft) and H.05 (for large aircraft). Additionally, an ATD is scheduled to conclude this fiscal year that will establish baseline data on future open-loop, laser-based IRCM architectures for planned Reliance collaboration in the tactical aircraft arena (TACAIR DIRCM). With regard to surface ship combatants, 1996 plans to pursue a laser-based IRCM ACTD for the large-ship class have been superseded by the inclusion of the technology (from its successful 1994-95 ATD) into 6.4 development work in conjunction with the Advanced Integrated EW System (AIEWS).

Capabilities to attack hostile command and control (C^2) networks will vastly improve with the development of transmitters with more efficient power amplification; modern, digital, EA modulation formats; and greater angular precision. These enhancements will effectively increase jamming power on victim systems and reduce interference with U.S. and allied systems in the vicinity. A coordinated tri-service effort will develop signal separation, recognition, analysis, and countermeasure techniques against specific waveforms used in C^2 applications. These ES capabilities will be consolidated with the jamming improvements developed as an electronic attack measure to produce an improved ability to selectively disrupt hostile communications and weapon control networks.

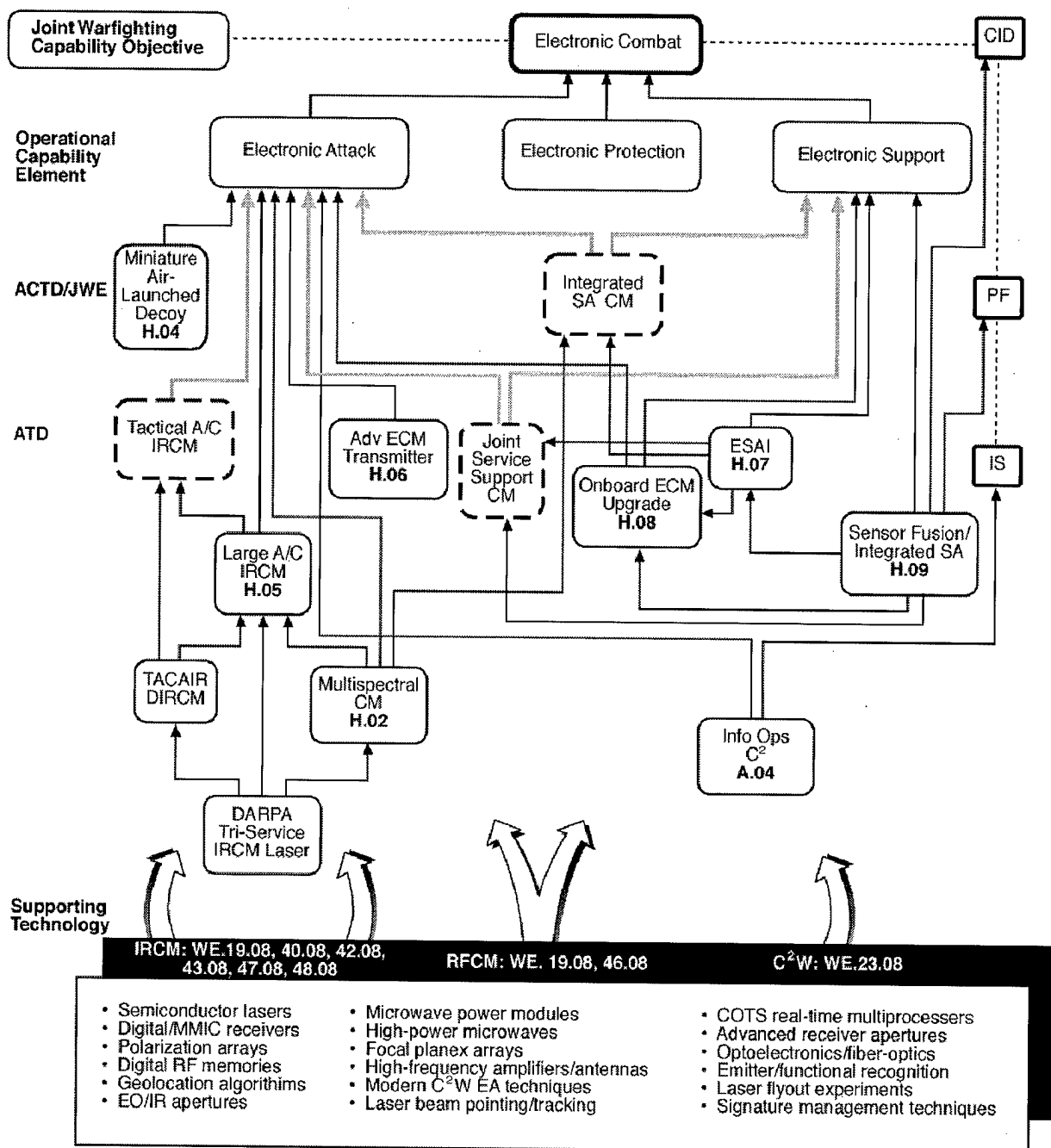


Figure IV.H-2. Technology to Capability—Electronic Combat

Table IV.H-3. Defense Technology Objectives—Electronic Combat

DTO No.	Title
H.02	Multispectral Countermeasures ATD
H.04	Miniature Air-Launched Decoy ACTD
H.05	Large Aircraft Infrared Countermeasures (IRCM) ATD
H.06	Advanced Electronic Countermeasures Transmitter ATD
H.07	Enhanced Situation Awareness Insertion ATD
H.08	Onboard Electronic Countermeasures Upgrade ATD
H.09	Sensor Fusion/Integrated Situation Assessment Technology Demonstrations
A.04	Information Operations C ²
WE.03.08 (past)	Combat Aircraft IRCM (TACAIR DIRCM ATD portion thereof)
WE.09.08 (past)	DARPA/Tri-Service IRCM Laser Technology
WE.19.08	High-Power Microwave Aircraft Self-Protect Missile Countermeasures
WE.23.08	Modern Network Command and Control Warfare Technology
WE.40.08	Infrared Decoy Technology
WE.42.08	Laser Aircraft Self-Protect Missile Countermeasures
WE.43.08	Advanced Multiband Infrared Countermeasures Laser Source Solution Technology
WE.46.08	Coherent Radio Frequency Countermeasures Technology
WE.47.08	Imaging Infrared Seeker Countermeasures Technology
WE.48.08	Missile Warning Sensor Technology

Similarly, a coordinated development is under way to design and integrate critical digital receiver/processor technologies to yield next-generation EW receivers and receiver upgrades. These receivers will be capable of performing warning, signal parameter collection, and situation assessment; and assisting the functions of threat geolocation and combat ID. Associated architectures will integrate the advantages of broadband, channelized monolithic receivers “on a chip” with commercial, real-time, parallel digital signal processors to yield an affordable, adaptable, software-reconfigurable capability. A concurrent affordability thrust is planned by the Navy in FY97–98 to “productize” the 6.2-developed monolithic microwave integrated circuit (MMIC) receiver-channelizer, with firm expectations to achieve hundredfold reductions in cost, size, weight, and increased reliability. In conjunction with DARPA/AF work on advanced digital receiver components/interconnects, these capabilities will serve to fill a number of future operational deficiencies that are now represented by more than a dozen individual systems.

The major push in the Suppression of Enemy Air Defense (SEAD) area is the Miniature Air-Launched Decoy (MALD) ACTD Program (H.04). To augment the EW “triad” of the future (stand-off communications jamming, SEAD, and standoff radar jamming), a joint development effort is being planned to design and develop the next-generation support jammer. Key to the program is the adoption of a reconfigurable pod/UAV concept that will not depend on a dedicated airframe in the future. Synergies of the technologies involved will also have joint applications to affordable upgrades to jamming systems of all three services and their respective platforms (DTAP DTO WE.46.08, Coherent RF Countermeasures Technology, and H.06/H.08).

Table IV.H-4. Demonstration Support—Electronic Combat

Demonstration	Operational Capability Elements			Service/ Agency	Type of Demonstration		
	Electronic Attack	Electronic Protection	Electronic Support		DTO	ACTD	ATD
Multispectral Countermeasures	●	Not Addressed in This Joint Warfighting Science Technology Plan	○	Army	H.02		X
Miniature Air-Launched Decoy	●		○	DARPA, Air Force	H.04	X	
Large Aircraft Infrared Countermeasures	●		●	Air Force	H.05		X
Advanced Electronic Countermeasures Transmitter	●			Navy	H.06		X
Enhanced Situation Awareness Insertion			●	Air Force	H.07		X
Onboard Electronic Countermeasures Upgrade	●		○	Air Force	H.08		X
Sensor Fusion/Integrated Situation Assessment Technology Demonstrations	○		●	Army, Navy, Air Force	H.09		
TACAIR DIRCM	●		●	Navy	Part of Past DTO WE.03		X
DARPA/Tri-Service IRCM Laser Technology	●			DARPA, Army, Navy, Air Force	Past DTO WE.09		
Integrated SA CM	●		●	Army	(Planned)		
Joint Service Support CM	●		●	Army, Navy, Air Force	(Planned)		
Tactical Aircraft IRCM	●		○	Navy, Air Force	(Planned)		

● Strong Support

○ Moderate Support

Figure IV.H-3 is a roadmap for developing and demonstrating the technologies required to support the operational advances in Electronic Combat. This roadmap concentrates on the themes of IRCM (air, land, and sea platforms); offensive C² Warfare/Information Warfare; precision emitter location and battlespace SA; upgrades to our aging joint combatant platforms; and the valuable “force multiplier” aspects of support jamming.

6. Summary

Figure IV.H-4 shows how this investment strategy will provide incremental improvements to Electronic Combat. This section on the Electronic Combat JWCO describes a well-balanced approach to achieve platform protection and electronic support to all joint combatants. The plan emphasizes solutions to the formidable, worldwide IR missile threats; multispectral situation awareness; countering the C² hierarchies of the hostile force while preserving real-time knowledge of the enemy; and countering the enemy early in the engagement process via the EC triad of C² Warfare, SEAD, and RF support jamming.

EC demonstrates vital support to the Chairman of the Joint Chiefs of Staff and his *Joint Vision 2010* concepts of Full-Dimensional Protection, Dominant Maneuver, and Precision Engagement. As an “enabler,” EC demonstrates several, critical important synergies with the Information Superiority, Combat Identification, and Precision Force JWCOs, *with an overall focus on assuring survivability to the joint warfighter.*

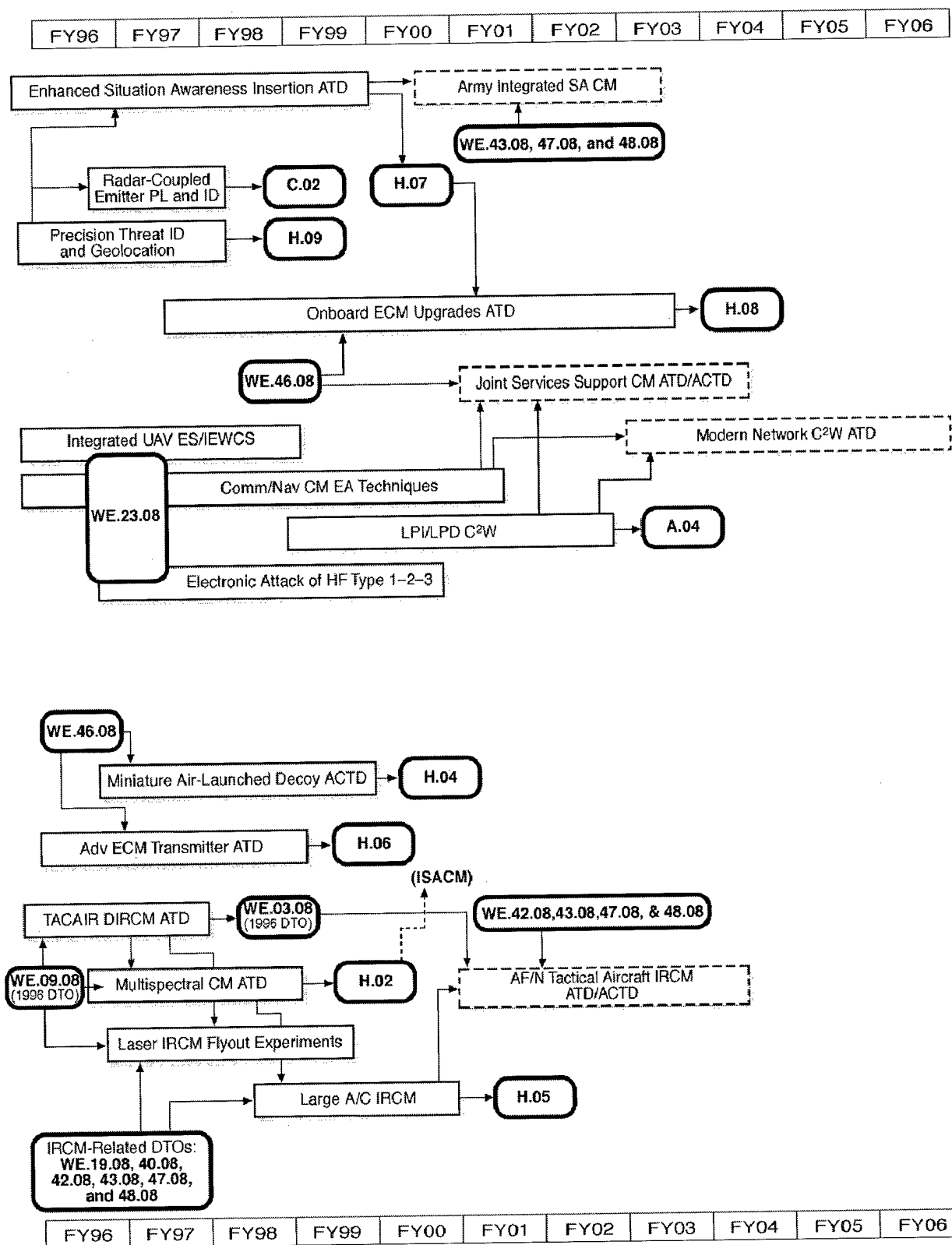


Figure IV.H-3. Roadmap—Electronic Combat

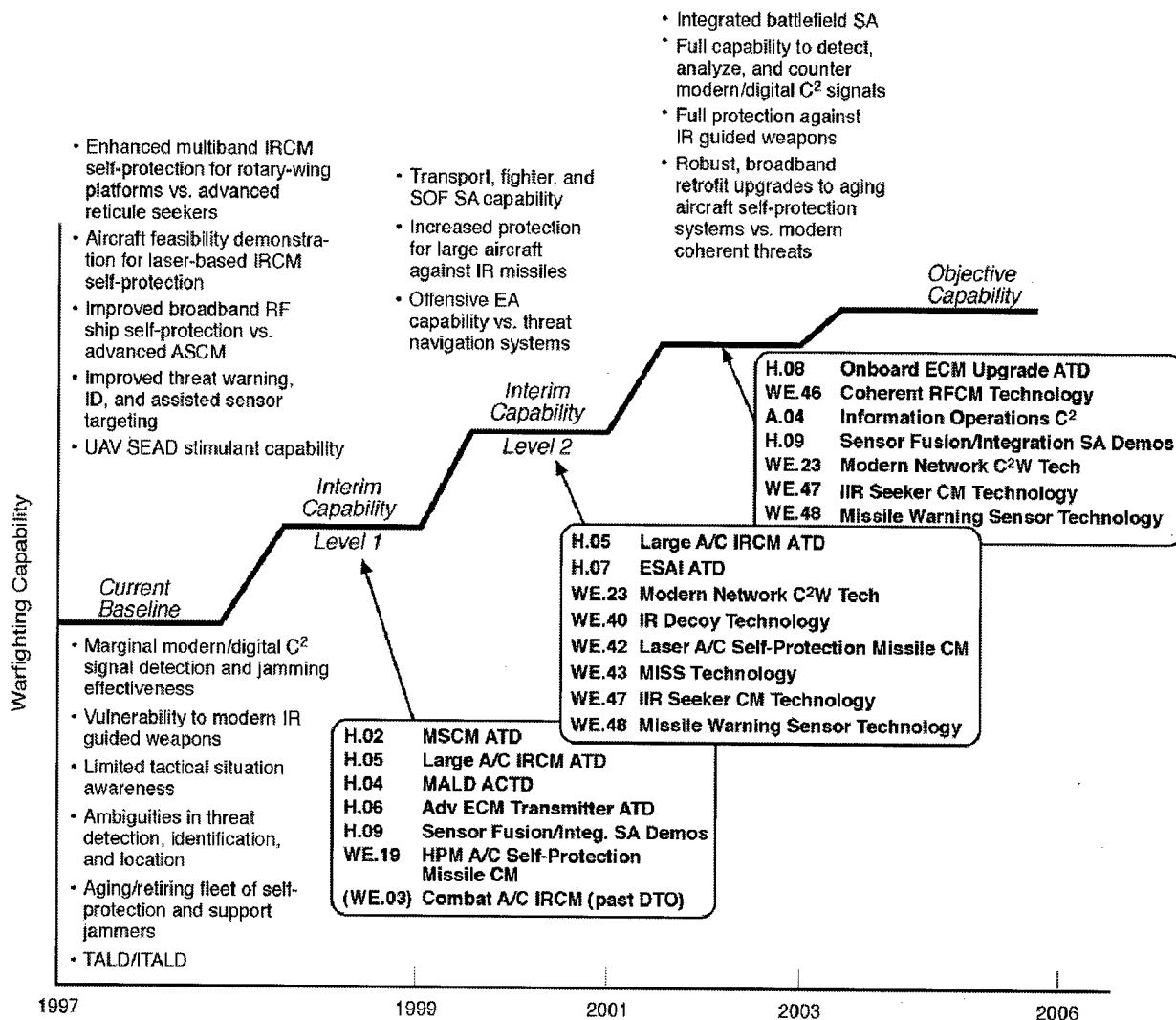


Figure IV.H-4. Progress—Electronic Combat

I. CHEMICAL/BIOLOGICAL WARFARE DEFENSE AND PROTECTION

1. Definition

The Chemical/Biological (CB) Warfare Defense and Protection area focuses on technologies to counter the threat of chemical and biological weapons, and to ensure the safety and mission effectiveness of U.S. forces operating in a contaminated environment with minimal impact on logistics. Contamination avoidance—to include the ability to detect, identify, characterize, and warn—is the highest priority of the DoD CB defense program. In addition to contamination avoidance, the program includes force protection (individual, collective, and medical) and decontamination.

2. Operational Capability Elements

The key operational capabilities in CB Warfare Defense and Protection are (1) contamination avoidance to include the ability to detect, identify, and warn of CB attacks, (2) force protection that encompasses individual, collective and medical protection, and (3) decontamination. Figure IV.I-1 illustrates how CB warfare defense and protection impacts all aspects of the battlefield, particularly in supporting the national 2 MRC global power projection strategy.

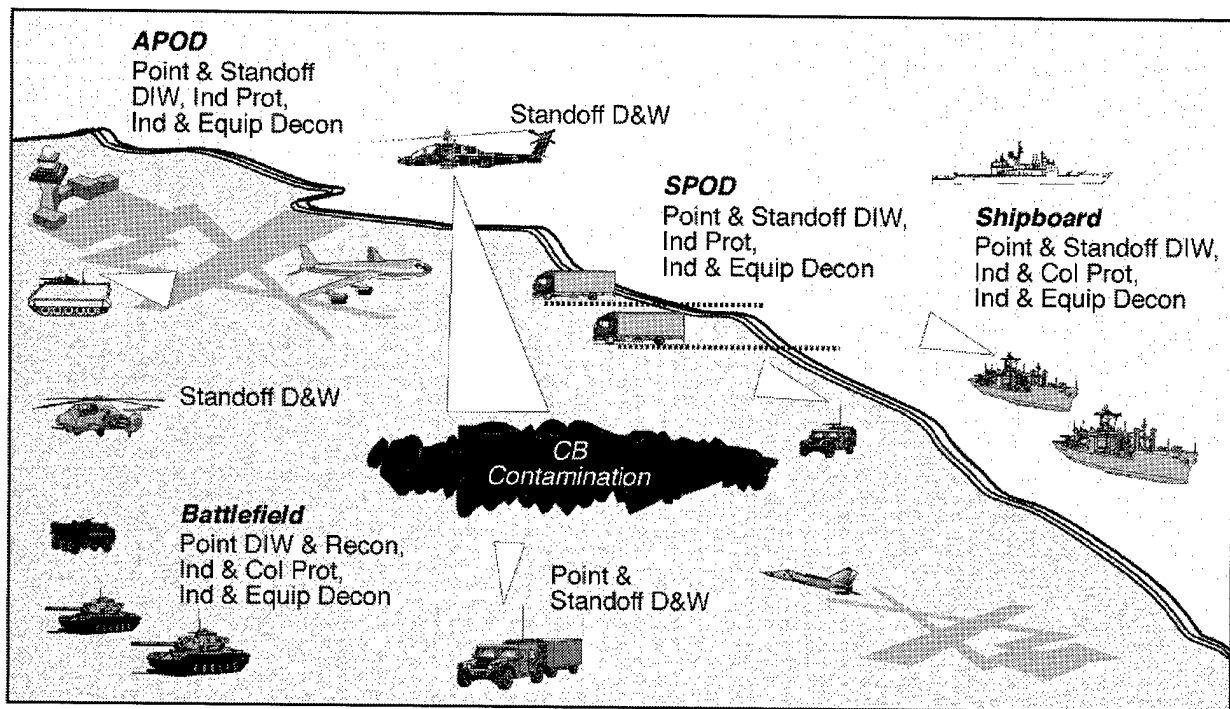


Figure IV.I-1. Concept—Chemical/Biological Warfare Defense and Protection

Operational capabilities for CB Warfare Defense and Protection are driven by the Defense Technology Objectives (DTOs) included in the *Joint Warfighting Science and Technology Plan* and *Defense Technology Area Plan*. Technologies supporting these objectives will be refined through ACTDs, ATDs, other technology demonstrations, and various technology thrusts.

Contamination Avoidance. Technologies for the detection, identification, characterization, and warning of an attack are the cornerstone of defense against CB warfare. The key operational capabilities, as listed across the top of Figure IV.I-2, are:

- Early warning of a chemical/biological attack
- Point detection (or local warning) of a chemical/biological attack
- Warning and reporting of chemical and biological attacks.

Early Warning. Early warning of CB agents is key to the effective avoidance and protection against contamination. Early warning of a CB attack is a high JCS/CINC/JROC counterproliferation priority. Early warning, which complements local point detection, is intended primarily as a means of detecting and tracking chemical and biological agent clouds and providing information to commanders downwind that an attack has begun that involves agent released from a CB weapon. Intelligence capabilities provide information of an enemy's chemical or biological warfare capabilities (e.g., the size and nature of an enemy's stockpile). In contrast, early warning provides information as early during an attack as possible (from tens of seconds to tens of minutes before units are exposed to CB agent) so that commanders have increased options for operational responses, including which protective posture to assume. Early warning may be implemented through standoff detection using a variety of laser and passive optical detector technologies at ranges up to 100 km from the contamination, through point detectors deployed on remotely controlled platforms (e.g., unmanned aerial vehicles (UAVs)), or through the forward placement of point detectors (e.g., airdrops, Special Operations Forces (SOF) emplacement). Technology is being developed to accomplish this under DTSE.09.02, Multifunction Laser. While a single technology (or technology suite) with combined multiagent chemical and biological detection is a goal of these efforts, such a solution is not planned for transition out of tech base during the Future Years Defense Plan (FYDP). Current technology thrusts for early warning focus on separate systems for chemical and biological detection.

The most likely near-term approach will continue to rely on complementary detection technologies. For biological agents, current and near-term technologies seek to identify the presence of higher than normal concentrations of aerosols or particulate matter in the atmosphere. If these substances are present, data are examined to determine whether the aerosol/particulate formation is natural or man-made. Simultaneously, other sensors will seek to detect whether the aerosol or particulate contains biological material. If the material is biological, other sensors (e.g., a biological point identification system mounted on a UAV) may be deployed into the aerosol cloud to determine whether the material is a biological warfare agent. As technologies mature, new systems will be able to detect, identify, and characterize an increasing number of toxic agents, more reliably, and from greater distances. Technical barriers associated with developing these technologies include overcoming attenuation of laser energy by atmospheric absorbents and providing algorithms to discriminate between natural atmospheric species and biological agents.

One of the key early warning defense technology objectives—standoff and remote biological warfare agent detection—recently has been transferred out of tech base and is being funded jointly by the Joint Program Office for Biological Defense (JPO-BD) and the Counterproliferation Support Program. This program seeks to provide maneuver forces, other forces at airbases and sea-ports, and (possibly) civilians in population centers with timely warnings of biological agents. Technologies being evaluated in an ACTD include standoff detectors and sensors mounted on UAVs.

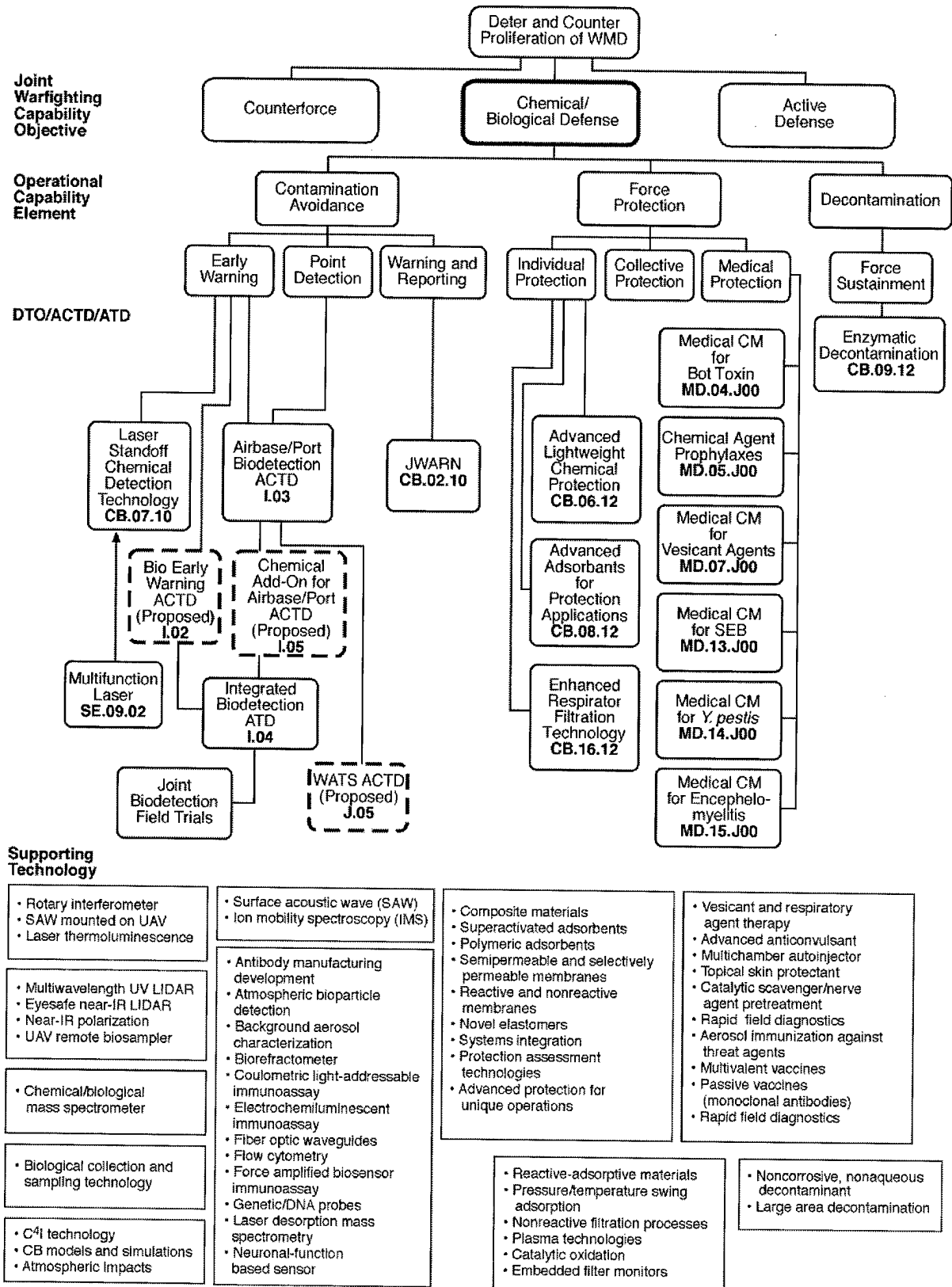


Figure IV.I-2. Technology to Capability—Chemical/Biological Warfare Defense and Protection

Point Detection. The overall goal of point detection (also referred to as local warning) is to develop point sensor technologies that can rapidly detect the presence of biological warfare agents, accurately identify biological warfare agents, and enhance the sensitivity, selectivity, reliability, and reduced size of warfare agent detectors. The program is divided into two parts—biological and chemical. Technologies under consideration in the near- and mid-term future cannot address both of these threats using the same technology. However, there are efforts to develop a single suite of sensors to detect all potential CB threats. Chemical and biological detectors will be incorporated as separate modules and could be upgraded as newer technologies emerge. Understanding atmospheric propagation effects is important to this function. These technologies are included under DTOs SE.52.01, Weather/Atmospheric Impacts on Sensor Systems and SE.53.01, On-Scene Weather Sensing and Prediction Capability.

Point detection improves visualization of CB hazards in a local environment through the exploitation of emerging technologies such as immunoassays, deoxyribonucleic acid/gene probes, various forms of spectroscopy, and other physical/chemical characterization technologies. The problems associated with this effort include (1) the development of sensor technology with sufficient sensitivity and discrimination that can detect, identify, and quantify the presence of biological and chemical hazards without false alarm and (2) the integration/development of C³I technology to permit rapid, automatic collection, collation, dissemination, and display of CB hazard information to various command levels. Heretofore, the primary S&T focus has been in sensor development. However, it is becoming increasingly evident that new technologies are required to integrate sensor information with other battlefield situation awareness information (geographical, meteorological) in order to properly design the software and hardware for the digital battlefield of the future.

The strategy for the biological detection technology effort is to develop a suite of complementary technologies to ensure that a capability in biological detection is achieved. Several technologies are currently being pursued in the Integrated Biodetection Advanced Technology Demonstration initiated in FY96. In addition, the JPO-BD sponsors a yearly field trial and evaluation of emerging technologies. The evaluation will provide recommendations to advance the development of relevant technologies, return immature technologies to the laboratory for additional development, or terminate the development of inadequate technologies.

The strategy for chemical detection is similar to that for biological detection. Currently there are two technologies being considered for a small system capable of individual warrior issue: ion mobility spectroscopy (IMS) and surface acoustic wave (SAW) devices. These are in a more mature state of development than biological detection technologies. In addition, mass spectrometry is being examined for its applicability to both the chemical and biological detection problem. An evaluation of the state of development of IMS and SAW technologies will conclude in early FY97 and will lead to selection of the most promising technology to pursue for the Joint Chemical Agent Detector (JCAD) to start demonstration/validation in late FY97 and engineering and manufacturing development in FY99.

Warning and Reporting. Warning and reporting is the critical link between CB detection and CB protection. The goal of this effort is to provide sufficient, timely information to commanders at all levels through early and direct warning capabilities so they may develop options on how to conduct their mission and decide the appropriate protective posture to assume. Warning and reporting is a critical issue in contamination avoidance. The services have agreed to expedite development of this issue by integrating ongoing hardware and software into a Joint Warning and Reporting

Network (JWARN) to be fielded in FY99. Technologies will be developed to provide increased management and control functions, as well as to integrate features of the emerging Global Command Control System (GCCS). The long-term goal of JWARN is to increase warning time by eliminating manual and voice transmission of data and replacing it with digital transmission, and providing significantly improved modeling and simulation capabilities to identify and predict the location and nature of CB hazards on the battlefield and to serve as a commander's decision aide.

Force Protection. The key operational capabilities, as listed across the top of Figure IV.I-2, are Individual Protection, Collective Protection, and Medical Protection.

Individual Protection. The goals of individual protection technology efforts are to (1) improve protection against current threats and add protection against future threats, (2) minimize mission degradation by reducing the impact of the use of individual protection on the soldiers performance, and (3) reduce logistics burden. The key components of individual protection are ocular/respiratory protection and percutaneous protection. Both components support general warfighter requirements such as the Army's Land Warrior Program, as well as specialized applications for the Navy and Air Force. Advanced filtration technologies to reduce breathing resistance and selectively agent-impermeable membranes to increase uniform comfort will reduce individual performance degradation. Because of the high interest in providing protection against biological agents for both U.S. forces and their supporting civilian infrastructure in global force projection, initiatives will examine the feasibility of using lightweight, disposable biological masks against such hazards.

Collective Protection. The collective protection technology base efforts seek to maintain protection against current threats and add protection against future threats. At the same time, collective protection technology efforts seek to reduce logistical burdens through the development of improved filter materials with longer useable lifetimes. Collective protection efforts focus on (1) improvements to current reactive-adsorptive materials, (2) advanced nonreactive filtration processes, (3) advanced reactive filtration, (4) regenerable filtration processes for NBC protection of military vehicles, aircraft, ships, shelters, and buildings, and (5) reduced logistics burden.

Medical Protection. Medical protection consists of three primary functions: (1) pre-exposure preventative measures, (2) post-exposure treatment, and (3) diagnostic capabilities. These functions are applied to defense against chemical and biological threats. Technology efforts will provide a number of medical products for preventing illness or personnel degradation when percutaneous or aerosol CB agents are used on the battlefield. For personnel exposed to these agents, a number of initiatives will seek to ameliorate or preclude the effects of inhaled or percutaneous chemical agents or provide relief from the symptoms of biological agents. Current technologies only provide partial protection against a number of percutaneous or inhaled chemical agents, and only a limited number of vaccines are available against biological agents. Some specific treatments are available for exposure to a limited number of biological agents. Before effective treatment can be applied, the causative chemical or biological agent must be identified, at least by type.

Decontamination. Decontamination is defined as the process of removing or neutralizing a surface hazard resulting from a chemical or biological agent attack. The objective of decontamination technology efforts is to develop methods that are effective, are environmentally safe, react with chemical agents or disinfect biological agents, and do not impact the operational effectiveness of the surface or equipment being decontaminated. Current decontamination materials are caustic and rely heavily on water. Moreover, current methods for decontamination cannot be used to

decontaminate large, critical areas, such as seaports or airports, the interiors of sea or air transport vehicles, or sensitive equipment, such as electronics and avionics. Critical studies are needed to define the decontamination technology issues that must be addressed as part of the national global force projection and our ability to simultaneously deploy in two potentially contaminated MRCs.

3. Functional Capabilities

Table IV.I-1 shows the functional capabilities required to produce the operational capabilities composing chemical/biological defense and protection. Specific technology programs are listed under each functional capability.

4. Current Capabilities, Deficiencies, and Barriers

Table IV.I-2 presents the key technologies being pursued to overcome current operational limitations in the functional capabilities that compose CB Defense.

For *early warning*, the technological issues are (1) discrimination of biological warfare agents from each other and from naturally occurring biological materials in the atmosphere; (2) size, weight, and power requirements of chemical and biological detection systems (meeting these constraints may require tradeoffs in range and sensitivity); (3) aerosol background (naturally occurring biological materials such as pollen may cause high false alarm rates for biodetection systems); (4) man/machine interface; (5) sensor integration on various platforms (e.g., UAVs); (6) on-the-move standoff detection of chemical and biological agents; and (7) sensitivity of standoff detection systems.

For *point detection*, the technological issues are (1) development of real-time detection of biological materials (current capabilities require 15 or more minutes to detect biological agents and longer to identify agents); (2) unique identification of biological materials (current efforts are focused on generic detection of aerosols and particulates and identification of a limited number of agents); (3) improved sampling and collection technologies for warfare agents; (4) small, light-weight chemical detector (current capabilities provide detection for units but are not useful for use by an individual); (5) decrease in false alarm rate; and (6) sampling and collection of suspect aerosols.

For *warning and reporting*, the technological issues are (1) digitization of battlefield sensor information; (2) automation of detection and warning processes; (3) collation and display of relevant information at various command levels; (4) integration of other sensor information such as geolocation, meteorology, etc.; and (5) integration of data into appropriate models for analysis and presentation.

For *individual protection*, the technological issues are (1) development of materials that reduce heat and other stress burdens on the soldier and are more selective in precluding transport of agents across the ensemble barrier but pass heat and perspiration; (2) provision of clear criteria for dexterity, tactility and mobility requirements; and (3) provision of masks that can be adapted to a number of specialized aircrew applications.

For *collective protection*, the technological issues are (1) development of longer lifetime filters/filter materials for collective protection shelters and (2) develop regenerative filter processes and materials.

**Table IV.I-1. Functional Capabilities Needed—
Chemical/Biological Warfare Defense and Protection**

Functional Capabilities	Operational Capability Elements						
	Contamination Avoidance			Force Protection			Decontamination
	Early Warning	Point Detection	Warning and Reporting	Individual Protection	Collective Protection	Medical Programs	Force Sustainment
<i>Chemical and Biological Detection Systems</i>							
1. Chemical Point Detection		●					
2. Biological Point Detection		●					
3. Chemical Early Warning	●						
4. Biological Early Warning	●						
5. Warning and Reporting			●	○			
<i>Modeling</i>							
6. CB Modeling	●	●	○				
<i>Nonmedical Protection</i>							
7. Advanced Filtration Technology				●	●		
8. Advanced Materials for Percutaneous Protection				●			
9. Systems Integration				●	●		
10. Protection Assessment Technologies				●			
11. Advanced Protection for Unique Operations				●	●		
<i>Decontamination</i>							
12. Enzymatic Decontamination							●
13. Sensitive Equipment Decontamination							●
14. Aircraft Interior Decontamination							●
<i>Medical Chemical Defense</i>							
15. Vesicant and Respiratory Agent Therapy						●	
16. Advanced Anticonvulsant						●	
17. Multichamber Autoinjector						●	
18. Topical Skin Protectant						●	
19. Catalytic Scavenger/Nerve Agent Pretreatment						●	
20. Rapid Field Diagnostics						●	
<i>Medical Biological Defense</i>							
21. Aerosol Immunization Against Threat Agents						●	
22. Multivalent Vaccines						●	
23. Passive Vaccines (Monoclonal Antibodies)						●	
24. Rapid Field Diagnostics						●	

● Strong Support

○ Moderate Support

**Table IV.I-2. Goals, Limitations, and Technologies—
Chemical/Biological Warfare Defense and Protection**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Chemical/Biological Detection			
Small, lightweight, rapid detection and characterization of all threat chemical agents	<i>Chemical and Biological Detection Systems</i> Chemical point detection	No mustard agent detector Detectors are not sufficiently miniaturized	Miniaturization technology IMS, SAW, and other technologies with agent concentrator
Rapid, all biological agent detection and characterization	Biological point detection	No portable systems Limited number of agents No rapid detection Inadequate sampling and collection system	Size, weight, power, reduction technology Near-real-time detection technology Nonagent specific toxic hazard identification (neuronal sensor)
Lightweight on-the-move detection (field-of-view 360° wide x 60° high). High-value site defense.	Chemical early warning	Vapor detection only No miniaturized system No unattended sensor	FTIR with moving background algorithm DISC/DIAL Coherent frequency agile laser technology Remotely employable technologies
Early warning of bio attack. Tracking of threat agent clouds.	Biological early warning	No eye-safe laser Aerosol could detection only No miniaturized systems No unattended sensors	Eye-safe laser technology Wideband tunable laser technology Remotely employable technologies
Fully integrated, interoperable, joint service, real-time warning, reporting, and mapping of all CB hazards	Warning and reporting	Manual Voice, radio, and paper reports Detection systems not integrated into GCCS	Radio relay automation NBC report preparation automation Computation mapping
Integrate transport and diffusion models for chemical, biological, and radiological hazards on a single platform	<i>Modeling</i> CB modeling	Not fully integrated in wargames	Gaussian puff model Computational fluid dynamics Rapid calculation of high fidelity model

**Table IV.I-2. Goals, Limitations, and Technologies—
Chemical/Biological Warfare Defense and Protection (continued)**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Individual Protection			
Protect force from CB contamination and ensure ability to sustain operations and accomplish mission in a CB contaminated environment	<i>Nonmedical Protection</i>		
	Advanced filtration technology Advanced materials for percutaneous protection Systems integration Protection assessment technologies Advanced protection for unique operations	Significant improvements in respiratory protection not likely in near future without a material (filter) breakthrough or using a powered system Ability to satisfy final performance goals may require multiple systems and/or power as in case of thermal degradation Full definition of the land warrior program is needed to satisfy future compatibility requirements Attempting to use one mask for all joint service missions may result in performance reductions for some missions Mission requirements for weight, protection, and launderability force tradeoffs; no single material fulfills all requirements currently Requirements for protection and tactility for gloves for tradeoffs Promising materials for percutaneous protection do not meet affordability requirements; unsuitable for mass production Inadequate capabilities for the unique operational aspects of the marine environment, such as fire-fighting/damage control, flight deck operations, and high-intensity SPECWARS operations	New concepts in respiratory protection: enhanced protection studies; material and composite technologies Protective system integration and analysis, quantify mission performance, performance testing, performance models for predicting current and future equipment Protective material and test technologies: improve test methodology for protection assessment; improve aerosol stability; investigate effects of different aerosol sizes on protection New/improved filtration systems: develop engineered adsorbent—superactivated adsorbents and polymeric adsorbents; new catalytic systems will be developed; improved particulate filtration technologies Selectively permeable materials for percutaneous protection Various reactive and nonreactive lightweight materials and membranes for protection against all identified C and B hazards
Operational Capability Element: Collective Protection			
Ensure ability to sustain operations and accomplish mission in a CB contaminated environment	Advanced filtration technology Systems integration Advanced protection for unique operations	Limited basic research funding to understand link between physical and adsorptive properties of various materials in order to predict and optimize filtration performance No adequate means to measure filter life in the field No clearly defined requirements for collective protection	Reactive-adsorptive materials Advanced nonreactive filtration processes Advanced reactive filtration processes for NBC protection of military vehicles, aircraft, ships, shelters, and buildings Regenerative filtration processes (pressure- and temperature-swing adsorption, PSA/TSA) Embedded monitors Plasma technologies Catalytic oxidation (CATOX)

**Table IV.I-2. Goals, Limitations, and Technologies—
Chemical/Biological Warfare Defense and Protection (continued)**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Medical Protection			
Maintain technological capability to meet present requirements and counter future threats. provide individual-level prevention and protection to preserve fighting strength. Provide medical management of chemical casualties to enhance survival and expedite and maximize return to duty.	<i>Medical Chemical Defense</i> Vesicant and respiratory agent therapy Advanced anticonvulsant Multichamber autoinjector Topical skin protectant Catalytic scavenger/nerve agent pretreatment Rapid field diagnostics	Need expansion of chemical/biological medical training program Advanced product development and FDA approval process for fielding of chemical products Current downsizing and monetary restrictions Integration of DoD/tri-service needs (better joint coordination and representation)	Vesicant and respiratory agent therapy Advanced anticonvulsant Multichamber autoinjector Reactive topical skin protectant Catalytic scavenger treatment for chemical agents Rapid field diagnostics
Sustain effectiveness of U.S. armed forces operating in a BW environment to (1) prevent casualties by use of medical countermeasures, (2) diagnose disease with forward deployable kits and confirmation assays, and (3) treat casualties to prevent lethality and to maximize return to duty	<i>Medical Biological Defense</i> Aerosol immunization against threat agents Multivalent vaccines Passive vaccines (monoclonal antibodies) Rapid field diagnostics	Need expansion of chemical/biological medical training program Current downsizing and monetary restrictions Integration of DoD/tri-service needs (better joint coordination and representation) Length of time for FDA approval of existing bio agent vaccines Rapid stockpiling of vaccines identified by threat priority	Aerosol immunization against biological threat agents Multivalent vaccine against biological threat agents Pretreatment against biological threat agents Rapid diagnosis kits
Operational Capability Element: Decontamination			
Ensure ability to sustain operations and accomplish mission in a CB contaminated environment	Enzymatic decontamination Sensitive equipment decontamination Aircraft interior decontamination	Current decontaminant (DS2) is effective in chemical decontamination, yet has a surface corrosive effect Limited assessments have been made to determine scope of problems associated with large area decontamination (LAD); consequently, there are no formal requirements for LAD Environmental and safety requirements limit choice of decontaminants Assessment of methods and technologies to decontaminate compartment interiors needed	Noncorrosive, nonaqueous decontaminant for field/equipment Environmentally safe decontamination of electronic and sensitive equipment Sorbent decontaminant Large area decontaminant dissemination techniques and technologies Surface Raman spectrometer to monitor decontaminant Quaternary ammonium complexes Enzymatic decontaminants

For *medical protection*, the technological issues are (1) development of vaccines against remaining threat list biological agents; (2) development of FDA-acceptable testing protocols for vaccines to determine vaccine efficacy; (3) development of improved topical skin decontamination material; and (4) development of prophylaxes against nerve agents and vesicants.

For *decontamination*, the technological issues are (1) development of a less corrosive, non-aqueous-based decontamination material; (2) development of technologies for dissemination of decontaminants over large surface areas such as seaports and airports; (3) provision of technologies for decontamination for sensitive closed areas (such as cargo holds or ship compartments) and sensitive equipment (such as electronics and avionics); and (4) development of reactive materials for self-decontamination.

5. Technology Plan

Technology demonstrations and joint field trials provide a means for the rapid field testing of technical options to solve operational needs. These demonstrations support the CB Warfare Defense and Protection Joint Warfighting Objectives (JWCO). Table IV.I-3 lists the Defense Technology Objectives (DTOs) that, when attained, will enable the operational capabilities to meet the objective of the JWCO. Table IV.I-4 illustrates how these demonstrations and supporting technologies are structured to support the JWCO. The demonstrations are cross referenced with the operational capabilities in Figure IV.I-3. Each DTO is described in the *Defense Technology Objectives of the Joint Warfighting Science and Technology and Defense Technology Area Plan*. Relationships among DTOs are plotted in the technology roadmap, Figure IV.I-3. Figure IV.I-4 provides a notional path for the contribution of each DTO toward the overall CB Warfare Defense and Protection goals of the JWCO.

**Table IV.I-3. Defense Technology Objectives—
Chemical/Biological Warfare Defense and Protection**

DTO No.	Title
I.02	Biological Early Warning ACTD (Proposed)
I.03	Airbase/Port Biological Detection ACTD
I.04	Integrated Biodetection ATD
I.05	Chemical Add-On for the Airbase/Port Biological Detection ACTD (Proposed)
CB.02.10	Joint Warning and Reporting Network
CB.06.12	Advanced Lightweight Chemical Protection
CB.07.10	Laser Standoff Chemical Detection Technology
CB.08.12	Advanced Adsorbents for Protection Applications
CB.09.12	Enzymatic Decontamination
CB.16.12	Enhanced Respirator Filtration Technology
J.05	Wide Area Tracking System ACTD (Proposed)
MD.04.J00	Medical Countermeasures for Botulinum Toxin
MD.05.J00	Chemical Agent Prophylaxes
MD.07.J00	Medical Countermeasures for Vesicant Agents
MD.13.J00	Medical Countermeasures for Staphylococcal Enterotoxin B
MD.14.J00	Medical Countermeasures for <i>Yersinia pestis</i>
MD.15.J00	Medical Countermeasures for Encephalomyelitis Viruses

Table IV.I-4. Demonstration Support—Chemical/Biological Warfare Defense and Protection

Demonstration	Operational Capability Elements							Service/ Agency	Type of Demonstration		
	Contamination Avoidance			Force Protection			Decontami- nation				
	Early Warning	Point Detection	Warning and Reporting	Individual Protection	Collective Protection	Medical Programs					
Biological Early Warning ACTD (Proposed)	●							D	I.02	(P)	
Airbase/Port Biological Detection ACTD		●	●	●		●	●	D	I.03	(P)	
Integrated Biodetection ATD	●	●						D	I.04		X
Chemical Add-On for the Airbase/Port Biological Detection ACTD (Proposed)		●						D	I.05	(P)	
Joint Warning and Reporting Network (JWARN)	●	●	●					D	CB.02.10		
Advanced Lightweight Chemical Protection				●				D	CB.06.12		
Laser Standoff Chemical Detection Technology	●							D	CB.07.10		
Advanced Adsorbents for Protection Applications				●	●			D	CB.08.12		
Enzymatic Decontamination							●	D	CB.09.12		
Enhanced Respirator Filtration Technology				●	○			D	CB.16.12		
Wide Area Tracking System (WATS) ACTD (Proposed)	●	●						D	J.05	(P)	
Medical Countermeasures for Botulinum Toxin						●		D	MD.04.J00		
Chemical Agent Prophylaxes						●		D	MD.05.J00		
Medical Countermeasures for Vesicant Agents						●		D	MD.07.J00		
Medical Countermeasures for Staphylococcal Enterotoxin B (SEB)						●		D	MD.13.J00		
Medical Countermeasures for <i>Yersinia pestis</i> (Plague)						●		D	MD.14.J00		
Medical Countermeasures for Encephalomyelitis Viruses						●		D	MD.15.J00		

● Strong Support

○ Moderate Support

D DoD/Joint Service

(P) Proposed

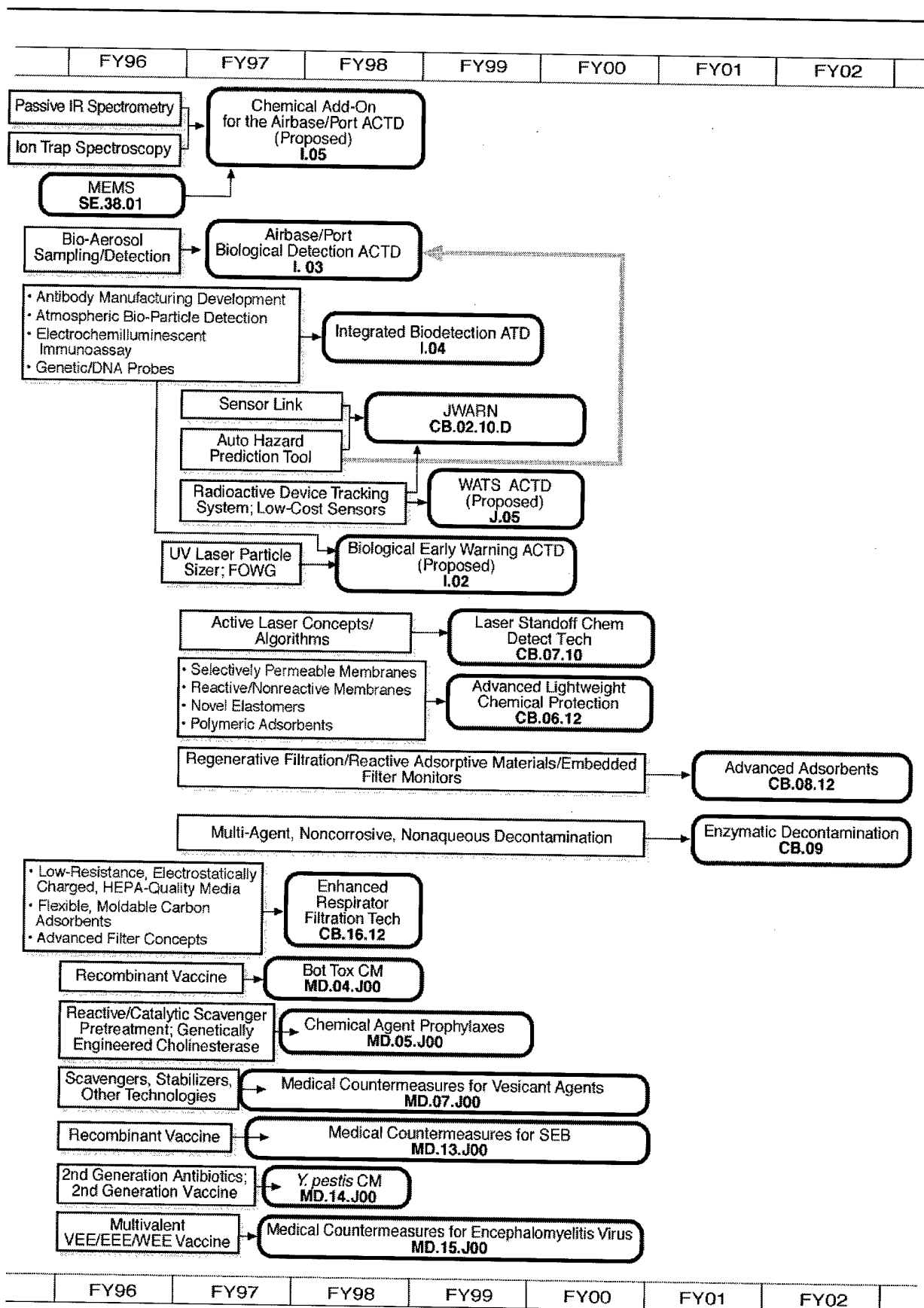


Figure IV.I-3. Roadmap—Chemical/Biological Warfare Defense and Protection

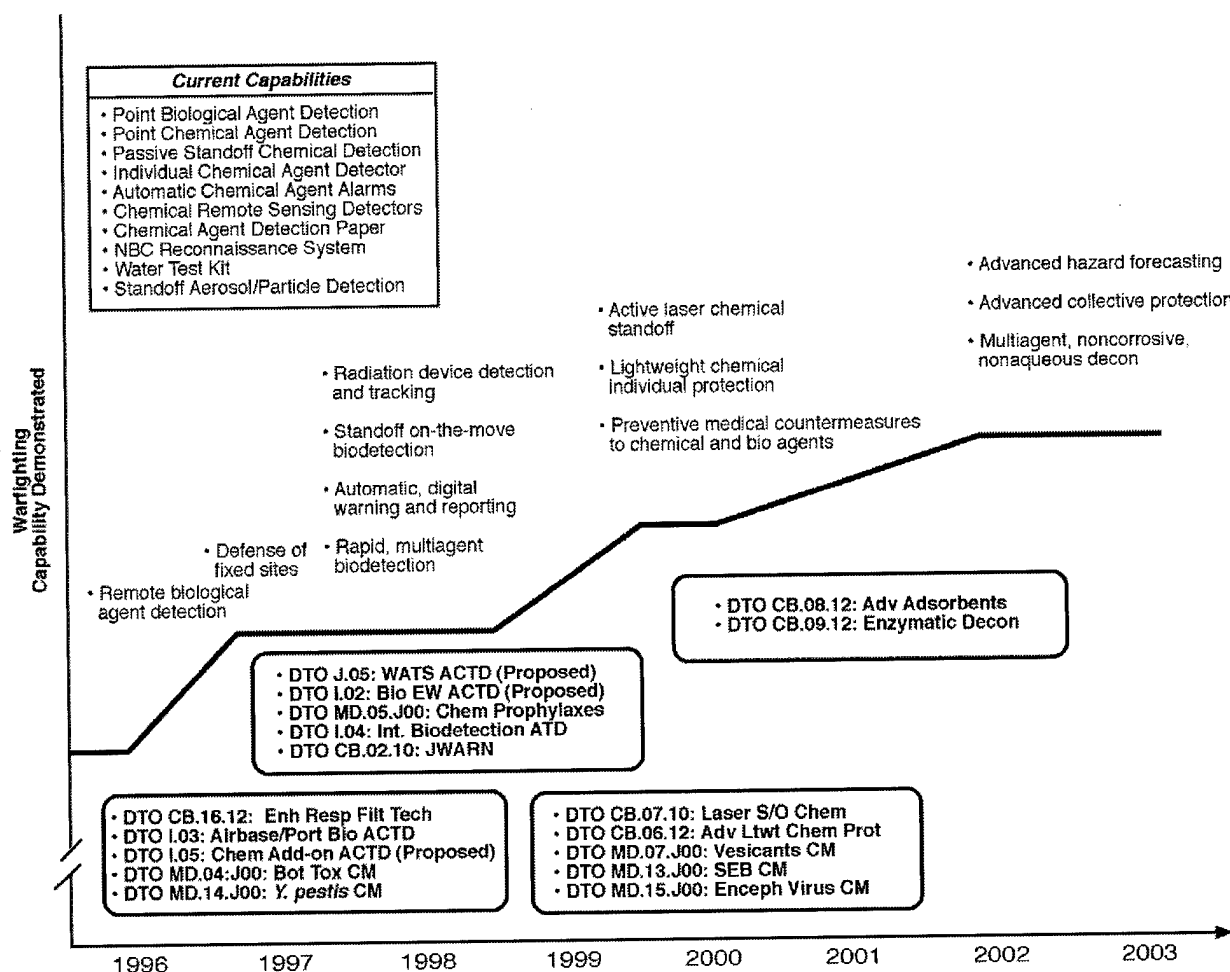


Figure IV.I-4. Progress—Chemical/Biological Warfare Defense and Protection

6. Summary

Science and technology efforts in CB warfare defense provide the basis for significant future advances in protecting U.S. forces from the CB threat and address the number 1 priority of the CINC/JROC Counterproliferation JWCO. Warning and reporting is key to detection efforts because it integrates detection systems into the digital battlefield and provides commanders with information to accurately visualize the battlefield and assess warfighting options. Achieving these objectives will ensure that the warfighter is equipped with state-of-the-art capabilities and will not face the same deficiencies encountered during Operation Desert Storm.

J. COUNTER WEAPONS OF MASS DESTRUCTION

1. Definition

Weapons of mass destruction—nuclear, biological, and chemical—along with their associated delivery systems, pose a major threat to our security and that of our allies and other friendly states. Thus a key part of our strategy is to seek to stem the proliferation of such weapons and to develop an effective capability to deal with these threats (Reference 15).

In line with this guidance from the President and related congressional direction, a national program to counter the proliferation of nuclear, biological, and chemical (NBC) weapons of mass destruction (WMD) has been established. The status of the national counter-WMD effort is provided in the annual *Report on Activities and Programs for Countering Proliferation*, prepared by the congressionally mandated Counterproliferation Program Review Committee (CPRC).

In *Proliferation: Threat and Response* (April 1996), Secretary of Defense William Perry described DoD's contributions to national counterproliferation efforts that have been integrated into the defense planning process. In concert with CPRC's planning, warfighters have identified and prioritized the qualifying factors for accomplishing assigned counter-WMD missions. These requirements involve improved intelligence concerning WMD threats, and enhancements in capabilities for passive defense, active defense, and counterforce against NBC hazards.

The technology development and demonstration activities reported in this section focus on improving military capabilities for the counterforce portion of the counter-WMD mission. Section I, Chemical/Biological Warfare Defense and Protection, includes science and technology (S&T) programs reported in this section in the previous (May 1996) JWSTP.

Counterproliferation S&T in this section is defined to include the capability to detect and evaluate the existence of WMD R&D and manufacturing capability; and identify and assess the weapon capability of alert and launched WMDs on the battlefield to permit the proper level of counterforce to be exerted promptly. This includes counterforce against targets covering entire spectrum of WMD storage and production facilities and agent defeat capability (Reference 16).

These counterforce capabilities respond to 6 of 15 areas designated by the CPRC as development priorities (Reference 17):

- Detection, characterization, and defeat of underground WMD facilities
- Collection, analysis, and dissemination of actionable intelligence to the warfighter
- Target planning for WMD targets
- Detection and tracking of WMD and related shipments
- Support for Special Operations Forces
- Defense against paramilitary, covert delivery, and terrorist WMD threats.

Joint Vision 2010 presents the Chairman of the Joint Chiefs of Staff's vision for future military capabilities. This vision calls for the application of four operational concepts—dominant

maneuver, precision engagement, full dimensional protection, and focused logistics—by robust, high-quality forces to provide the United States with the capability to dominate an opponent across the range of military operations.

The enhanced counterforce capabilities being developed through the S&T programs described in this section are preconditions for the realization of *Joint Vision 2010*. Improved counterforce capabilities can be used to deter or prevent proliferant use of WMD during a contingency, allowing U.S. forces to accomplish full spectrum dominance.

One of the core objectives in proliferation protection policy is to convince potential and actual proliferants that NBC weapons will be of no value because the United States and its coalition partners will have the capability to deny or limit the political or military utility of NBC weapons, and because the damage inflicted by U.S. and coalition forces in response will far outweigh any potential benefits of use (Reference 18).

2. Operational Capability Elements

Figure IV.J-1 shows how counterforce operates within a spectrum of counter-WMD capabilities and contingencies. In addition to the specific functions ascribed, it is appropriate to regard counterforce capabilities as having relevance to aspects of the proliferation threat. Effective counterforce capabilities are critical for convincing potential adversaries that no benefits result from threats to use WMD.

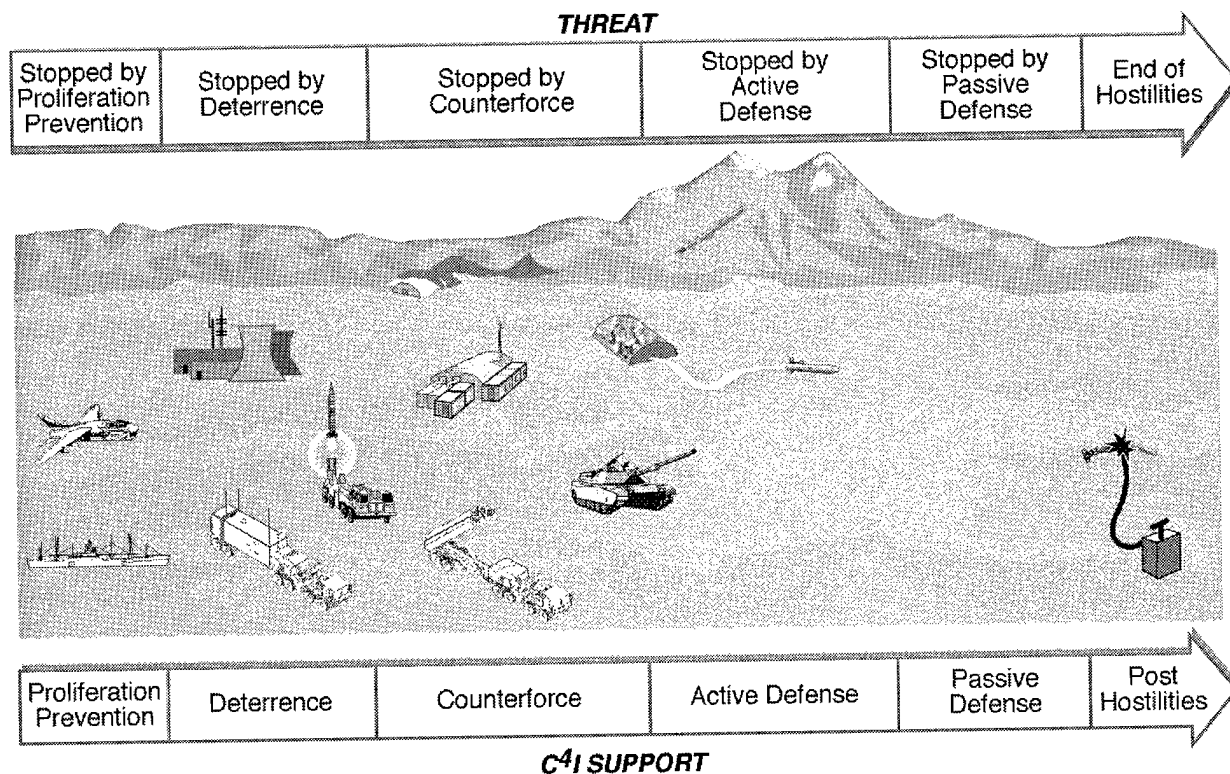


Figure IV.J-1. Concept—Counter Weapons of Mass Destruction

3. Functional Capabilities

Four sets of operational capabilities are needed to accomplish counterforce missions:

- WMD targets must be acquired and identified. Once identified, targets must be characterized to disclose suitable targeting options.
- Forces must be capable of rapidly planning and executing attacks against these targets.
- Options for defeat of WMD, including conventional high-explosive payloads as well as advanced payloads optimized for defeat of WMD agents, must be developed and validated. Engineering must be accomplished to configure such options as munitions or other mechanisms suitable for employment by operational forces to defeat WMD targets.
- Capabilities are also needed to assess the consequences of attacks. Planners must be able to predict and minimize the collateral hazards associated with attacks against WMD targets.

Table IV.J-1 shows relationships between these operational capabilities and a range of functional capabilities associated with the counterforce mission. Additional capabilities (e.g., survivable C⁴I) are also required to accomplish these missions.

**Table IV.J-1. Functional Capabilities Needed—
Counter Weapons of Mass Destruction**

Functional Capabilities	Operational Capability Elements			
	Timely Target ID	Prompt Planning and Execution	Target Defeat/BDA	Minimize Hazard
1. Identification and Characterization Sensors	●	○	○	●
2. WMD Target Planning Tools	○	●	●	●
3. Sensor Data Fusion	●	○	○	●
4. WMD Proliferation Path Analysis	●	○		
5. Real-Time Weather Data and Forecasts	●	●		●
6. Collateral Effects Prediction	○	●	○	●
7. Enhanced Penetrating Munitions		●	●	●
8. Enhanced Lethality Warheads		●	●	●
9. Agent Defeat (Validated Methods/Warheads)		●	●	●
10. Hard Target Smart Fuzing		●	●	●
11. All-Weather Guidance		●	●	●
12. Battle Damage Assessment Sensors		●	●	

● Strong Support

○ Moderate Support

4. Current Capabilities, Deficiencies, and Barriers

Table IV.J-2 shows interrelationships between the operational and functional capabilities and goals, limitations (shortfalls in capability), and technology requirements.

**Table IV.J-2. Goals, Limitations, and Technologies—
Counter Weapons of Mass Destruction**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Timely Target Identification and Characterization			
Find and characterize WMD production, storage, or related facilities that are on or below the ground (at shallow or moderate depth). Find mobile missile launchers either hidden or in transport. Find and characterize very hard or deeply buried underground WMD facilities to include tunnels.	ID and characterization sensors WMD target planning tools Sensor data fusion WMD proliferation path analysis	Few sensor capabilities for finding either mobile missile launchers or buried WMD targets Little exploitation of all source information to identify and describe WMD targets Minimal real-time intelligence and targeting information for warfighters	Advanced SAR/radar imaging Unattended ground sensors (UGSs) with seismic, acoustic, electromagnetic, and NBC capabilities Multisensor imaging Remote BW/CW sensors Low-cost and man-portable sensors Microsensors Real-time data fusion/integration ATR and automated handling of massive data streams Automated proliferation path analysis for critical node identification
Operational Capability Element: Prompt Attack and Planning			
Develop operationally suitable, integrated, computerized force application recommendations with confidence bounds and collateral effects/predictions/minimization for WMD targets.	ID and characterization sensors WMD target planning tools Sensor data fusion WMD proliferation path analysis Real-time weather data and forecast Collateral effects prediction	No decision aid to determine where in WMD development, production, and employment process counterforce attacks have highest probability of success and minimum collateral effects	Targeting calculation capabilities that include (1) soft, bermed, cut-and-cover, and deeply buried targets; (2) structural response and functional kills of internal equipment; (3) restrike decision based on BDA; (4) tunnel portal and adit disruption; (5) advanced conventional/enhanced weapon payloads; (6) optimization to minimize collateral effects; and (7) real-time weather data input
Operational Capability Element: Reliable Defeat/Battle Damage Assessment			
Acquire means to defeat WMD targets at times and under circumstances chosen by the U.S.	Enhanced penetrating munitions Enhanced lethality warheads Agent Defeat (Validated Methods/Warheads) Hard target smart fuzing All-weather guidance BDA sensors	No available earth penetrator that can destroy deeply buried or very hard WMD targets No earth penetrator with payloads for BW/CW agent defeat or neutralization Limited, highly accurate all-weather delivery capability No subsurface BDA No real-time, all-source data fusion	Advanced penetrating weapons Void-sensing, depth-sensing fuze Highly accurate, all-weather guidance/delivery Weapon-borne sensor to provide penetration/detonation history High temperature incendiary and BW/CW agent defeat payloads Real-time, all-source sensor data fusion

**Table IV.J-2. Goals, Limitations, and Technologies—
Counter Weapons of Mass Destruction (continued)**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Minimal Collateral Effects			
Develop an operationally suitable, integrated all-weather WMD source/transport/effects prediction capability for effects on military forces and civilian populations resulting from (1) accidental release from WMD facility, (2) enemy use of WMD, or (3) U.S. attack on WMD or related facility. Develop means to minimize collateral effects resulting from U.S. attack on WMD or related facility.	WMD target planning tools Sensor data fusion WMD proliferation path analysis Real-time weather data and forecast Collateral effects prediction Agent Defeat (Validated Methods/Warheads) Hard target smart fuzing All-weather guidance BDA sensors	No integrated, automated and validate NBC hazard prediction tools for wide ranging WMD targets and U.S. weapons No sensors and tools able to provide detailed equipment, enemy WMD, and WMD facility characterization No special weapons that achieve functional kill while minimizing NBC release	Accurate models for expulsion of NBC materials High-resolution, in-theater, real-time weather data and forecasts Accurate models for terrain effects on transport of NBC models Lethality assessment of dispersed NBC materials Targeting methods and advanced weapons to minimize expulsion of NBC materials Sensors and tools for WMD facility, equipment, and enemy WMD weapon characterization Real-time, all-source sensor data fusion

5. Technology Plan

The development strategy employed for counterforce emphasizes near-term technology demonstrations and field trials. These activities are based, in part, on concurrent technical activities that develop enabling technologies for these counterforce counter-WMD applications. They also require survivable C⁴I. Some of these interrelationships are depicted in Figure IV.J-2. Table IV.J-3 presents the DTOs that contribute to improvements in counter-WMD counterforce capabilities, and Table IV.J-4 identifies applicable technology demonstrations. Figure IV.J-3 presents the timelines and relationships associated with these activities.

The following presentations emphasize those portions of the DoD Science and Technology program that have been defined as Defense Technology Objectives (DTOs). Additional activities make important contributions to DoD counterforce counterproliferation capabilities. The Armed Forces Radiobiological Research Institute has work in progress to develop and validate options for defeat of threat chemical and biological agents and to establish interactions in which multiple threat agents are present. Concurrently, important programs are being accomplished in the DoD Counterproliferation Advanced Technology Development program to develop and evaluate the special equipment needed by Special Operations Forces (SOF) for accomplishment of counterforce counterproliferation missions.

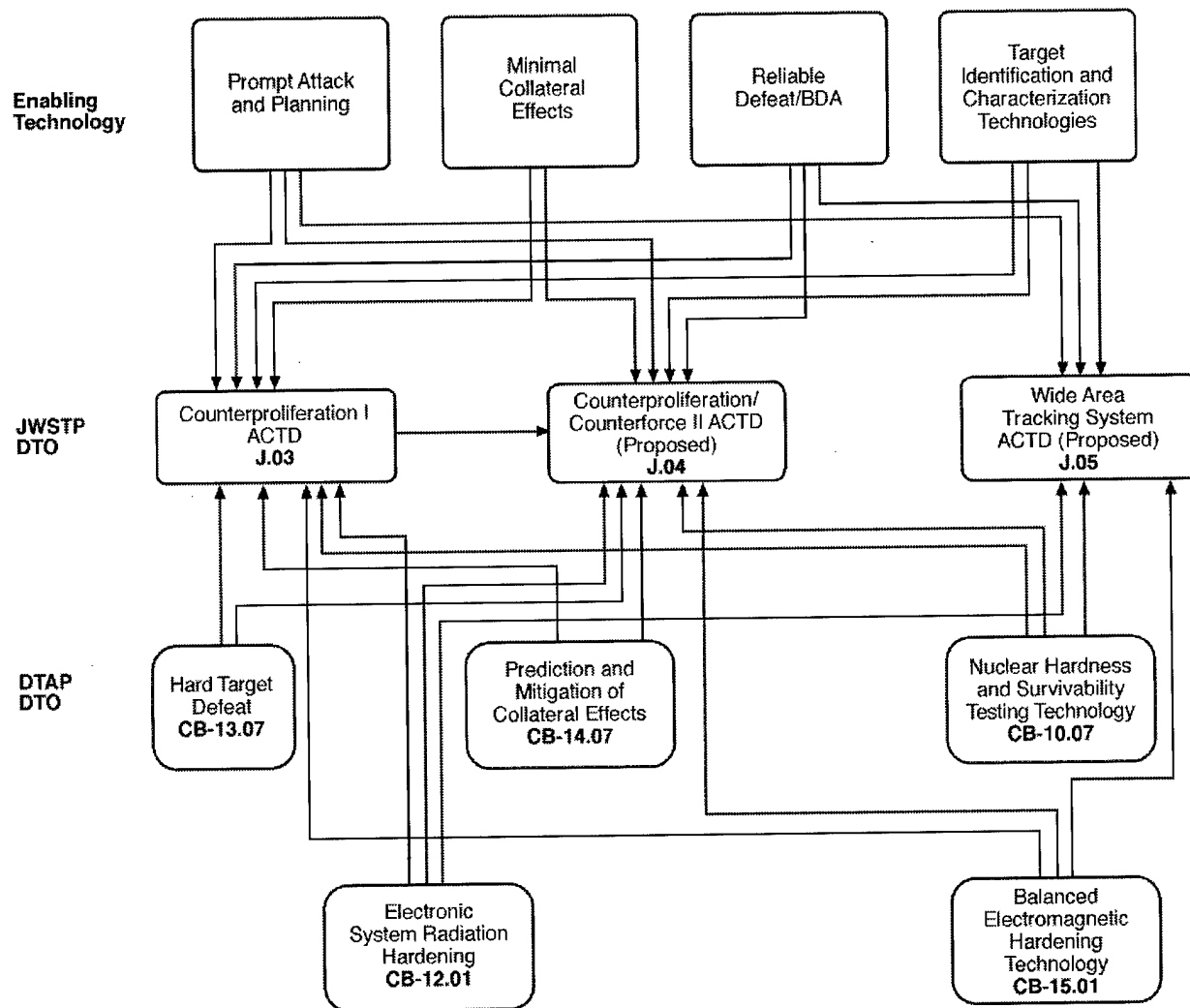


Figure IV.J-2. Technology to Capability—Counter Weapons of Mass Destruction

**Table IV.J-3. Defense Technology Objectives—
Counter Weapons of Mass Destruction**

DTO No.	Title
J.03	Counterproliferation I ACTD
J.04	Counterproliferation II/Counterforce ACTD (Proposed)
J.05	Wide Area Tracking System ACTD (Proposed)
CB.10.07	Nuclear Hardness and Survivability Testing Technologies
CB.12.01	Electronic System Radiation Hardening
CB.13.07	Hard Target Defeat
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.15.01	Balanced Electromagnetic Hardening Technology

Table IV.J-4. Demonstration Support—Counter Weapons of Mass Destruction

Demonstration	Operational Capability Elements					Service/ Agency	Type of Demonstration		
	Timely Target ID	Prompt Attack	Target Defeat/BDA	Collateral Effects	Survivable C ⁴ I		DTO	ACTD	ATD
Counterproliferation I ACTD	●	●	●	●		DSWA	J.03	X	
Counterproliferation II/Counterforce ACTD	●	●	●	●		DSWA	J.04	(P)	
Wide Area Tracking System ACTD	●					DSWA	J.05	(P)	
Nuclear Hardness and Survivability Testing Technologies	●	●	●	●	●	DSWA	CB.10.07		
Electronic System Radiation Hardening					●	DSWA	CB.12.01		
Hard Target Defeat		●	●	●		DSWA	CB.13.07		
Prediction and Mitigation of Collateral Hazards				●		DSWA	CB.14.07		
Balanced Electromagnetic Hardening Technology					●	DSWA	CB.15.01		

● Strong Support

○ Moderate Support

(P) Proposed

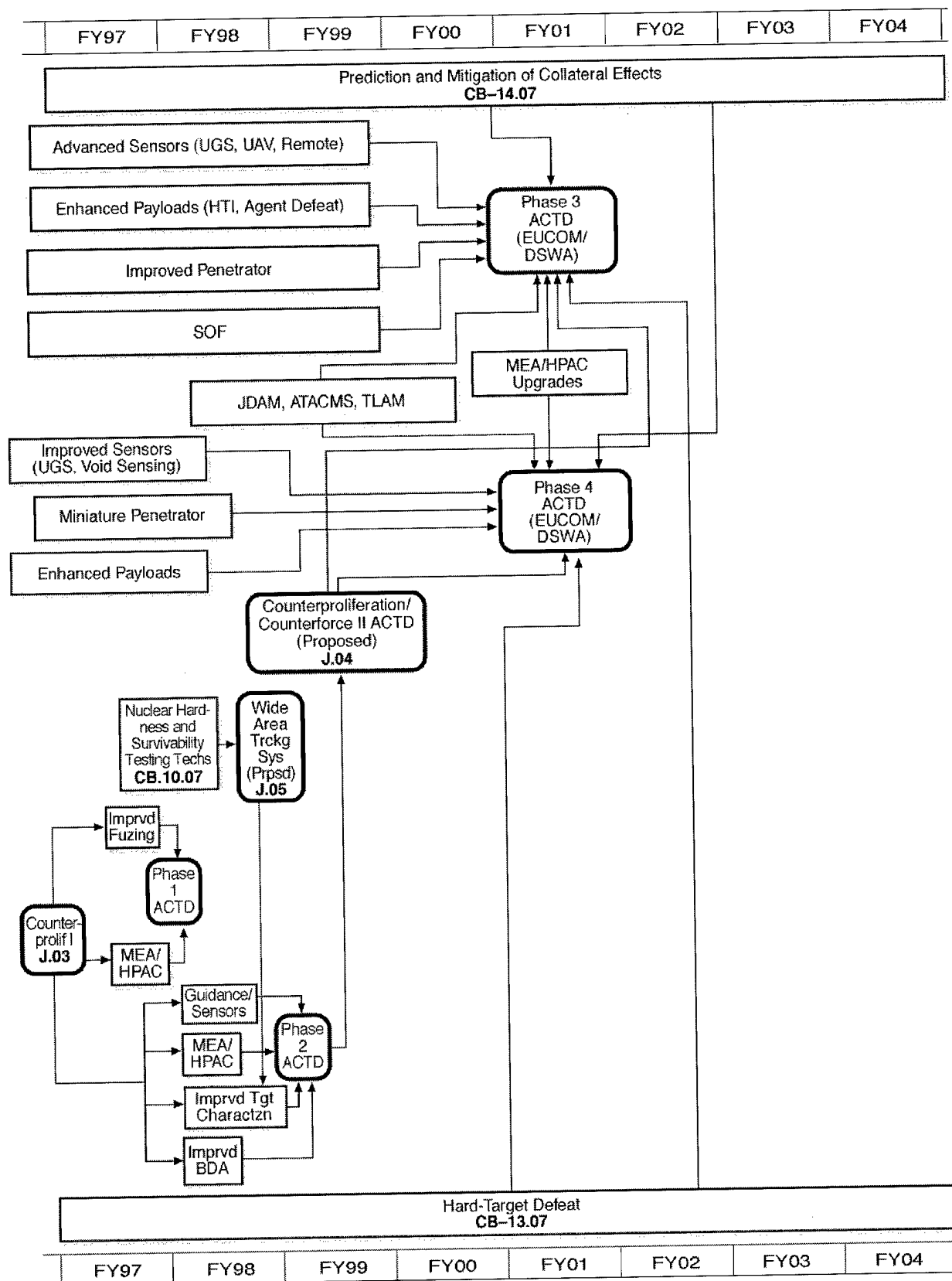


Figure IV.J-3. Roadmap—Counter Weapons of Mass Destruction

6. Summary

Table IV.J-5 depicts the enhancements in capabilities for defeat of WMD targets that are the objectives in this JWCO area.

Table IV.J-5. Counter-WMD Counterforce Program Enhancements

Stages in CWMD ACTD Activities	I	II	III	IV	V
WMD Targeting Priorities	Above ground Biological storage	Buried (but not at great depth) Cut-and-cover Chemical weapon production	Tunnel portal closure Additional surface tar- gets	Special nuclear tar- gets C ³ I for WMD More classes of above-ground targets	Hard/deeply buried WMD Functional kill
DTO	J.03	J.03	J.04	J.04	J.04
FY	1996	1998	2000	2002	2004

GLOSSARY AND REFERENCES

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

A/C	aircraft
AAV	autonomous armored vehicle
ABIS	Advanced Battlespace Information System
ABL	airborne laser
ACTD	Advanced Concept Technology Demonstration
ADC	analog-to-digital conversion/converter
ADSAM	air-directed surface-to-air missile
AF	Air Force
AGTFT	Antijam GPS Technology Flight Test
AIEWS	Advanced Integrated Electronic Warfare System
ALERT	air/land enhanced reconnaissance and targeting
ALISS	Advanced Lightweight Influence Sweep System
AMCM	airborne mine countermine
AOSN	autonomous ocean sampling network
APOD	air point of debarkation
ARL	Army Research Laboratory
AS	Arsenal Ship
ASCIET	All-Service Combat ID Evaluation Team
ASIC	application specific integrated circuit
ASTAMIDS	Airborne Standoff Minefield Detection System
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
ATR	automatic target recognition
AUV	autonomous underwater vehicle
AWACS	Airborne Warning and Control System
AWFT	Antimateriel Warhead Flight Test
BADD	battlefield awareness and data dissemination
BAMB	bending annular missile body
BAT	Brilliant Antitank
BC ² A	Bosnia Command and Control Augmentation
BCID	battlefield combat identification
BCIS	Battlefield Combat Identification System
BDA	battle damage assessment
BMDO	Ballistic Missile Defense Organization
BPI	boost-phase intercept
BRA	Basic Research Area
BRP	<i>Basic Research Plan</i>
BW	biological warfare
C&C	cut and cover
C ²	command and control
C ² I	command, control, and intelligence
C ² W	command and control warfare
C ³	command, control, and communications
C ³ I	command, control, communications, and intelligence
C ⁴	command, control, communications, and computers
C ⁴ I	command, control, communications, computers, and intelligence

C ⁴ ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CAS	close air support
CASTFOREM	Combined Arms Support Task Force Evaluation Model
CATOX	catalytic oxidation
CB	chemical and biological
CC&D	camouflage concealment and deception
CCD	charged-coupled device
CECOM	U.S. Army Communications–Electronics Command
CEP	circular error probable
CID	combat identification
CIMMD	close-in man-portable mine detector
CINC	commander in chief
CJTf	Commander Joint Task Force
CM	countermeasure
CMD	cruise missile defense
COA	course of action
COBRA	coastal battlefield reconnaissance and analysis
COMNAVAIRLANT	Commander, Naval Air Forces, Atlantic
CONOPS	concept of operations
CONUS	continental United States
COTS	commercial off-the-shelf
CPRC	Counterproliferation Program Review Committee
CSS	combat service support
CTF	common technical framework
CW	chemical warfare
DARPA	Defense Advanced Research Projects Agency
DCOR	Defense Committee on Research
DCS	Deputy Chief of Staff
DDR&E	Director, Defense Research and Engineering
DF	direction finding
DIA	Defense Intelligence Agency
DII	Defense Information Infrastructure
DIRCM	directional infrared countermeasure
DIS	distributed interactive simulation
DISC/DIAL	differential scattering/differential absorption of light
DIW	detection, identification, and warning
DLA	Defense Logistics Agency
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DOE	Department of Energy
DRB	Division Ready Brigade
DRFM	digital radio frequency memory
DSB	Defense Science Board
DSP	Defense Support Program
DSTAG	Defense Science and Technology Advisory Group
DSWA	Defense Special Weapons Agency
DTAP	<i>Defense Technology Area Plan</i>
DTO	Defense Technology Objective
DUSD	Deputy Under Secretary of Defense

DUSD(AT) D&W	Deputy Under Secretary of Defense (Advanced Technology) detection and warning
EA	electronic attack
EC	electronic combat
EEE	Eastern equine encephalitis
EFOG	enhanced fiber-optic guided
EFOG-M	Enhanced Fiber-Optic Guided Missile
EHF	extremely high frequency
ELF	extremely low frequency
EM	electromagnetic
EMI	electromagnetic interference
EMTD	Enhanced Moving Target Detection
EN-TD	Explosive Neutralization Technology Demonstration
EN-Tech Demo	Explosive Neutralization Technology Demonstration
EO	electro-optic(al)
EOD	explosive ordnance demolition; explosive ordnance disposal
EP	electronic protection
EPA	Environmental Protection Agency
EPLRS	Enhanced Position Location and Reporting System
ERASER	Enhanced Recognition and Sensing Laser Radar
ERT	enhanced reconnaissance and targeting
ES	electronic support
ESAI	enhanced situation awareness insertion
ESM	electronic support measure
ESSM	Evolved Sea Sparrow Missile System
EUCOM	U.S. European Command
EW	electronic warfare
EXCOM	Executive Committee
FAC	forward air controller
FAR	false alarm rate
FDA	Food and Drug Administration
FLOT	forward line of own troops
FMTV	Family of Medium Tactical Vehicles
FOWG	fiber optic wave guide
FPA	focal plane array
FXXILW	Force XXI Land Warrior
FY	fiscal year
FYDP	Future Years Defense Plan
G&C	guidance and control
GaAs	gallium arsenide
GBR	ground-based radar
GCCS	Global Command and Control System
GHz	gigahertz
GOTS	government off the shelf
GPS	Global Positioning System
HAE	high-altitude endurance
HDRRM	high-density radiation-resistant microelectronics

HF	high frequency
HFSWR	High-Frequency Surface-Wave Radar
HIMARS	High-Mobility Artillery Rocket System
HP	high power
HPAC	Hazard Prediction Assessment Capability
HPT	Hazard Prediction Tool
HSOK	hunter/standoff killer
HSS	hunter sensor suite
HUMINT	human intelligence
IADS	Integrated Air Defense Simulation
IBAD	Interim Biological Agent Detector
IC	integrated circuit
ID	identification
IDA	Institute for Defense Analyses
IEC	Integration and Evaluation Center
I/F	interface
IFEM	Integrated Force and Execution Management
IFF	identification friend or foe
IFOR	Implementation Force
IIR	imaging infrared
IMINT	imagery intelligence
IMS	ion mobility spectroscopy
IMU	inertial measurement unit
INFOSEC	information security
IPB	intelligence preparation of the battlefield
IR	infrared
IRCM	infrared countermeasure
IS	information superiority; information security
IS&T	information systems and technology
ISAR	inverse synthetic aperture radar
ISR	intelligence, surveillance, and reconnaissance
ISX	Information Superiority Experiment
IW	information warfare
IW-D	defensive information warfare
JAHUM	Joint Advanced Health and Usage Monitoring
JAMC	Joint Amphibious Mine Countermeasure
JCAD	Joint Chemical Agent Detector
JCM	joint countermine
JCOS	Joint Countermine Operational Simulation
JCS	Joint Chiefs of Staff
JCSE	joint continuous-strike environment
JDAM	Joint Direct Attack Munition
JEM	jet engine modulation
JETS AOA	Joint Emitter Targeting System Analysis of Alternatives
JFACC	Joint Force Air Component Command
JL	Joint Logistics
JMRR	Joint Monthly Readiness Report
JPO-BD	Joint Program Office for Biological Defense
JPPRTS	Joint Power Projection/Real-Time Support

JPSD	Joint Precision Strike Demonstration
JRAMS	Joint Readiness Automated Management System
JROC	Joint Requirements Oversight Council
JSIMS	Joint Simulation System
JSTARS	Joint Surveillance Target Attack Radar System
JTAV	Joint Total Asset Visibility
JTF	Joint Task Force
JTMD	joint theater missile defense
JTR	joint training readiness
JV 2010	<i>Joint Vision 2010</i>
JWARN	Joint Warning and Reporting Network
JWARS	Joint Warfare Simulation
JWCA	Joint Warfighting Capability Assessment
JWCO	Joint Warfighting Capability Objective
JWE	Joint Warfighting Experiment
JWP	Joint Warfighting Panel
JWSTP	<i>Joint Warfighting Science and Technology Plan</i>
KE	kinetic energy
kHz	kilohertz
km	kilometer
LAD	Logistics Anchor Desk, large area decontamination
LADAR	laser radar
LCAC	landing craft air cushion
LCPK	low-cost precision kill
LOCAAS	low-cost antiarmor submunition
LOS	line-of-sight
LPD	low probability of detection
LPI	low probability of intercept
LRS	littoral remote sensing
LWIR	long wavelength infrared
m	meter
M&S	modeling and simulation
MAE	medium-altitude endurance
MALD	miniature air-launched decoy
MC&G	mapping, charting, and geodesy
MCM	mine countermeasures
MEA	More Electric Aircraft
MEADS	medium extended air defense system
MEMS	microelectromechanical systems
MH/K	mine hunter killer
MISS	multiband infrared source solution
MITL	man-in-the-loop
MLRS	Multiple-Launch Rocket System
MLS	multilevel security
mm	millimeter
MMIC	monolithic microwave integrated circuit
MMT	miniaturized munition technology
MNS	Mine Neutralization System, Mission Need Statement

MOE	measure of effectiveness
MOUT	military operations in urban terrain
mph	miles per hour
MPM	microwave power module
MRC	major regional conflict
MRL	multiple rocket launcher
MSCM	multispectral countermeasures
MSTAR	moving and stationary target acquisition and recognition
MTI	moving target indicator
MUDSS	Mobile Underwater Debris Survey System
MWS	Missile Warning System
NBC	nuclear, biological, and chemical
NCCOSC	Naval Command, Control and Ocean Surveillance Center
NDI	nondestructive inspection
NLOS	nonlethal operating system
NRT	near-real time
NSTC	National Security Science and Technology Council
NTM	national technical means
NVESD	Night Vision and Electronic Sensor Directorate
O&M	operations and maintenance
OASD	Office of the Assistant Secretary of Defense
OATSD(CBM)	Office of the Assistant to the Secretary of Defense for Chemical and Biological Matters
ODDR&E	Office of the Director, Defense Research and Engineering
ONR	Office of Naval Research
OPSEC	operations security
ORSMC	off-route smart mine countermeasure
OSD	Office of the Secretary of Defense
OUUSD(A&T)/S&TS/EW	Office of the Undersecretary of Defense for Acquisition and Technology/Strategic and Tactical Systems/Electronic Warfare
P ³ I	preplanned product improvement
PAC-3	PATRIOT Advanced Capability 3
P _d	probability of detection
PDM	program decision memorandum
PGMM	Precision Guided Mortar Munitions
P _k	probability of kill
PLAID	position location and identification
POM	program objective memorandum
PRCMRL	Precision Rapid Counter Multiple Rocket Launcher
PRG	Program Review Group
PSA/TSA	pressure-swing adsorption/temperature-swing adsorption
PSTS	Precision SIGINT Targeting System
R&D	research and development
RAMICS	Rapid Airborne Mine Clearance System
RBV	rapid battlefield visualization
RF	radio frequency
RFCM	radio frequency countermeasures
RFPI	Rapid Force Projection Initiative

RFPICC	Rapid Force Projection Initiative Command and Control
RISTA II	Reconnaissance Infrared Surveillance Target Acquisition, Second Generation Technology II
RL	U.S. Air Force Rome Laboratory
ROV	remotely operated vehicle
R&S	reconnaissance and surveillance
RT	real time
RTIC	real-time information in the cockpit
S&T	science and technology
SA	situation awareness
SABER	Situation Awareness Beacon with Reply
SADL	situation awareness data link
SAR	synthetic aperture radar
SAW	surface acoustic wave
SBIR	space-based infrared
SBIRS	Space-Based Infrared System
SBL	space-based laser
SEAD	suppression of enemy air defense
SEB	staphylococcal enterotoxin B
SEI	specific emitter identification
SENGAP	Small Engine Advanced Program
SF/ISA	sensor fusion/integrated situation assessment
SFOR	Security Force
SHARP	System-oriented High-range-resolution Automatic Recognition Program
SiC	silicon carbide
SIGINT	signals intelligence
SINCGARS	Single-Channel Ground and Airborne Radio System
SIP	system improvement program
SM-2	Standard Missile 2
SMTS	Space and Missile Tracking System
SNR	signal-to-noise ratio
SOF	Special Operations Forces
SORTS	Status of Resources and Training System
SPOD	surface point of debarkation
SSPC	U.S. Army Space and Strategic Defense Command
STIL	Streak Tube Imaging LIDAR
STOW	synthetic theater of war
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
SUO	small unit operations
T/R	transmit/receive
TA	target acquisition
TAC	tactical
TACAIR	tactical aircraft
TAPSTEM	Training and Personnel Systems Science and Technology Evaluation Management
TARA	Technology Area Review and Assessment
TBM	theater ballistic missile; tactical ballistic missile
TC AIMS	Transportation Coordinator Automated Information Management System
TD	technology demonstration
TDA	tactical decision aids

TEM	Terrain Evaluation Module
TENCAP	tactical exploitation of national capabilities
THAAD	Theater High-Altitude Area Defense System
THEL	tactical high-energy laser
TLAM	Tomahawk Land Attack Missile
TMD	theater missile defense
TPEDIT	Time-Phase Force Deployment Data Editor
TTP	tactics, techniques, and procedures
TUAV	tactical unmanned aerial vehicle
TWMP	Track Width Mine Plow
TWMR	Track Width Mine Roller
TRADOC	U.S. Army Training and Doctrine Command
UAV	unmanned aerial vehicle
UFO	UHF follow-on
UGS	unattended ground sensor
UGV	unattended ground vehicle
UHF	ultra-high frequency
UJTL	Universal Joint Task List
U.K.	United Kingdom
USMC	United States Marine Corps
USSOCOM	U.S. Special Operations Command
UUV	unmanned underwater vehicle
UXO	unexploded ordnance
VEE	Venezuelan equine encephalitis
VHF	very high frequency
VHSIC	very high speed integrated circuit
VMF	variable message format
VMMD	vehicle-mounted mine detector
WATS	wide area tracking system
WEE	Western equine encephalitis
WMD	weapons of mass destruction

REFERENCES

1. *Defense Science and Technology Strategy*, Director of Defense Research and Engineering, May 1996, reprinted January 1997.
2. *Basic Research Plan*, Director of Defense Research and Engineering, January 1997.
3. *Defense Technology Area Plan*, Director of Defense Research and Engineering, January 1997.
4. *Joint Vision 2010*, Joint Chiefs of Staff, 1996.
5. *National Security Science and Technology Strategy*, National Science and Technology Council, 1995.
6. *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan and the Defense Technology Area Plan*, Director of Defense Research and Engineering, January 1997.
7. *Advanced Concept Technology Demonstration (ACTD) Master Plan*, Deputy Undersecretary of Defense for Advanced Technology, August 1996.
8. *Chairman of the Joint Chiefs of Staff Instruction S-3210.01*, January 2, 1996.
9. *Dictionary of Military and Associated Terms*, Department of Defense Joint Pub 0-1, cited in Maurer, Martha, *Coalition Command and Control*, The Center for Advanced Concepts and Technology (ACT), National Defense University, May 1996.
10. *Command and Control: The Literature and Commentaries*, National Defense University, September 1993.
11. *Advanced Battlespace Information System*, Task Force Final Report, May 1996.
12. R. Steeb et al., *Rapid Force Projection: Exploring New Technology Concepts for Light Airborne Forces*, Documented Briefing, Arroyo Center, National Defense Research Institute, DB-169-A/OSD, 1996.
13. R. Steeb et al., *Rapid Force Projection Technologies: A Quick-Look Analysis of Advanced Light Indirect Fire Systems*, Documented Briefing, Arroyo Center, National Defense Research Institute, DB-168-A/OSD, 1996.
14. *Defense Science Board 1994 Summer Study on Military Operations in Built-up Areas*.
15. *A National Security Strategy of Engagement and Enlargement*, The White House, February 1996.
16. *Defense Science and Technology Strategy*, Director, Defense Research and Engineering, May 1996.
17. *Report on Activities and Programs for Countering Proliferation*, Counterproliferation Program Review Committee, May 1996.
18. *Proliferation: Threat and Response*, April 1996.