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The Balanced Technology Initiative (BTI) is a program started by the 99th Congress to enable the DoD to correct gaps in U.S. conventional warfighting capabilities. The BTI program seeks quantum jumps in capabilities, not evolutionary improvements, and strives to realize these jumps by applying advanced technology.

This is an edited version of the second annual report to the Congress. In the past year, the program has achieved several noteworthy milestones and successes. The report highlights accomplishments, explains management actions, describes new projects and expanded projects, and discusses potential future projects.

The report briefly describes the operational utility, technical approach, progress to date, and planned activities for 25 BTI projects in 6 major thurst areas including: Advanced Armament, Target Acquisition, Battle Management - C3I, Smart Weapons, Special Operations, and High Power Microwaves.

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THE DEPARTMENT OF DEFENSE

THE BALANCED TECHNOLOGY INITIATIVE

ANNUAL REPORT

BASED UPON

THE ANNUAL REPORT TO CONGRESS

MARCH 1991

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EXECUTIVE OVERVIEW

Quantum jumps in conventional capability

The Balanced Technology Initiative (BTI) is a program started by the ninety-ninth Congress to enable the Department of Defense to correct gaps in our conventional warfighting capabilities. The BTI program seeks quantum jumps in capabilities, not evolutionary improvements, and strives to realize these jumps by applying advanced technology.

Slightly over a year has passed since the BTI program was restructured[1] to better comply with the intentions of the enabling legislation and subsequent Congressional direction. We have made progress and are pleased with the overall results. In accordance with Congressional direction, the Director of Defense Research and Engineering (DDR&E) is responsible for the Balanced Technology Initiative. The restructuring created the position of Director, BTI. This executive now reports directly to the DDR&E and is authorized to manage the BTI program by direct contact with the Services through their Acquisition Executive organizations.

Edited for general release

This is an edited version of the the second annual report to the Congress submitted in compliance with the direction provided in the FY 1990-91 Defense Authorization Act.

Since the last annual report, the BTI program has achieved several noteworthy milestones and successes. We also cancelled one program and redirected three others in performing our line management responsibilities. This executive overview:

- Highlights accomplishments
- Explains management actions
- Describes new projects and expanded projects
- Discusses potential projects as required by Congressional language.

HIGHLIGHTS

Enhanced Aircraft Survivability

A major BTI project achieved considerable success in demonstrating avionics systems and subsystems capabilities that enhance survivability when operating in defended airspace. The capability is applicable to a variety of large combat aircraft, such as bombers, gunships, and special operations transports.

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1 The Department of Defense, The Restructured Balanced Technology Initiative Program, Report to the Congressional Committees on Armed Services and Committees on Appropriations, January 1990.

Phase I of the current program was completed this year. A Phase II effort will start in FY 1991 and will build upon the results of the earlier phase.

Artificial Intelligence Module

Hawkeye employed in Desert Storm

The AI Module project is nearly completed. AI Module produces intelligence reports by processing, analyzing, and correlating intelligence message text with stored data including terrain, roads, doctrine, etc. The prototype system has been operating for a year and is being refined and extended to be more useful. The U:S. Seventh Corps was performing a field evaluation of the AI Module in Europe when the corps was ordered to Saudi Arabia. The users renamed the system "Hawkeye" and deployed it. Twenty-one AI Module units were operated in support of Desert Shield/Desert Storm. The Army plans to use AI Module in the Intelligence School. Later, AI Module will be fielded to operate in conjunction with the future All Source Analysis System (ASAS).

Image Exploitation System (IES)

The IES is a processor that operates on imagery from a synthetic aperture radar (SAR) such as ASARS II and cues human image interpreters (photo interpreters) to likely enemy forces. The system uses stored terrain data, enemy operating doctrine, enemy organization structure, etc., to identity enemy units and deduce their type. IES will increase the productivity of image interpreters and greatly reduce the fatigue caused by this very exacting work. IES successfully completed the first phase of a program with progressively more difficult goals of speed and accuracy. IES support was requested for Desert Storm. The system was being tested with combat imagery when the war ended.

Ultrawide Bandwidth/High Power Microwave Technology

Congressional interest project

Nearly all contracts are in place for the Congressionally mandated Ultrawide Bandwidth/High Power Microwave Technology (UWB/HPM) program. Fabrication of radars for UWB/HPM experiments is underway, and source selection is complete for a light-activated microwave source. Laboratory testing of the effects of ultrawide bandwidth microwave radiation on a widely proliferated U.S. tactical radar system has been completed. Earlier, BTI published a design handbook to help designers harden electronic systems against microwave radiation.

X-Rod

Antiarmor improvements

Two contractors are pursuing entirely different approaches in this high risk, high payoff project to develop a guided hypervelocity round for tank 120mm main guns. Both contractors have demonstrated components and subsystems and have had successful system critical design reviews. We increased FY 1991 funding for this Congressional Special Interest program beyond that shown in the last annual report.

Short Range Attack Weapon (SRAW)

This man-portable, guided weapon is capable of defeating all projected future tanks at 500 meter range. It has soft launch so that it can be fired from bunkers and inside of buildings, an important feature for urban fighting. Two contractors successfully passed critical design reviews and one was selected to complete the project. This BTI project produces and tests pre-FSD prototypes; the Marine Corps budget contains funding for FSD.

Millimeter Wave BAI Weapon (MMW Maverick)

Both contractors completed brassboard seekers in this Congressional Special Interest project. Both brassboards performed well against realistic target arrays in captive carry tests at Eglin AFB, FL, (low clutter environment) and at Grayling, MI (high clutter). These seekers work especially well against moving vehicles and rotating antennas, and they work against arrays of stationary vehicles. The seekers can be used in both direct fire and indirect fire modes. Tests in free flight will occur this year.

Uncooled Focal Plane Array

Low cost night vision devices

This project advances the technology of uncooled focal plane arrays and applies these arrays to weapon sights, security surveillance systems, and weapon seekers. Two sensor technologies are being used; both have achieved an interim goal of 0.3 Kelvin NETD[2] and are making good progress toward the final goal of 0.1 Kelvin. One technology has been demonstrated in a security surveillance system with good results. These sensors will lead to small, light weight, relatively inexpensive thermal imaging systems for numerous applications.

Low Cost Antiarmor Submunition (LOCAAS)

A competitive Phase I evaluation of three LOCAAS designs was completed, and the most expensive design was eliminated from the project. The remaining two are now in the second of three phases. One design uses laser radar (ladar) for finding and identifying targets; the other uses millimeter wave radar. Both rely on new and innovative technology not used by any other developmental submunition. We have instituted a thorough government analysis of the designs to establish realistic estimates of performance and cost.

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2 Noise Equivalent Temperature Difference

MANAGEMENT ACTIONS

Management flexibility essential to BTI success

The program described in our last annual report has been refined by numerous management decisions. The flexibility to manage the entire BTI program with minimal restrictions is an important strength of BTI and should be preserved. The decisions of major significance to the program are discussed next.

Navy Electrothermal (ET) Gun

Sea-skimmer presents difficult technical challenges

The Navy ET Gun project is intended to meet a particular mission need. The gun and its guided projectile will be the lethal part of a system to protect ships against supersonic, maneuvering, sea skimming antiship missiles that evade longer range defenses. Another BTI project, Target Acquisition for Ship Defense (TASD), is developing a radar intended to become the acquisition and fire control part of the system. For the system concept to be successful, the radar must be accurate to within about 0.1 milliradian in angle. This is a very challenging requirement in the difficult multipath environment of the mission. The TASD radar will be delivered this year and will be used in multipath tracking tests. Until these tests are complete, we will not be certain that the system concept is adequate.

Possible multipath problems and serious FY 1991 budget constraints resulted in a management decision to limit the Navy ET Gun project to essential gun and propulsion development and to add both radar and electro-optics tracking tests. This action reduced the FY 1991 budget for this project from $16.7 million to $4.3 million and extended the project one year to FY 1993. The Navy has budgeted to continue development after the BTI project has been completed.

Battalion Targeting System (BTS)

BTS project rescheduled

The FY 1991 Appropriation specifically reduced funding for BTS by $7 million.[3] To accommodate this reduction, the project has been rescheduled, extending the final demonstration by about a year to FY 1994 and slightly increasing the total cost to $58.2 million. Contract actions for preliminary engineering design and concept definition were terminated.

The replanned project depends more on in-house engineering and analysis. The possible use of the CL-227, a Congressional Special Interest system, as the sensor platform is still under consideration. The BTS project does not include development of an unmanned aerial vehicle.

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3 "Department of Defense Appropriation Bill, 1991," Report 101-521.

PROJECTS NOT BEING PURSUED

BTI has never had an Emitter Strike System project, although we described such a system as an example of a possible new BTI project. The project was to be an advanced technology version of the long-abandoned Position Location and Strike System (PLSS). PLSS precisely located emitters from standoff ranges and controlled weapons to destroy the emitters. The FY 1991 Appropriation reduced the BTI budget by $4 million on the presumption that we intended to start this project.

Planned effort dropped

Classified Project 1, meeting a need of the Special Operations Command, was shown in the program plan in our last report. It was never started because Congressional approval was denied. The FY 1991 Appropriation subsequently reduced the BTI funding by the $35.5 million initially planned for this project.

NEW PROJECTS AND EXPANDED PROJECTS

Advanced Tactical Radio Technology (Speakeasy)

Potential solution to communications problems

Speakeasy is one of two new BTI projects for FY 1991. It is a joint development with all the Services to introduce emerging technology into the next generation tactical combat network radios. Speakeasy will use a common architecture that maximizes the use of digital microelectronic technology. This will result in unprecedented versatility in frequency, bandwidth, and waveform and is expected to solve many of the current communications incompatibilities and vulnerabilities. The Air Force is acting as the BTI executive agent for Speakeasy.

Multi Mission Seeker (MMS)

MMS is the other new FY 1991 project. Tracking of helicopters against a clutter background is uncertain with current seekers. The MMS project will apply a classified technology to overcome this problem. An earlier BTI project developed an instrument that is now in use to quantify and characterize the phenomenon being exploited and to provide the data needed for seeker design. All services are participating; the Army is acting as executive agent for BTI.

Phase II Enhanced Survivability

Phase II projects approved

The complete description of the Phase II effort has been designated "for official use only."

Image Exploitation System

Phase I of the IES project demonstrated that an image of a 10 by 10 nautical mile area can be processed in 15 minutes with 75 percent accuracy. Current efforts to improve speed and

accuracy are making good progress. The project was given approval to conduct Phase II of the planned three phase program to realize improvements and to make the capability available for Desert Shield/Desert Storm. The Phase II goal of 10 minutes and 80 percent accuracy is to be achieved in a field demonstration in 1991.

Deep Battle Weapon

Smart submunition will destroy missile launchers

Finding and destroying mobile missile launchers is a very difficult problem. Our means to locate the launchers must be coupled with a weapon that can search a large area and acquire/reacquire the launcher even if it is camouflaged or partly obscured. The goal of this BTI project is a submunition that can perform this search and then destroy the launcher. This project did not appear separately in the FY 1990 budget because we expected it to merge with the LOCAAS project. However, other technical approaches were found to be better for the LOCAAS antiarmor mission, so a separate effort is being completed for the missile launcher mission.

POTENTIAL PROJECTS

The Authorization Conference report for FY 1991 asks that we identify other programs that should be considered for inclusion in BTI.[4] In the process of planning for new starts, we defined and evaluated about 50 potential projects that met the presumed funding constraints of BTI. Two of the highest ranking candidates -- the Advanced Tactical Radio Technology and the Multi Mission Seeker -- were selected as FY 1991 new starts. Of the others, the projects discussed in the following paragraphs (numbers 1 - 4) were excellent candidates, but funding to pursue them was not available.

We also considered what programs could be included if constraints were relaxed to permit larger projects. This review led to projects that are carried closer to a Milestone II decision, i.e., these projects develop pre-FSD prototypes. Eight such projects are listed (numbers 5 - 12) and briefly described here. They are not being pursued at this time.

These eight projects are bigger than those now in the BTI program. Each would require about $50 million to $120 million while the present projects require about $20 million to $60 million. Project duration would typically be three to five years which could be shortened to two to four years if streamlined procurement were authorized. In any case where a subsequent Service program is intended, the Service would be expected to define requirements and the concept of operations, perform comparisons with any alternative way to meet the need, and prepare for whichever development milestone is appropriate. This approach exploits the ability of BTI to demonstrate a capability in near operational environments so that it can be transitioned to an FSD/modification program easily with relatively low risk.

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4 The specific request was for the "...(6) Identification of other on-going or potential research and development programs, projects, and activities not currently provided for under this section that should be considered for inclusion under the Balanced Technology Initiative in order to improve conventional defense capabilities." (Sec. 211 of Report 101-331, the Authorization Conference Report for FY 1991)

High Power Microwave Demonstration (HPM)

Four promising candidates unfunded

This project would demonstrate a testbed HPM source for countering electronic systems in radars, guidance, aircraft, communications, etc. Basic work that develops susceptibility data on electronic systems and that develops source technology is currently being done in the BTI Ultrawide Bandwidth Radar and HPM thrust area. The HPM Demonstration would build a fieldable prototype of an offensive/defensive system.

Aviation Fiber Optic Guided Missile (FOGW)

This concept is a light weight (70 lb), soft-launched, fiber optic guided weapon suitable for use from helicopters and fixed wing aircraft against bunkers, fighting vehicles, artillery, and helicopters. The fiber optic guidance permits man-in-the-loop selection of the target (to avoid fratricide) and permits indirect fire (to improve survivability). The advanced technology needed is the image processing to quickly recognize the target and select the aimpoint. The weapon would automatically guide to the aimpoint. The weapon would be relatively inexpensive because the image processing and most of the guidance processing would be done on the launch platform instead of on the missile.

Terminal Defense Munition (TDM)

This project would develop a guided round for Navy 5-inch guns for defense against sea skimming missiles. This could be considered a more capable replacement for Close In Weapon System (CIWS) for many ships. If successful, a current BTI project, Navy Electrothermal Gun, will perform this mission on ships equipped with CIWS.

CL-20

CL-20 is a new energetic material for explosives, ammunition propellant, and missile propellant. It is both more energetic and safer than current materials. It is important because of its potential for very wide application and added safety. The Navy is characterizing the materiai and scaling up the production process. The BTI project would apply the material to warheads and rocket motors.

Variable Flow Ducted Rocket (VFDR)

Eight larger pre-FSD candidates

A solid rocket booster is integral with the VFDR combuster. The VFDR uses several technologies consumable closures, nozzleless booster, etc., that have not yet been applied to an integrated missile system. The VFDR airframe would be demonstrated with the AMRAAM seeker and would extend the "no escape zone" by a factor of two or three.

Submarine Torpedo Defense (SMTD)

This project would demonstrate an antitorpedo torpedo for close-in self protection of submarines and the detection, classification, and localization (DCL) system needed to employ the torpedo. This project was started in BTI and then was unfunded because of the limited budget. The Navy had budgeted funds to carry on development after the BTI project was completed, but was unable to continue the work that BTI abandoned. The Navy plans to resume the program, but it will be on a protracted schedule. As a BTI pre-FSD project, the schedule would be shortened from six years to three, and the Navy would budget for the follow-on development.

X-Rod All Up Round

X-Rod is a guided hypervelocity 120 mm round for tank main guns. We would extend the BTI X-Rod program to a pre-FSD prototype with testing of two concepts adequate to support a Milestone II decision. Each contractor would produce and test about 30 all up rounds after extensive component subsystem and captive carry testing.

Guided Multiple Launch Rocket System

The accuracy of the MLRS can be improved by a factor of six or more by use of a low cost inertial measurement unit (IMU). The payoff for conventional warfighting is great, particularly when MLRS carries smart submunitions. The project would first use an available IMU, then would transition to a micromechanical IMU currently in development to obtain a low-cost guided round. The only exotic technology involved is the micromechanical IMU, currently funded by SDI.

Light Fighting Vehicle (Light Tank)

Application of mature technologies

This project would demonstrate a composite hull and chassis, advanced engine, light fighting vehicle with gun or missile armament for the deployability and transportability needed by the Marine Corps. There would be a provision for add-on armor to obtain the higher survivability needed by the Army. The technologies needed are reasonably mature. The project would produce prototypes for testing prior to Milestone II.

Land Mine Detect and Clear

An ultrawide bandwidth (UWB) radar could be used for detection of buried mines, and a high power microwave (HPM) source and a gun could be used for clearing. Basic experiments and measurements that are needed to assure system effectiveness are underway in the current BTI UWB/HPM project.

Air-To-Surface Standoff Weapon

Standoff capability

This project would apply conformal carriage and advanced shaping, materials, and construction to achieve a low drag, low observable, versatile 2000-lb standoff weapon for destruction of shelters, command posts and other hard targets. It would employ an imaging seeker and a boosted warhead. The project would be coordinated with the planning for the Navy 1000-lb cluster Advanced Interdiction Weapon System, now called Joint Standoff Weapon, to provide the best overall program for DOD.

Air Launched Conventional Attack Missile

A 200-km precision guided missile for strategic bombers (B-52s and B-1Bs) would provide a worldwide, quick reaction capability. Two classes of missions could be supported:

- With a data terminal on the launch aircraft to receive targeting data and the appropriate submunitions the system would be effective against mobile targets, such as artillery companies, missile launchers, and tank companies.

- With an autonomous precision guidance system (AGCW) and a hard cased warhead, the system would be effective against hard fixed targets, e.g., buried command posts, hardened shelters and power plants.

The project would use an existing missile, the Army Tactical Missile (ATACMS), now in production. The B-52 could carry at least twelve missiles, and each could be used against a different target.

CONCLUDING REMARKS

Operational successes achieved

The BTI program is achieving solid results. Elements of the enhanced aircraft survivability project are being applied. The AI Module (Hawkeye) earned rave reviews in Saudi Arabia. The Uncooled Focal Plane Array project has demonstrated a surveillance camera that provides true uncooled thermal imaging using BTI detectors. The Automatic Target Handoff System, developed by the Army for attack helicopters and demonstrated on the F-16 as part of the BTI Advanced Close Air Support project, will be installed in the Block 30 F-16s configured for close air support. Every year will provide more successes, and we expect, some failures.

Risk management a high priority

Many of the projects are risky. The Director of Defense Research and Engineering and the BTI management are the harshest technical critics of the projects. When a technical problem or deficiency in system concept is discovered, we act quickly to correct the problem or redirect or cancel the project, reallocating resources for the best overall program. This flexibility to manage the overall program with a minimum of external constraints is key to both output and economy.

Both the FY 1990 and FY 1991 programs were planned later than desired, a consequence of the total rethinking and restructuring that occurred in the Fall of 1989. We plan to define changes to the FY 1992 program by July 1991 after reviewing the needs expressed by the CINCs, the JCS, and the Services. We believe we then will be prepared to discuss with Congress a few outstanding projects that can be started in FY 1992.

SECTION I
INTRODUCTION

SUMMARY

The Balanced Technology Initiative (BTI) is a program started by the 99th Congress to enable the Department of Defense to correct gaps in conventional warfighting capabilities. BTI attempts to achieve quantum jumps in capability by the application of advanced technologies.

BTI focus: Develop "Leap Ahead" capabilities for conventional warfare

Slightly over a year has passed since the BTI program was restructured to better comply with the intentions of the enabling legislation and subsequent Congressional direction. We have made progress and, all in all, are pleased with the results. The major thrust areas and the associated projects that resulted have evolved in a manner that reflects the principal focus of BTI: the application of advanced technologies to the demonstration of system concepts that will provide leap-ahead improvements in our ability to fight a conventional war.

In accordance with Congressional direction, the Director of Defense Research and Engineering (DDR&E) is responsible for the Balanced Technology Initiative. As a result of the restructuring, the position of Director, BTI, was created. This executive now reports directly to DDR&E and is authorized to manage the BTI program by direct contact with the Services through their Acquisition Executive organizations. We plan to continue to reduce the number of BTI projects while increasing their size to ensure that high payoff advanced technologies are demonstrated and fielded as soon as possible. The result is a sharpened focus on "leapfrog" technologies.

Fewer but larger projects

EXPLOITATION OF THREAT VULNERABILITIES BY ADVANCED TECHNOLOGIES

The last annual report contained a discussion of the vulnerabilities of the postulated threat based upon a competitive strategies analysis. At that time, our perception of the threat posed by the Soviet Union and the Warsaw Pact was changing rapidly. Events in the Soviet Union, Eastern Europe, Panama, and, most recently, the Persian Gulf, proved the validity of the assessment that high intensity conflict, such as a general nuclear war with the Soviet Union, is less likely now, but the probability of regional conventional conflicts and low intensity conflicts remains high. The vulnerabilities identified are still operative, because the military threat across the spectrum of conflict intensity is based upon the capabilities represented by U.S. and Soviet-type, high technology conventional weapons such as tactical ballistic missiles, new generation anti-tank weapons, advanced fighter aircraft, and antiship missiles, which are becoming increasingly available to third world countries.

Vulnerabilities based on competitive strategies analysis

A continuing need

In what was almost a premonition of recent events in the Persian Gulf region, it has been noted:[5]

> U.S. interests...may be threatened by increasingly capable...regional military powers. ...Defense of these interests will have to consider the proliferation of advanced conventional weapons systems, the availability of conventionally armed tactical ballistic missile delivery systems, and even the possibility of nuclear, chemical, and biological weapons.

Threat vulnerabilities still valid

The basic vulnerability categories formulated in the competitive strategies analysis can still be usefully applied to guide the selection of future high leverage BTI projects. These include:

- Counterair -- the capability to neutralize an enemy's offensive and defensive tactical air forces, to include aircraft, tactical ballistic missiles, and air breathing missiles. Specific goals: Disrupt sortie generation capability, enhance friendly airbase defense, and improve friendly battle management/command, control, communications, and intelligence (BM/C3I) capabilities.

- Counter penetration -- the capability to negate the enemy's maneuver forces including tanks, armored fighting vehicles, etc., used to penetrate forward defenses. Specific goals: Attack concentrated fire support elements, attack maneuver units in assault formations, and disrupt sustained operations via deep attacks.

- Counter troop control -- the capability to disrupt the enemy's command, control, and communications process. Specific goals: Exploit combat inflexibility at the tactical level, exploit difficulty in automating control process, capitalize on enemy timelines.

The report of 15 March 1990 covered how advanced technologies can be applied to each of these vulnerability areas.[6] Operational capabilities required to exploit vulnerabilities were also identified.

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5 The Department of Defense, *The Restructured Balanced Technology Initiative Program*, Report to the Congressional Committees on Armed Services and Committees on Appropriations, January 1990, p. 4.

6 The Department of Defense, *The Annual Report of the Balanced Technology Initiative Program (U)*, Report to the United States Congress Committees on Armed Services and Committees on Appropriations, March 15, 1990, pp. 6,7.

PHILOSOPHY OF THE BALANCED TECHNOLOGY INITIATIVE

BTI Program Objective

The overall goal of BTI is the timely and appropriate utilization of technology to improve our conventional defense capabilities. This goal will be met by developing and demonstrating systems, subsystems, components, and devices in pre-FSD projects chosen by the DDR&E. Table 1 lists the principal BTI projects that comprised the FY 1990 program.

Why there is a BTI Program

The BTI concept is a response to deficiencies in the nation's conventional defense posture as perceived by Congress. Some in the Congress were concerned that the massive defense buildup of the 1980s was biased toward strategic warfare to the detriment of conventional warfighting capability. Some were concerned that our superior technology was not being applied adequately to conventional defense needs. Everyone agreed that the time interval between the identification of a requirement and deployment of systems to the field is so long that we fail to take advantage of new technology in a timely fashion. The Congressional solution was to appropriate funds to allow the Secretary of Defense, through the DDR&E, to show how advanced technology can be applied to meet the needs of conventional defense in a timely manner.

Demonstrated solutions to operational needs

BTI addresses these deficiencies directly. First, the major thrust areas are areas of major operational needs. Requirements are established in response to identified needs of the operational users and the Services, but the projects are insulated from the Service competition for resources. Second, BTI emphasizes the application and demonstration of advanced technology as opposed to the development of this technology.

With the benefit of the recent restructuring, the BTI program has evolved since its inception in accordance with the following principles:

- BTI should apply technology rather than develop it.
- BTI should improve military capability, not push technology.
- BTI should speed the application of new technology by demonstrating systems to provide needed capabilities.
- BTI should be sensitive to Service requirements.
- BTI should give preference to projects that can benefit more than one Service.
- BTI projects achieve their ultimate success only when they are transitioned to fielded systems that provide operational utility.

Table 1. FY 1990 BTI Projects

Advanced Armament Projects
- Advanced Mine Project (AMP)
- Army Electrothermal Gun (ET Gun/A)
- Enhanced Kinetic Energy Weapon (X-Rod)
- Follow-Through Torpedo Warhead (FTTW)
- Ground Launched Hellfire (GLH)
- Navy Electrothermal Gun (ET Gun/N)
- Short Range Anti-Tank Weapon (SRAW)

Target Acquisition Projects
- Battalion Targeting System (BTS)
- Multi Sensor Aided Targeting (MSAT)
- Target Acquisition for Ship Defense (TASD)

Battle Management - C3I Projects
- Artificial Intelligence Module (AIM)
- Combat Vehicle Command and Control (CVCC)
- Image Exploitation System (IES)
- Tactical Use of National Technical Means (TACNAT)

Smart Weapons Projects
- Advanced Close Air Support Technology (ACAST)
- Autonomous Guidance for Conventional Weapons (AGCW)
- Electro-Optical Countermeasures/Targeting (EOCM/T)
- Fiber Optic Naval Weapons (FOGW)
- Infrared Countermeasures Technology (IRCM)
- Low Cost Anti-Armor Submunition (LOCAAS)
- Millimeter Wave Seeker Demonstration (MMW)

Special Operations Projects
- Swimmer Delivery Vehicle (SDV)
- Enhanced Aircraft Survivability
- Systems Applications for Uncooled Focal Plane Arrays (UCFPA)

High Power Microwave Projects
- Ultrawide Bandwidth /High Power Microwave Project (UWB)

Technology application v. development

Usually BTI should apply technology rather than develop it. This is consistent with the thought that we have good technology in hand but are slow to apply it. Technology development is normally a long-term process, and the Services and the Defense Advanced Research Projects Agency (DARPA) are the proper organizations to manage this process.

BTI is the proper OSD organization to manage the application of advanced and emerging technology whether developed in industry, the Services, or DARPA.

Requirements pull v. technology push

BTI looks for near-term operational payoff. BTI was born of the need to improve military capabilities, not to push technology. Strong Congressional backing for prototypes in 1985 and 1986 was an attempt to address the issue of technology application to operational needs. This role is now properly the function of BTI.

Emphasis on demonstrated performance and utility

The maturity of technology is a critical judgment in the Milestone II decision to enter full scale development (FSD) of a system. The Services are rightly reluctant to enter FSD with technology that has never been applied, because this can lead to excessive development cost and time. Use of the technology in an application that demonstrates performance and operational utility is the BTI way to show that the technology is ready for a development program.

Focus on systems

Operational utility is best demonstrated by systems that perform or contribute to the accomplishment of a particular military mission or task. Although BTI can sometimes apply technology to a component or subsystem of a larger system, it is usually necessary to demonstrate the objective capability at the system level. Therefore, BTI must be able to focus on the overall system requirement, even though the actual project may focus on a critical advanced technology part of the system.

Transition to fielded capability

The ultimate objective of military research and development is the improvement of military capability. This improvement occurs only when the research is transitioned to the Services for completion of development, procurement, and deployment to the field. Therefore, Service or CINC recognition of a need and Service support for follow-on FSD are important factors in the selection of BTI projects. Service support can be in the form of planning for FSD to meet the operational need. Budgeting for FSD is interpreted as the strongest show of support, but this generally should not be expected because of the risk of the projects chosen for BTI.

When does the BTI approach make sense?

Obviously, not everything should fall under the auspices of BTI. The Services continue to have the major responsibility for the development and application of technology. The BTI concept does not envision an additional set of projects with additional costs to DOD. There are no first order increases or decreases in cost. BTI merely changes the rules for choosing and managing a small part of what will be done, placing the responsibility and authority for this part at the OSD level. There are certain times and circumstances when it makes sense to have OSD choose and manage projects. For example:

- When a project is viewed as extraordinarily important or national in character. Possibilities include the antiarmor program and VHSIC.
- When Service organizations fail to meet an important need (recognized by them, OSD, or the Congress) for whatever reason. Possibilities include the light tank, battalion targeting, standoff weapons, and a dogfight missile.

- When Service organizations fail to exploit a technology with great potential benefit. Possibilities are guided projectiles and fiber optic data links for reconnaissance and weapons guidance.

- When Service efforts are duplicative or inadequate. Possibilities are microwave susceptibility, high power microwaves, and low cost design approaches.

- When a joint project can serve the needs of more than one Service. Possibilities are the standoff air-to-surface missile, a dogfight missile, and short range air defense.

These possibilities are illustrative of the wide spread of project size, technological content, and phase of the acquisition process of projects that are consistent with the overall goals of the BTI program. Some such projects may not be appropriate for BTI, but there are currently BTI projects that fit each of the aforementioned categories.

The Services have so many demands on their resources that they are often unable to assume the risk that is typical of BTI projects. BTI provides OSD with the capability to reduce the risk of employing advanced technology by making the first application to a pre-FSD prototype.

Effect of Budget Adjustments on the BTI Program

Avoid sub-optimization

As part of the overall Department of Defense research, development, and acquisition program, BTI is subject to funding adjustments by Congress, the Program Decision Memorandum process, etc. To the maximum extent possible, we intend to accommodate these adjustments by a process of project prioritization and termination, rather than by across-the-board reductions that result in under funding the projects. This approach should ensure that at least the highest priority projects will achieve their operational and technical goals on schedule and within cost objectives.

BTI Project Selection Criteria

Emphasis on top-down planning

The role of top-down planning was described in the January 1990 report on the restructured BTI program. Our commitment to top-down planning is as strong as ever, but our process for top-down planning is shifting to a greater reliance on the opinions of the CINCs and other field commanders and less reliance on simulation and analysis. Table 2 lists criteria that have been established as the basis for the structuring and selection of BTI projects.

In summary, candidate programs are evaluated on their potential for "leapfrog improvement" of our conventional warfighting capability, user/service interest, and the likelihood that a Service will build upon the work of BTI to achieve an operational capability. The BTI program is designed to support a wide range of U.S. military forces as they engage in special operations, low-intensity conflicts, or general conventional warfare.

Program selection process

Table 2. BTI New Start Criteria

Major criteria:

- Conventional warfare
- Advanced technology sufficiently mature to be applied to a demonstration
- Militarily significant in one or more ways:
  - Great enhancement or revolutionary change to mission
  - Pervasive effect on large number of systems
  - Low cost, affordable
- User and Service support

Additional criteria:

- Joint operational impact
- Synergy -- enhances performance of other systems
- Responsive to fast changing needs
- Not redundant with Service programs
- Demonstration within BTI funding constraints
- Compatible with current or emerging doctrine

Future Direction of BTI

Sharpened focus

At the start of BTI there was an attempt to balance the BTI program among the Services and among the mission and technology areas initially specified by Congress. This led to a program that was doing a little bit of a lot of things and prompted the criticism that the program lacked focus. The current program and new starts were chosen by applying criteria as already discussed. Consequently, the program focus is sharper following the restructuring. It will continue to sharpen as the role of BTI evolves.

How should BTI be managed and directed?

With funds and guidance from Congress for discretionary capability in the area of conventional defense, The Secretary of Defense delegated authority to the Director, Defense Research and Engineering, to structure and manage the BTI program to meet Defense needs and the intent of Congress. The Assistant Secretary of Defense for C3I advises the DDR&E with respect to needs and projects in the area of C3I. The CINCs, Joint Staff, and the Services participate with OSD offices (R&E, C3I, PA&E, Policy)[7] in the definition and evaluation of possible projects to be conducted in the BTI program. They assist in establishing needs, organizational and doctrinal constraints, and tactics for operational use. The Service R&D organizations are a source of project proposals and technical approaches.

The DDR&E oversight groups and the ASD(PA&E) mission area groups participate in several ways. They propose projects and technical approaches; they provide information about related projects; they assist in the coordination to make maximum use of ongoing activities and avoid duplication; they provide the background of previous efforts to satisfy the operational need; and they exercise oversight of the BTI program.

The character of BTI

It is important to understand what BTI is *not*. Funded at about $200 million per year, BTI cannot fund large programs such as those directed at major platform development or at entire mission areas such as antisubmarine warfare. These billion dollar problems are more properly addressed within the Services. BTI is currently best suited to more limited problems such as improving battalion combat capability.

Summation

In summary, we feel that BTI is providing the Department of Defense with a valuable tool to solve crucial and persistent problems when those problems are not being adequately addressed by Service programs. The BTI program has been restructured to a reduced number of focused, valuable projects. This will continue to become more apparent as we use a consistent philosophy to choose projects of recognized importance.

The major thrust areas and their included projects were listed in Table 1. The following sections discuss the technical content and the operational utility of the projects in the six major thrust areas in more detail.

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7 R&E, Research and Engineering; C3I, Command, Control, Communications, and Intelligence; PA&E, Program Analysis and Evaluation.

SECTION II
ADVANCED ARMAMENT THRUST AREA

Specific projects in the advanced armament area include:

- Advanced Mine Project (AMP)
- Army Electrothermal Gun (ET GUN/A)
- Navy Electrothermal Gun (ET GUN/N)
- Enhanced Kinetic Energy Weapon (X-Rod)
- Follow-Through Torpedo Warhead (FTTW)
- Ground Launched Hellfire (GLH)
- Short Range Anti-Tank Weapon (SRAW)

Primary goal: Defeat various types of enemy armor at extended range

Secondary goal: Antiship missile defense

The projects in this area are concerned primarily with the development and demonstration of gun and ammunition systems. The offensive goal on land is to be able to defeat current and projected enemy armor systems at various ranges. The Short Range Anti-tank Weapon (SRAW) is a 500-meter system easily carried by one person, whereas the Army Electrothermal Gun, X-Rod, and Ground Launched Hellfire are vehicle mounted, extended range systems (4 to 8 km). The Follow-Through Torpedo Warhead is designed to defeat advanced submarine hulls, and the Advanced Mine System is a significant improvement to current land mine capabilities. An additional defensive objective is to develop a gun system to counter the supersonic, maneuvering, sea-skimming missile threat to naval vessels.

Many of the programs in this thrust area relate to the DARPA Armor/Antiarmor program. The DARPA program develops basic technology to be transferred into various systems. BTI demonstrates some of these advanced technologies and facilitates their transfer into Service FSD programs.

The electrothermal gun projects in BTI are coordinated with related efforts in DARPA, DNA, and the Services. The Electric Gun Topical Review Steering Group and the Joint Electric Armament Committee provide oversight of the U.S. electric gun program and prevent duplication. The BTI program is a major component of the overall Army Electrothermal Chemical Program.

Funding for the Advanced Armament Thrust Area is shown in Table 3.

Table 3. Advanced Armament Thrust Area Funding ($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
111.1	48.2	44.5	18.3	3.0	225.1

ADVANCED MINE PROJECT (AMP)

Remote control of minefields

AMP is a scaled back version of the original BTI mine-countermine project. The new effort focuses on the development and demonstration of two-way communication with minefields and on the design and development of a remotely controlled antihelicopter mine.

Operational Utility of AMP

The ability to communicate with a family of wide-area mines will give the battlefield commander the flexibility to activate and deactivate a minefield to permit the passage of his own forces or to deny the passage of enemy armored vehicles or helicopters. An antihelicopter mine will deny nap-of-the-earth flight to helicopters, forcing them to fly higher where they will be more vulnerable to forward area air defenses. Other applications include the protection of fixed site assets, interdiction of helicopter airfield operations, and the denial of helicopter minesweeping efforts.

Technical Approach of AMP

The command and control features of remote turn-on and turn-off are provided by secure two-way communications. These communications also allow operators to benefit from the observations of sensors on the advanced mines. The antihelicopter mines are intended to be distributed over the ground and remain passive until airborne helicopters enter their area of influence. These munitions search for, detect, track, identify, engage, and incapacitate helicopters. They will function over 360 degrees of azimuth and zero to ninety degrees of elevation against hovering or maneuvering helicopters.

AMP Progress to Date

The command and control portion of AMP is basically complete. Brassboard testing was completed in the first quarter of FY 1991. This consisted of tests of power consumption, radiated power, and command capability in vegetation with and without line of sight. The project manager, the Army PM Mines, and the Engineer School are jointly developing a plan to transition this portion of the project from BTI to the Army. The results of this activity may be applied to the Wide Area Mine and the antihelicopter mine.

The plan for the test phase of the antihelicopter mine portion of this project has been completed and tests are underway. The functions to be tested include dispensing the individual mines, the ability of the mines to detect and acquire targets, and command and control.

AMP Planned Activity

Remotely commanded mines are transitioning to the Army and will be in an Army proof-of-principle phase in FY 1992. The full scale development is scheduled to begin in FY 1994. Brassboard tests of three antihelicopter mines will begin at Sandia National Laboratory in April 1991. Upon completion, one or two of the competing concepts will be selected for prototyping under the BTI project. The project will transition to the Army in FY 1993-94 for full scale development.

ELECTROTHERMAL GUN (ET GUN)

Different applications of technology

There are two ET Gun sub-projects, one Army and one Navy, which address different parts of the ET Gun problem. They both require a compact pulse power module for generating, storing, and transferring the electrical pulse to the weapon, and they require the development of a plasma cartridge optimized to take advantage of the energy available in the working fluid. The goal of the Army BTI effort is to develop a 120 mm gun and ammunition system that will defeat all projected enemy armor at ranges up to 4 km. The goal of the Navy BTI effort is to develop a high rate of fire 60 mm gun system that can defeat all supersonic maneuvering, sea skimming missiles attacking our surface ships.

The Army BTI project, in concert with the Defense Nuclear Agency (DNA), is developing the pulse power module to store the electrical energy and form the proper shape of electrical pulse to provide propulsion to the projectile. The Navy project addresses the challenge of gun design, particularly the handling of the electrical energy in a high rate of fire gun.

Operational Utility of ET Gun

Improved effectiveness

The Army ET Gun project will improve the range of battlefield gun systems and enhance the ratio of kills per hit. These performance improvements will be accompanied by improved efficiency, reduced size and weight, improved safety, reduced vulnerability, and the extended utility of conventional gun barrel designs. The naval application of the ET Gun, coupled with the development of a suitable guided projectile, will provide effective ship defense against the emerging antiship missile threat. If successful, the ET gun technology resulting from these projects also will have potential application to future howitzer designs.

Technical Approach of ET Gun

Controlled electrical pulse creates plasma

The approach taken by the ET Gun projects attempts to maximize the performance of conventional gun tube technology through the development of a propulsion system to increase muzzle velocity and projectile kinetic energy. The concept employs a large, shaped electrical pulse which is fed into the breech of the gun, where it creates a plasma from the fuel. The plasma is injected into an insensitive oxidizer in the reacting chamber, creating a highly energetic working fluid that propels the projectile down the gun tube. This approach permits lower cost guided rounds and reduced danger to the gun user and vehicle.

Exploitation of the potential of ET gun technology requires the demonstration of tactically deployable pulse power sources, cartridge development, control of interior ballistics, and system integration.

ET Gun Progress to Date

The Army portion of the program began in the last half of FY 1989. This effort takes the technology from the laboratory to the range and begins the iterative process of scaling power systems to weapon-size configurations.

The Navy effort was a new start in FY 1990. The design of the 60mm gun mount and autoloader assembly has been completed, and parts are being fabricated. Testing has begun of 60mm ET propellant cartridges at one of the two contractor facilities. This early testing is yielding excellent results. Due to concerns with the present Navy concept of a hit-to-kill system, BTI directed the Navy to substantiate the system concept further. The Navy has responded with a series of effectiveness studies and lethality/vulnerability testing of representative cruise missile warheads to validate the current concepts. Based on this analysis and the progress of the other system components, a decision will be made in FY 1992 to either continue the project as planned or to redirect it.

ET Gun Planned Activity

The large caliber version of the ET gun is to be tested with the pulse power module early in FY 1992. If successful this gun could be used in a tank beyond the planned Block III. The smaller caliber, high rate of fire gun to be demonstrated in FY 1992 will fit the Navy Phalanx close-in-weapon-system mount. When coupled with the BTI Target Acquisition for Ship Defense project, the Navy ET Gun project will have potential as an antijam, anticlutter, low cross section antiship missile killer.

Ultimately, the objectives of these projects are to demonstrate the technology as an upgrade of the M1 tank 120mm gun, as a new gun for future tanks, and as an upgrade for the Phalanx Close-In Weapons System (CIWS) to intercept low flying antiship missiles.

ENHANCED KINETIC ENERGY WEAPON (X-ROD)

120mm guided KE round

The purpose of the X-Rod project is to demonstrate guided, 120mm advanced kinetic energy projectiles for existing tank guns capable of defeating current and projected threat armored vehicles at ranges up to four km. To accomplish this goal, the project must provide significant advancements in range, accuracy, and lethality of tank-launched projectiles. This project will provide tank compatible (gun, storage, etc.), affordable rounds which provide these advances. X-Rod is the only program that is developing guided kinetic energy long rod penetrators.

Operational Utility of X-Rod

Improved kill ratios possible

In 1985 the Defense Science Board identified a major opportunity to negate numerical advantages in opposition armor.[8] It concluded that the ability to hit and kill attacking enemy tanks at ranges beyond our current capability would greatly improve U.S. tank force effectiveness. Projectiles with X-Rod capabilities have been modeled in several simulations which indicate major increases in effectiveness and survivability for both offensive and defensive operations when compared to current U.S. capabilities. X-Rod will improve tank exchange ratios and survivability by providing increased accuracy and lethality at increased effective operational ranges.

Technical Approach of X-Rod

Improved lethality given a hit

Improvements in lethality are obtained by higher impact velocities, achievable via rocket boost after gun launch and longer kinetic energy penetrators or novel penetration concepts. Increased range is provided by higher velocity, in-flight stability, and reduced drag. Higher probability of hit and terminal accuracy are provided by projectile guidance.

To obtain improved terminal accuracy of X-Rod at extended operational ranges, two different guidance approaches are being developed. One approach incorporates a millimeter wave (MMW) seeker in the projectile for autonomous, true fire-and-forget guidance. This approach is compatible with the existing tank fire control system. The other approach uses command guidance of the projectile, relying upon an upgraded Multi-Target Acquisition System (MTAS) MMW target acquisition and guidance sensor on the launch platform and a command guidance uplink to the projectile in flight.

X-Rod Progress to Date

Acceptable risk and cost

The X-Rod program was started in 1987 as a three phase projectile development effort. Phase I produced initial projectile and system designs. Two contractors were selected to continue into Phase II in March 1988. The Phase II efforts, completed in December 1989, demonstrated critical technologies for the X-Rod approaches. The technology

8 Final Report of the 1985 Defense Science Board on Armor/Antiarmor.

demonstration efforts confirmed the potential for major improvements in antiarmor capabilities that can be achieved at acceptable risk and cost.

For the command guided approach, Phase II provided demonstrations of mechanisms for in-flight discard of the booster casing, MMW command guidance uplink/downlink and tracking transponder using breadboard electronics, and roll initialization/projectile track. For the fire-and-forget approach, a form-fit-function MMW transceiver was fabricated with brassboard terminal seeker electronics which were then demonstrated statically and dynamically. Critical MMW components and maneuver mechanisms were tested, and gun-fired slugs were used to establish the projectile launch environment. Both contractors developed guidance algorithms and performed wind tunnel tests, tests on proposed propulsion ignition/primer systems, and system/projectile simulations and modeling. The contractors also provided initial design studies examining the potential application of X-Rod concepts with the Advanced Tank Cannon System.

Phase III of the X-Rod project was started in 1990. Both contractors have been active in refining projectile/system simulations and models, preparing for guidance and subsystem and guide-to-hit demonstrations, and fabricating models for additional wind tunnel testing and integrated guidance demonstrations. The contractors have continued design, modeling and simulation, and performance improvement efforts for the guidance test rounds and for the objective all-up round. Both contractors had successful preliminary design reviews early in 1991. Army financial participation began in FY 1991 with the addition of $2.11 million.

X-Rod Planned Activity

Phase III under way

Phase III activities began in the third quarter of FY 1990. Both the fire-and-forget and the command guided concepts will be developed in Phase III with a down-select later in the phase. The Phase III efforts will be conducted in two parts. The 30-month Phase IIIA effort will demonstrate concept viability and performance including guidance system accuracy and in-flight maneuver capability. Phase IIIA will develop, fabricate, and demonstrate critical system elements and culminate in free flight guidance and corrective maneuver guide-to-hit experiments of both the fire-and-forget and command guided designs. Phase IIIB will complete the fabrication and integration of system elements not completely addressed in Phase IIIA and will fabricate, integrate, deliver, and test all-up, fully functional X-Rod rounds. The intent is to fund both Phase II contractors through Phase IIIA and to select one contractor for Phase IIIB. Results achieved at milestones in Phase IIIA could alter this plan since elements with the highest inherent risk are being investigated early in the phase. Demonstrated performance failure in any of the high risk areas could lead to an early downselection.

Transition to Army

When Phase IIIA is successfully completed, the X-Rod program will transition to Army management. Full Army funding is expected to be available for Phase IIIB and follow-on development. Transition is planned for mid FY 1993. Although not a formal program within the Armament Enhancement Initiative, X-Rod will be a candidate for the Block III main armament program.

FOLLOW-THROUGH TORPEDO WARHEAD (FTTW)

Operational Utility of FTTW

The purpose of this BTI project is to overcome a serious deficiency in existing ASW capability.

Technical Approach of FTTW

The Naval Surface Warfare Center (NSWC) has devised a novel concept to obtain the desired weapons effects on advanced vessels. The current BTI project is intended to demonstrate the performance of this design approach. The project is structured to consider component design and fabrication, target design, test, and fabrication, and overall system testing.

FTTW Progress to Date

Development an iterative process

Two iterations are required to demonstrate the technical approach of FTTW. The first iteration consisted of the design and development of component technology. The Naval Surface Weapons Center demonstrated projectile penetration at full scale, recorded deceleration data for fuze development, built an analytical model to perform warhead design tradeoffs, investigated explosive survivability, and developed design tools for projectile/fuze simulations. The second iteration, currently under way, will demonstrate a refined design to improve upon first iteration penetration performance while packaging the required payload in an optimum design.

FTTW Planned Activity

The schedule for the remaining portion of the project has been determined to be challenging but achievable. There are several technical problems with the fuze and the projectile to be solved. A dynamic test of selected components would be useful to validate the analytic model, but there is no current funding for such a test.

GROUND LAUNCHED HELLFIRE (GLH)

Operational Utility of GLH

Congress recognized the potential utility of a ground-launched Hellfire capability and directed that a system be developed for the U.S. Army Ninth Infantry Division. The operational needs of this light infantry division mandated adaptation of the airborne Hellfire system to a wheeled vehicle. The HMMWV was ultimately selected as the vehicle of choice.

Extended range antiarmor for the Light Infantry Division

Current Army division antiarmor capability is presently limited in range to less than four kilometers with two kilometers as the practical operational limitation. Adaptation of the laser-guided Hellfire missile to a launcher mounted on a ground vehicle and supported by forward deployed laser designator teams could effectively increase the range of the division antiarmor capability to the maximum range of the Hellfire missile -- about eight kilometers.

Technical Approach of GLH

Off-the-shelf item program

As a quick-reaction type project, the decision was made to maximize the use of non-developmental off-the-shelf hardware developed for the Swedish Shore Defense System. Sweden funded development of a fixed ground launcher for Hellfire. Two of these launchers and the single launch control box were adapted to fit in a standard cargo version HMMWV (M998) chassis.

GLH Progress to Date

The GLH project is essentially complete. Following completion of a functional configuration audit in early CY 1991, field testing and evaluation will be conducted at Hunter-Liggett in California. Upon completion of the user evaluation and live firing demonstrations, the system will have completed all the major requirements for production readiness. No production decision is anticipated at this time.

GLH Planned Activity

Specific user not identified

Since this project was initiated, the Army reviewed the GLH concept but did not validate any formal requirement for GLH. There currently is interest, but no formal requirement, in the 82nd Airborne Division.

SHORT RANGE ANTI-TANK WEAPON (SRAW)

Operational Utility of SRAW

20-lb system; 500-meter range

Improved man-portable antitank weapons are needed by Army and Marine infantrymen to defeat modern tanks at short range. The goal is to develop an effective system that weighs less than 20 pounds and is less than 40 inches long with high probability of kill out to 500 meters. Soft launch is required so that the weapon can be fired from inside bunkers and buildings, an important feature for urban fighting.

Technical Approach of SRAW

Two approaches

The challenge is to incorporate advanced guidance and control with a lethal warhead design into a small, lightweight system. Other issues to be addressed include soft launch, propulsion, low cost, and overall systems integration. Two awards were made in February

1990 for the 30-month Phase II Proof-of-Principle effort. One approach uses a fly-over, shoot-down concept; and the other is a direct attack, tandem warhead system.

SRAW Progress to Date

Early downselect

Both contractors provided acceptable designs and analyses at critical design reviews in December 1990, but the direct attack design was somewhat behind schedule and over budget. When the Marine Corps reduced their funding for FY 1991, BTI decided to eliminate the direct attack concept and proceed with only the fly-over, shoot-down (top attack) concept. The contractor pursuing the top attack technology will also investigate applicability of his design to direct attack.

SRAW Planned Activity

FSD in FY 1993

The BTI project produces and tests pre-FSD prototypes. Upon successful completion of the BTI demonstration, the project will transition to the Marine Corps. Marine Corps funding is already in place to begin FSD in FY 1993.

SECTION III
TARGET ACQUISITION THRUST AREA

Find them first

The primary goal of this thrust area is to provide manned battlefield and naval weapons systems with the capability to rapidly locate, identify, and target enemy forces so that they may be engaged and destroyed before they can effectively engage friendly forces. A secondary goal is to satisfy the intelligence and targeting requirements of small unit commanders by applying advanced technologies in vehicles, sensors, and displays to the problem of determining the size, location, and movements of enemy forces. The projects in this area include:

- Battalion Targeting System (BTS)
- Multi-Sensor Aided Targeting (MSAT)
- Target Acquisition for Ship Defense (TASD)

BTI funding for the Target Acquisition Thrust Area is summarized in Table 4.

Table 4. Target Acquisition Thrust Area Funding ($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
77.7	22.3	28.6	19.5	13.2	161.3

BATTALION TARGETING SYSTEM (BTS)

BTS is a FY 1990 new start in the Target Acquisition thrust area. The BTS will demonstrate a simple, non-burdensome target acquisition system that will provide real-time targeting information to lower echelon, front-line fighting elements. The BTS is intended to be based and supported at the battalion level and to impose no additional force structure requirements.

Funds reduced in FY 1991

The FY 1991 Appropriation reduced funding for BTS by $7 million to permit "Congress to address this project's military utility and affordability during the next budget review...[and to prevent]...premature commitment to a complex technology integration endeavor expected to cost more than $90,000,000."[9] To accommodate this reduction, the project has been

9 The Department of Defense Appropriation Bill, 1991, Defense Subcommittee, Senate Appropriations Committee, Report 101-521, October 11, 1990, p. 229.

rescheduled. The final demonstration has been postponed to FY 1994. The estimated total cost has increased slightly to $58.2 million. Contract actions for preliminary engineering design and concept definition were terminated.

Operational Utility of BTS

Locally controlled surveillance for assessment, maneuver planning, and targeting

The BTS will provide real-time situation and targeting information to lower echelon, front-line fighting units. Typically, the commanders of these units cannot afford to wait for information supplied by higher headquarters when executing organic operations day or night, under adverse environmental conditions, or in difficult terrain. Mission performance requires information on the nature and location of the threat within 5 to 20 kilometers of friendly units. The system will provide information on enemy forces including infantry units, individual or groups of vehicles, helicopters, command posts, tanks, and the logistics tail. The system will also fit within the organization elements of the battalion.

Meet needs of forward units

The BTS concept will focus on meeting the information and targeting needs of the maneuver element, but may also aid the fire support, air defense, and intelligence function areas. The BTS will be able to locate, discriminate, and classify threats with sufficient accuracy to permit attack with an appropriate weapon system. The system will be organic to regiments, brigades, separate battalions, and division cavalry squadrons.

Technical Approach of BTS

Sensors, processors, and platforms

The system concept is for an unmanned aerial vehicle (UAV), developed by the UAV Joint Program Office, containing infrared (IR) and radar sensors with data downlinked to a terminal in a HMMWV or truck type vehicle that carries additional ground-based sensors, displays, and data processing equipment required to process and display target reports. The aerial sensor platform will be small enough to be carried on a trailer behind the HMMWV and be capable of launch and recovery in front-line regions. The range of the airborne sensors will be sufficient for target acquisition and situation assessment from a standoff position.

Army studies to define the sensors, processors, and benefits

The preliminary specification for BTS, now being developed, is based on Army studies and technology assessments of sensors, processors, and air vehicles. Potential airborne sensor suites of different levels of complexity are being modeled in approved Army scenarios and evaluated against user-generated targeting and surveillance requirements. This modeling will define a baseline BTS sensor suite and processing requirements. The operational benefit of the baseline BTS will be determined using the Army's JANUS simulation war game.

BTS Progress to Date

Operational Concept developed by CAC

An operational concept paper for BTS has been drafted and staffed through the Army's Combined Arms Command, which has been designated the TRADOC system manager for BTS.

The technology assessments have been completed, and the Army simulation models have been upgraded to include BTS capability. Initial data runs with these models are complete, and the sensor concept studies will provide results in the third quarter of FY 1991. TRADOC JANUS scenarios are currently being modified to include BTS in preparation for the operational utility evaluations.

BTS Planned Activity

Design objective system; i.e., integrate for near-term demonstration

The replanned project will depend mainly on in-house engineering and analysis. An engineering design and integration contract will be awarded to define, design, and integrate the near-term demonstration system. The intent is to integrate existing sensor, platform, and ground station technologies, augmented by technologies that are in advanced development. The airborne sensor platform to be used in the BTS project demonstration has not yet been determined. The CL-227, which is a Congressional Special Interest system, is under consideration. Another possibility for the BTI demonstration is a sensor pod carried by a helicopter or a slow-moving fixed wing aircraft. This project does not include the development of an unmanned aerial vehicle. Whatever air vehicle is needed for a future objective system will be determined by the Army and the UAV Joint Program Office based on the results of the BTI project. The ground station of the objective system will likely be an adaptation of the Army Common Ground Station or the Short Range UAV ground station.

MULTI SENSOR AIDED TARGETING (MSAT)

Integrated approach to targeting requirements

The objective of the Multi Sensor Aided Targeting (MSAT) project is to develop aided or automatic targeting to assist operators of ground vehicles. The project will demonstrate deployable systems that are capable of processing input data from different sensors to automatically inform users of the location and identity of potential targets.

Several BTI projects were merged into three complementary sub-projects to achieve the MSAT objective:

- The Fire Control and Target Acquisition System -- the demonstration of techniques for advanced fire control.
- Weapon Image Processor (ALADDIN) -- a high throughput, small volume digital data processor.
- Aided Target Recognition -- develop and evaluate algorithms to perform the automatic target recognition function; develop realistic synthetic imagery techniques.

Operational Utility of MSAT

Rapid target detection and fire control

In many conventional war scenarios, the forces of the United States and its allies find themselves outnumbered. To overcome an enemy's numerical superiority, our forces must be able to find and target enemy weapon systems rapidly. The objective of the Multi-Sensor Aided Targeting (MSAT) project is to develop an integrated targeting system that gives manned weapons a distinct advantage in finding and destroying enemy vehicles. The project will provide deployable systems that are capable of processing input data from different sensors to automatically inform users of the location and identity of potential targets. An integrated multi-sensor suite with processors and displays can greatly enhance situational awareness to find targets and deliver fire. MSAT can give our armored forces a leap-ahead capability. Individual sensors, such as advanced FLIR and MMW systems, are being developed under separate Army programs.

Technical Approach of MSAT

Four former BTI projects have been merged into three sub-projects to achieve the objectives of the MSAT program. The three sub-projects are:

Duplication of effort reduced

Fire Control/Target Acquisition System (FC/TAS) -- This sub-project was originally structured to provide an integrated suite of sensors, processors and algorithms designed to provide automatic target recognition (ATR) capabilities to future armored vehicles. Its current objective is to reduce the time required to locate, identify, and target enemy vehicles at extended ranges (5 km for ground targets, 10 km for air targets) through the use of advanced sensors and ATR capabilities. Sensors being examined include millimeter wave (MMW) radar, forward looking infrared (FLIR), and laser radar (LADAR). Advanced algorithms for ATR and multi-sensor fusion being developed in the ATR sub-project will be integrated with the advanced sensors. The advanced command guided projectiles originally funded under this effort have been terminated. Capabilities developed in the other sub-projects of MSAT will be incorporated into this effort for demonstration purposes and to reduce overall duplication of efforts.

Technology from MSAT will be integrated with the Extended Range Gunnery Fire Control System program conducted by ARDEC to provide advanced ATR and multi-sensor fusion for demonstration on the Tank Components Advanced Technology Test Bed (CATTB), an evaluation for the Block III tank.

Aladdin -- This sub-project is developing a high throughput, small volume processor compatible with smart munitions, missiles, fire control systems, and other platforms. The objective is to demonstrate a system simultaneously capable of 1 GFLOP and 500 MIPS in a device no larger than a 4.5-inch diameter by 6-inch long cylinder. This size will permit numerous constrained volume applications, and the high throughput will satisfy the demands of processing intensive applications.

Aladdin will initially support Ada and Image Algebra programming languages. Other high order languages can also be supported within the Aladdin operating environment.

There is significant user interest in the Aladdin processor beyond the MSAT program. Each service has applications that are being considered for Aladdin. MICOM has requested a prototype Aladdin processor for evaluation. The Air Force has funded a study to evaluate Aladdin as a core processor for avionics applications to replace the current standard. The Navy is also examining Aladdin technology for avionics applications. The SDI offices are interested in applying Aladdin, and information has been provided to the Space Exploration Initiative.

Wide spread interest in program

Aided Target Recognition -- This effort includes the development and evaluation of computer algorithms to automatically locate targets in the field of view of the seekers. The effort develops and evaluates single sensor algorithms, multi-sensor feature level fusion processing, laser vibration algorithms, and model based algorithms. Evaluation of existing algorithms continues to assess their target recognition performance and to identify specific areas for algorithm improvement. Calibrated multi-sensor imagery and signals are being collected for algorithm development and evaluation.

The Smart Weapons Operational Enhancement (SWOE) effort, formerly a separate BTI project, is incorporated into this sub-project. SWOE has developed an interim thermal modeling capability as a part of the effort to develop realistic thermal imagery for sensor and autoprocessor evaluation. The SWOE effort will be transitioned to the Army at the end of FY 1991.

MSAT Progress to Date

Fire Control/Target Acquisition System

Each contractor has accelerated the work on his sensor suite in preparation for the Phase II field demonstration. These preparations have included multipath tests at Hanscomb AFB and at Fort A.P. Hill. Integration of all hardware and software to the van environment is currently taking place. The emphasis at this time is on final refinement of the algorithm suites and last minute training of the algorithms to the selected target set to be used during the demonstration.

Sensor work accelerated

Aladdin

Both contractors continued to refine their respective Aladdin architectures. Each contractor is currently designing the integrated circuits required by their chosen approach. Significant progress has been made in the areas of custom chip design, software development, electrical and physical analysis, interconnection layout and fault detection and built-in-test (BIT). Interconnection protocols and internal communications have been examined in detail. This has resulted in a decision to include a second communication bus in one of the processors; a decision to modify the interconnect protocol in the other processor is pending.

Aided Target Recognition

ATR algorithms evaluated

Single sensor FLIR algorithms implemented in Multi-function Target Acquisition Processors (MTAPs) have been evaluated on the CCNVEO terrain board. As a result, algorithm enhancements were identified to improve performance and to extend MTAP application to second generation FLIR imagery. These improvements include a bimodal segmenter, range grid input, and model based recognizer. A comparative evaluation of an MTAP and the Westinghouse FLIR algorithm suite was conducted. The ATR performance has been assessed against various target types, clutter conditions, and ranges. This evaluation provided technical background in ATR performance for the Light Helicopter Source Selection.

Additionally, an algorithm evaluation task is using an iterative develop-test-refine cycle of ATRs to provide algorithm understanding. Calibrated multisensor imagery and signals are collected for algorithm development and evaluation. Growth and environmental effects for ATR algorithm development and evaluation are being developed.

MSAT Planned Activities

Fire Control/Target Acquisition System

Evaluation leading to downselection

Phase II culminates with field evaluation of the contractor's hardware and sensor suites. This evaluation is scheduled to begin in March 1991 at Fort A.P. Hill, Virginia, and continue for four weeks. The demonstration will be a van based, near real time demonstration of multisensor capabilities conducted in a low clutter environment. The results of this evaluation will be used to aid in the selection of one of the contractors to proceed to Phase III of the program. Phase III will be a 24 month effort focused on the development of a "generic" ATR module that can be integrated with the Extended Range Fire Control Gunnery System and subsequently demonstrated on the Tank CATTB. This ATR module will use the best algorithms available to the MSAT program and will draw on all pertinent technology in this thrust area.

Aladdin

Both contractors will complete the design of custom devices and begin fabrication. Packaging designs will also be finalized. Software activities will increase with actual support packages being started and subsequently developed. A series of engineering modifications will be considered by the government to enhance the baseline performance of the Aladdin processor and further increase the number of possible applications.

Aided Target Recognition

Major emphasis will be placed on evaluating the multisensor algorithm suites. The processing of all multisensor imagery collected during the Vision I field exercise will be completed by the feature fusion contractors. This will provide a more complete target set and will assess performance with laser radar data. Activity will continue with

Westinghouse to evaluate its feature fusion performance with the Longbow radar and TADS FLIR data. These data will be made a part of the overall multisensor data set. Coordination will continue with the Smart Weapons Operability Enhancement effort for the generation of realistic simulated imagery.

TARGET ACQUISITION FOR SHIP DEFENSE (TASD)

Operational Utility of TASD

Counter the sea-skimmer threat

The TASD project is intended to overcome the limitations of conventional ship-board self defense radar systems to provide fire control for the engagement of high-speed, very low altitude, maneuvering, low RCS antiship missiles. One potential application of TASD is the fire control system for the Naval ET Gun program. The system can also provide uplink communications for short range command guided weapons that require precision differential tracking capability and command guidance.

Technical Approach of TASD

Operate close to horizon

This project will demonstrate the dual-band (K_u and W) radar system concept for the detection and tracking of an incoming missile. Initial tracking is accomplished in the K_u band, with transition to the W-band narrow beam radar. Millimeter wave radar has some distinct advantages in this application. Very narrow beams can be formed with modestly sized antennas to provide the resolution and angular accuracy that permit radar operation very close to the horizon.

The system will track both the incoming target and the outgoing projectiles. When the target comes within firing range, the dual-band radar will provide precision conventional tracking for guidance of existing naval surface-to-air weapons and precision differential monopulse tracking for guided projectiles. In this instance, angular track accuracies on the order of 0.1 milliradian at three nautical miles may be required.

Differential tracking -- zero angular error

Differential tracking determines the difference between the target and weapon angle track signals. The radar signal processor determines the angular difference and projected flight paths of the two objects and initiates a control signal which is transmitted to the weapon. The guidance command maneuvers the weapon to close the angular difference. Several iterations of the process lead to intercept and kill of the target. To minimize cost and technical risk, the project approach is based upon maximum use of existing hardware with minor modifications.

The project has the following objectives:

- Demonstrate MMW radar detection, acquisition, and tracking of small low-flying objects over water.

- Demonstrate the sensitivity of these radars to these targets at ranges suitable for weapon reaction.
- Demonstrate the accuracy achievable with these radars on such targets in the self-defense environment of surface ships.
- Prepare a feasibility study and system design concepts for the incorporation of MMW radars into short range AAW weapon system concepts.

TASD Progress to Date

Component fabrication has been completed. The K_u-band radar is fully operational and has been integrated with the digital processor. These are ready for system-level integration tests. Certain noise and hardware problems have been resolved. Operational software is complete and is undergoing final system-level testing. Clutter filters and Kalman tracking filters have successfully passed independent operation and are supporting system-level tests.

TASD Planned Activity

Planned field and acceptance testing will be conducted to complete the TASD project.

SECTION IV
BATTLE MANAGEMENT/COMMAND, CONTROL, COMMUNICATIONS, AND INTELLIGENCE (BM/C3I) THRUST AREA

The area of BM/C3I offers outstanding opportunity to leverage high technology into improved operational capability. Good command decisions, based on accurate, timely intelligence information rapidly communicated to combat leaders, has a force multiplying effect. The BTI projects apply advanced technology to two different aspects of the BM/C3I problem. One approach addresses the requirement for enhanced command and control of fire and maneuver in small units. The other addresses the requirement for increased throughput and usability of high-level intelligence information.

Goals of BM/C3I thrust area

One goal of the BM/C3I area is to provide a force of fighting vehicles with the capability to operate as a unit, thereby increasing their effectiveness. Internetting and displaying the information provided by the collective sensors of the unit will allow each element in the force to be aware of the location of other elements and to exploit all the data supplied by multiple sensor suites. An additional goal is to provide the means for battlefield commanders to access and efficiently utilize the information available from National Technical Means and Theater intelligence resources.

BM/C3I projects

Projects in this thrust area include:

- Combat Vehicle Command and Control (CVC2)
- Artificial Intelligence Module (AIM)
- Image Exploitation System (IES)
- Tactical Use of National Technical Means (TACNAT)

The funding required for the BM/C3I thrust area is shown in Table 5.

Table 5. BM/C3I Thrust Area Funding ($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
68.9	12.4	6.9			88.2

COMBAT VEHICLE COMMAND AND CONTROL (CVC2)

Operational Utility of CVC2

Automation of combat vehicle cockpits

The objective of the CVC2 project is to overcome deficiencies in the way information is handled and processed by the crews of armored fighting vehicles. Currently, tank and other armored vehicle crews navigate and process order of battle information manually using paper maps with grease pencil overlays. The exchange of important tactical information, such as the location of friendly and enemy elements, relies upon voice radio communications and line-of-sight, manual reconnaissance. Enemy spot reports are correlated to map coordinates to derive data for supporting fire by estimation and manual triangulation. This process is inaccurate, time-consuming, and prone to error. Automation of these and other crew functions will increase the effectiveness of the crew and improve their ability to fight.

Technical Approach of CVC2

Electronics, communications, and software

The CVC2 approach is to develop and demonstrate the technologies for automating the cockpit of ground combat vehicles and for providing the networking of vehicles at the individual vehicle, platoon, company, and battalion commander echelons. CVC2 provides the required degree of cockpit automation through the development of three integrated elements. First, each fighting vehicle requires an electronics hardware suite of embedded processors, displays, data storage, and data bases to process, distribute, and display key tactical information. Second, the vehicles must have intervehicular communications to disseminate information among the various other vehicles in the battle formation. Third, the software and the soldier-machine interface must be implemented for order of battle displays, situation assessment, coordinating attack maneuvers, targeting, requesting/directing supporting fire, and updating and displaying digital map information.

Build on existing Army SAVA projects

The CVC2 is a joint BTI/Army project. The BTI portion concentrates on CVC2 concept definition and on the design of the interfaces among the soldier, the equipment, and the intervehicular communications. The vehicle hardware element is funded primarily by the Army under the Standard Army Vetronics Architecture (SAVA) program. The communications element will use available combat net radio assets to physically transmit the information. CVC2 leverages these efforts through the development of software and protocols for utilizing existing communications links to transmit digital tactical command and control information among internetted combat vehicle elements. The technical challenge is defining the functions to be performed and ensuring that these functions increase the overall effectiveness of the fighting vehicle. The BTI effort exploits the work done in simulation networking (SIMNET) to design and test the software and system functionality prior to fabricating hardware for field testing.

The project will design, build, test, and evaluate an integrated voice and data multifunction, lower echelon C3 system that interconnects with the higher echelon Army Tactical Command and Control System. Visual displays will be provided for:

- Intelligence data from battlefield sensors
- Command and control information
- Position location and navigation
- Logistics data (fuel, ammunition, etc.)
- Diagnostics and prognostics
- Embedded training

Nunn Amendment program

Nunn Amendment funding supports a parallel research and development effort between the U.S. and the Federal Republic of Germany under a CVC2 memorandum of agreement. The goals of this cooperative effort are to:

- Improve interoperability between allied ground combat vehicle forces
- Provide synergistic technology development and share research concepts and ideas
- Leverage the research and development resources of each country

The joint effort complements the BTI CVC2 project. The focus is on interoperability and includes the application of CVC2 technology development to current systems, such as the Leopard II and the M1A2 tanks. There will be a joint U.S./Germany demonstration of CVC2 interoperability in Germany in the summer of 1992.

Other related projects

Several ongoing programs interact with the CVC2 program directly or indirectly. CVC2 deals with command and control at the individual vehicle level. It implements the upper level Army Tactical Command and Control System of the Maneuver Control System at the battalion level and below. Common hardware and software will be used for the interface at the battalion level. This software can also be implemented in the Bradley Fighting Vehicle. The aviation community has an analogous program, the Rotorcraft Pilot's Associate, that is being considered for interoperability with CVC2. The ultimate goal is to apply CVC2 to the M1A2 and Armored Systems Modernization programs.

CVC2 Progress to Date

CVC2 projects on track and on schedule

Both the U.S. and the joint US/GE portions of the CVC2 projects are on track and on schedule. The CVC2 project successfully employed the SIMNET facility at Fort Knox, Kentucky, as a design tool. Company-level unit exercise experiments were conducted using CVC2-equipped tank simulators and soldiers from the U.S. Army Armor Center. The experiments assumed a perfect communications environment with no errors, transmission delays, or throughput limitations. As such, the results represent the load on the communications system. The statistics collected included message type, message preparation time, message review time prior to transmission, number of messages transferred between combat net radio networks, and others.

These experiments are particularly useful in that they provide a means to quantify the benefits of added capabilities. CVC2 capabilities that have been evaluated to date include an inertial position and navigation unit, a tactical display device, and a digital radio link. Measures of merit such as reduced fuel consumption, reduced planning time, improved reporting accuracy, and more rapid mission execution have been evaluated and have proven the value of CVC2 enhancements.

FY 1990 activities

Principal CVC2 project activities in FY 1990 included:

- Completion of the design effort and initiation of fabrication of the CVC2 suite for the M1A2
- Design and start of fabrication of the CVC2 suite for the Components Advanced Technology Test Bed (CATTB)
- Development of the Combat Net Radio Communications Protocol
- Company-level unit experiment using SIMNET
- Demonstration of the joint US/GE Long Haul Network Simulation
- Platoon-level unit experiment using the joint US/GE simulation capability

A new multidestination protocol was designed for the combat net radio environment. Initial results indicate a two- to ten-fold improvement in overall throughput when compared to the current baseline. Steps are being taken to have the new protocol accepted as the standard for the combat net radio environment.

CVC2 suitcase terminal development

Work has begun to define and specify the requirements for the CVC2 suitcase terminal, which will be required by non-M1A2 units desiring access to the CVC2 system. The suitcase terminal, which will be based on a laptop or light weight computer, must be consistent with other ongoing efforts such as the command and control systems for the Battalion and Below C2 System and the Light Infantry Division system. The intention is to meet all three needs with common hardware and use customized software, if necessary.

Interoperability concepts have been developed for fire support, air defense, aviation, intelligence electronic warfare, signal, chemical, and engineer elements as the interface with CVC2 in a battalion task force or company team. Analysis of planned hardware and software implementations was completed. An investigation of advanced voice, message, and graphics delivery and exchange techniques was accomplished in support of CVC2 groups. Voice recognition has been demonstrated for automatic composition of CVC2 messages and remote control of SINCGARS radios.

CVC2 Planned Activity

FY 1991 program plan

The FY 1991 program plan includes the following efforts:

- Integration of the CVC2 capability in the M1A2 leading to US and GE demonstration in FY 1992

- Integration and demonstration of CVC2 in the CATTB
- Design and fabrication of Extended CVC2 for the CATTB
- Demonstration of the joint US/GE battalion-level simulation leading to a joint experiment in FY 1992

All CVC2 experiments and field demonstrations should be completed in late FY 1992.

Preparations will begin for the battalion-level experiments at Fort Knox planned for October 91 through April 92. These exercises will demonstrate the interface between the Maneuver Control System (MCS) and the CVC2, the CVC2 suitcase, and the implementation of the multidestination protocol in the SIMNET tank simulators. Planning for the integration of CVC2 with the tank CATTB at the U.S. Army Tank and Automotive Command will continue. Initial testing and evaluation of the CVC2 workstations for the battalion tactical operations center will begin.

Possible French and British participation

Negotiations are underway by the Army to include United Kingdom participation in the CVC2 interoperability demonstration during the fourth quarter of FY 1992. France has also expressed interest. If France and the United Kingdom officially decide to participate in the CVC2 program, certain project modifications will be required. Additional user message formats will be needed to transmit unique French and British requirements across interoperability interfaces. These additional requirements have been anticipated, and the interface has been designed in a modular fashion.

CVC2 Resource Status

Table 6 shows the funding requirements for the different aspects of the overall CVC2 program including the Army funded VETRONICS program and the Nunn Amendment funded cooperative effort with the Federal Republic of Germany.

Table 6. CVC2 Funding
($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
21.7	23.7	17.1	6.7		69.2

Note 1: Includes Vetronics, BTI CVC2, and anticipated Nunn funding based on U.K. participation.

The total BTI funding line for FY 1989 and prior was $14.5 million. The FY 1991 and 1992 Nunn funding shown assumes that the United Kingdom enters the program.

ARTIFICIAL INTELLIGENCE MODULE (AIM)

Exploit intelligence information

This and the other remaining projects in BM/C3I thrust area support the second goal of improving the exploitation of intelligence information. IES and TACNAT, discussed later, will provide an enhanced capability to predict, locate, and target threats at deep ranges. AIM and TACNAT will provide a means to assimilate information into an assessment of the tactical situation for the commander. Operation Just Cause in Panama and Operation Desert Storm in Saudi Arabia have shown the need for this type of capability.

Operational Utility of AIM

Interpret information from sensors and other units

An expert system using artificial intelligence data bases and techniques will support the battlefield commander by improving the timeliness and accuracy of intelligence information provided. AIM, when combined with an advanced computer hardware base, will allow the intelligence analyst to rapidly process reports from all sources, determine the location and status of high value targets, estimate the enemy's capability in the near term, and translate a lack of information into intelligence system collection tasking. It performs automated military situation assessments and generates reports and maps more quickly and comprehensively than any developmental or fielded systems.

Technical Approach of AIM

This project exploits an open digital systems architecture and artificial intelligence technology. AIM will develop software to provide a common situation development framework for use by all intelligence staff elements at division, corps, and echelons above corps. The project will develop a standard set of intelligent analytical tools for integrating processed information from sources such as the Image Exploitation System and TACNAT with emphasis on fast, reliable, automatic throughput. The open systems architecture and artificial intelligence technology performs automatic situation assessment much more rapidly than any other fielded or development system.

AIM Progress to Date

Acceptance by field commanders

The AIM project is nearly completed. This system was used in a live exercise in Europe during 1990, processing over 356,000 digital messages and generating 18,500 Signals Intelligence messages. The AIM project has developed functional software to support the collection management, situation development, and high priority/high value targeting processes. Both truck-mounted and man-transportable ruggedized hardware have been developed. The hardware and software is designed to be compatible with the Army Common Hardware/Software Environment (Block 2).

Prototype used in Desert Storm

The initial truck-based prototype system was placed in operation with the Seventh U.S. Army Corps in Europe. Two systems are in use by the First and Third Armored Divisions. This test bed configuration is called HAWKEYE. It has been used in daily support of intelligence operations and in CENTAG and USAREUR command post exercises. HAWKEYE has performed successfully in at least four major exercises since it was introduced. The commanders of the Fifth and Seventh US Corps support the addition of

HAWKEYE to their indications and early warning capabilities. At their insistence, the 21 AIM prototype units were deployed to Saudi Arabia in support of Desert Shield and were used successfully in Desert Storm.

AIM Planned Activity

Operational service in Desert Storm

The Army Experimentation Site, Fort Lewis, Washington, is experimenting with the AIM system software in the same environment with the Marine Corps Intelligence Analyst System. USFORSCOM is also porting the systems environment to an Intel 486 system for conversion to the FORSCOM Automated Intelligence Support System (FAISS). A common file system is being developed to allow AIM and FAISS to exchange and share data in Desert Storm operations. Additional software functionality, expanding the system capabilities, and adding collection and analysis tools specifically suited to low-intensity, counter-terrorist, and nation building/peacekeeping missions has been proposed as a follow-on project. The Fifth Corps is considering AIM as an enhancement of the Fifth Corps simulation center control system. AIM functionality will also be available for use in Block 2 of the All Source Analysis System which will be hosted on Army Common Hardware (Block 2).

The BTI portion of the AIM program will be completed in FY 1991. Deployment of the system to Saudi Arabia will not affect completion of the program. The Army plans to use AIM at the U.S. Army Intelligence Center and School (USAICS). Additional Army funding is needed and has been requested by USAICS for operational systems support in FY 1991 and the outyears.

IMAGE EXPLOITATION SYSTEM (IES)

Operational Utility of IES

Major reduction in analyst workload

Existing and planned digital imaging systems collect data at rates beyond our ability to exploit the information effectively. The IES will perform automated, real-time analysis of multisensor images[10] to detect, recognize, position, and monitor military ground forces. The system will perform an initial screening of large amounts of image data, allowing human efforts to focus on high priority areas and on detailed analysis of objects of interest. By design, this capability will operate independent of the theater and level of conflict.

This approach will increase throughput by several orders of magnitude. Machine performance of repetitive, tedious tasks will speed the process, reduce the probability of human error, and allow analysis personnel to concentrate on critical aspects requiring human judgement. During peacetime, the IES will enhance the productivity of intelligence personnel in the areas of indications and warning (I&W) and in the treaty verification process. During wartime, the IES mission will expand to provide real-time input for

10 Images from sensors such as synthetic aperture radar (SAR) and infrared (IR) systems.

situation assessments, target development and acquisition, maneuver support, and the defeat of concealment or deception techniques.

Technical Approach of IES

Knowledge-based computer processing

The fundamental premise of the IES approach is that automated image exploitation using only image processing techniques independent of other supporting information is extremely difficult with the high false alarm rates characteristic of SAR and IR data. The IES development philosophy is to construct a knowledge based system incorporating information (knowledge) consistent with that used by image analysts to reason through the image-based observables and false alarms. IES currently uses multiple knowledge sources and databases (doctrinal, terrain, weather) in conjunction with signals intelligence to quickly and accurately exploit the imagery. This robust process removes the false alarms and increases confidence in the validity of the true detections.

IES Progress to Date

Requirements being met

The first development cycle of the IES project has been successfully completed. A formal demonstration of the capability was conducted in September 1990. The IES accurately processed information about Warsaw Pact forces that was gathered by an operational ASARS-2 system. The IES satisfied all the system requirements for speed, throughput, and accuracy that were levied on the system at this milestone. Subsequent testing results have validated the technical approach and the value of additional information sources. In response to operational requirements, the IES was being adapted to support Operation Desert Storm using a second SAR sensor. The system was being tested with imagery from the war when the conflict ended. Expanding the capability from Central Europe to Southwest Asia supports the program objective of a system that can operate in various theaters using information from a variety of sensors.

IES Planned Activity

The basic IES project was completed in FY 1990. Extension of IES to realize increases in speed and accuracy is described in Section 8.A.5.

TACTICAL USE OF NATIONAL TECHNICAL MEANS (TACNAT)

Operational Utility of TACNAT

Accelerate exploitation of valuable intelligence data

There is a wealth of intelligence information gathered by theater-level surveillance systems that cannot be fully exploited by tactical unit level commanders. Current and programmed sensors collect more intelligence data than can be effectively exploited in a timely fashion by human analysts. TACNAT is an effort to correct this deficiency. TACNAT technology provides automated solutions to traditional bottlenecks in intelligence analysis and addresses time intensive manual processes such as message handling, facility monitoring, and terrain analysis. The message handling capability speeds up the analysis and lessens the chance that

critical intelligence will be overlooked. The rapid execution of these functions is critical to defeating enemy weapon system cycle times. TACNAT provides knowledge-based expert systems which perform information extraction against digital intelligence message streams, force status assessments, and intelligence preparation of the battlefield. These tools greatly facilitate and accelerate the missions of collection management, sensor product exploitation, and targeting.

Technical Approach of TACNAT

Judicious application of computer automation using knowledge-based expert systems

TACNAT's automated tools for information correlation and fusion can have broad utility to tactical unit level commanders. Computer processing is optimized to handle the immense volume of data available at the intelligence centers at echelons above corps, corps, and division. This frees scarce analysts from the performance of mundane tasks and allows them to handle more subtle or complex problems that are best assessed by human intuitive techniques.

Automated message processing is used to screen and prioritize the large volume of incoming information. Automated facility monitoring allows a small number of analysts to keep track of the status of numerous enemy forces deployed in a large number of installations. Finally, automated terrain analysis reduces the strain and tedium of dealing with traditional cartographic products and lets the analysts concentrate on finding mobile targets.

TACNAT technology provides a top level view in that it aggregates numerous minor items of information that might appear insignificant in isolation. In addition, the system can provide consistency and continuity, both among different analysts and over time. The system can become a form of institutional memory on the installations and forces being monitored. Finally, TACNAT assists in optimizing both the timing and the selection of targets for the limited collection and strike assets.

TACNAT Progress to Date

Demonstrated in Europe

TACNAT development is essentially complete. TACNAT has demonstrated its utility to monitor, track, and target missions in a series of exercises against live targets in Europe. TACNAT has been successfully demonstrated against a variety of tactical units, including artillery, maneuver units, and air forces. Automated, accurate, and timely facility monitoring has been demonstrated.

The associated Terrain Production Facility is being transitioned to the Army Engineer Terrain Laboratory to enable the Army to produce terrain databases meeting Defense Mapping Agency Standards. TACNAT terrain analysis has consistently demonstrated the ability to reduce the size of an area to be searched and to perform such analyses much faster than current manual procedures.

TACNAT Planned Activity

TACNAT automated message handling and garrison monitoring technology will be deployed to a theater location in April 1991. The TACNAT tools will be employed to support monitoring, tracking, and targeting functions at echelons above corps.

SECTION V
SMART WEAPONS THRUST AREA

Offense and defense

This thrust area also has both offensive and defensive goals. The offensive goal is to apply "smart weapons" technology to precision guided standoff munitions to improve the effectiveness and survivability of air, land, and sea forces. The defensive goal is to apply advanced technologies to the task of countering the infrared missile threat to fixed-wing aircraft and helicopters. Specific projects include:

- Advanced Close Air Support Technology (ACAST)
- Autonomous Guidance for Conventional Weapons (AGCW)
- Electro-Cptical Countermeasures/Targeting (EOCM/T)
- Fiber Optic Naval Weapons (FOGW)
- Infrared Countermeasures Technology (IRCM)
- Low Cost Anti-Armor Submunition (LOCAAS)
- Millimeter Wave Seeker Demonstration (MMW)

Funding for the Smart Weapons Thrust Area is summarized in Table 7.

Table 7. Smart Weapons Thrust Area Funding Requirements ($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
40.5	32.3	23.3	5.0	227.2	

ADVANCED CLOSE AIR SUPPORT TECHNOLOGY (ACAST)

Operational Utility of ACAST

Goal: Penetrate, attack, and survive

Close air support (CAS) of troops in contact is an extremely difficult task in the modern high threat air defense environment. The tactics and weapons systems that were used in the permissive environment in Southwest Asia may not apply in many general or limited war scenarios. Yet the requirement to air deliver weapons in support of ground activities remains. We need the capability to deliver more weapons on target, increase survivability, and greatly improve day/night attack capability. Many of the technologies developed for smart weapons have potential application to this mission.

The purpose of the ACAST project is to develop and flight-demonstrate technologies that enhance the ability of a ground attack aircraft to find, identify, and destroy enemy ground targets on CAS and Battlefield Air Interdiction missions under day and night and adverse weather conditions. The project will exploit aircraft maneuverability and speed at low altitude in conjunction with electromagnetic emission covertness to increase survivability. Overall program goals include:

- First pass target acquisition and kill
- Survivable ingress and egress
- Night CAS/BAI capability

Technical Approach of ACAST

Apply and demonstrate advanced technologies

ACAST aids first pass target acquisition and kill through improved cueing, sensor aided target acquisition, and task automation. It is a result-oriented project that applies near-term technologies in a series of phased developments and flight demonstrations. The technologies cut across Service boundaries and apply to any aircraft required to perform the air-to-surface attack mission, night operations, or passive low-level operations.

Digitally internetted, ground attack operations between aircraft are being integrated with improved cueing, sensor-aided target acquisition, task automation, and precise weapon delivery for first pass target acquisition and kill. Aids are being developed to increase pilot situation awareness and to provide improved mission management and ingress/egress capability.

Technologies are being applied in a series of phased developments and flight demonstrations on the Air Force AFTI/F-16 technology demonstrator aircraft. Included are a sensor-aided acquisition radar (AN/APG-68), automated transfer of ground target data to the F-16, and display of the data on the heads-up display, an improved digital terrain system, an all-terrain ground avoidance system, night vision sensors and navigation FLIR, and an integrated helmet system.

ACAST Progress to Date

ACAST systems components integration and demonstration

This year's efforts have focused on test aircraft (AFTI F-16) modifications and test planning. Modifications to the technology demonstrator aircraft will be completed for flight test in early CY 1991. An automated target handoff system data link has been incorporated to permit a coordinated two-ship attack. The PAVE PENNY system has been installed to permit acquisition of laser designated targets. Recent exercises have demonstrated the capability to perform internetted operations between the test aircraft and a second F-16 and an Army fire support team vehicle. A helmet-steerable navigation FLIR, a night vision helmet, an APG-68 radar, and a digital terrain data storage and retrieval system have been installed for the next phase of demonstrations.

ACAST Planned Activity

ACAST testing supported by TAC

Flight test planning for the next phase of testing will be completed in June after initial flight envelope and systems tests at Edwards AFB, California. The flight tests will demonstrate the following capabilities:

- Improved tactical situation awareness
- All-terrain ground collision avoidance
- Manual night attack

Situation awareness will be provided by a digital terrain system that will provide intervisibility (line-of-sight) displays for both targets and threats with a comprehensive display of the dynamic ground situation. An integrated, ejection-safe, helmet mounted display will permit heads-up flight with accurate, passive estimation of target elevation and range states.

The ground collision avoidance system will prevent controlled flight into the ground from all aircraft attitudes by fuzing digital terrain data with a forward looking sensor. This capability will be an effective safety net for night, under-the-weather operations. Manual night attack will include the integration of a night vision device and navigation FLIR into a raster capable heads-up display to permit visual night attack.

The Air Force Tactical Air Command is the chief proponent for this project and considers the testing of near-term CAS enhancements to be a top priority. TAC looks to this program to define future CAS design requirements, particularly in the area of FLIR technology.

AUTONOMOUS GUIDANCE FOR CONVENTIONAL WEAPONS (AGCW)

The AGCW project is demonstrating a seeker that uses correlation of an infrared scene from an onboard sensor (a FLIR) with a stored image of the target area to achieve precision terminal guidance to fixed targets. The seeker can be adapted to cruise missiles, ballistic missiles, or bombs.

Operational Utility of AGCW

Long-range, surgical strike

The performance of the Tomahawk cruise missile in Operation Desert Storm showed the utility of autonomous weapons even though the Tomahawk conventional land attack missile has limited accuracy. A highly precise delivery system specifically designed for the attack of known, high value, fixed targets in any part of the world from standoff range can provide additional capability in the early phases of conventional attack or during SO/LIC operations. Successful demonstration of the concept requires a mission planning system, a weapon sensor and electronics for image processing, and algorithms for scene correlation and aimpoint selection.

Technical Approach of AGCW

Demonstrate mission planning and IIR terminal target acquisition

The BTI AGCW project includes efforts in mission planning as well as midcourse guidance and infrared imaging for target acquisition, terminal homing, and aimpoint selection. User prepared mission plans and existing intelligence data bases will constitute the basis of captive carry testing. This approach will ensure compatibility with existing user mission planning concepts. Midcourse guidance seeker functions and terminal target acquisition and tracking will be demonstrated in a realistic, free-flight aerodynamic environment.

Utility of PGMs proven in Desert Storm

AGCW has potential application to the GBU-24A/B (low-level laser guided bomb) and the AGM-130 rocket powered standoff weapons. It may also apply to other weapons such as the Advanced Interdiction Weapons System (AIWS) and other future standoff weapons.

AGCW Progress to Date

The aircraft adapter package and the AGCW control panel have both been installed and integrated into the aircraft airborne reference navigation system. The captive flight targets have been selected, and all the needed target information has been obtained. Free flight test targets and launch conditions have been selected. One of the targets did not already exist and had to be designed. The design is complete and construction has begun. Integration of the hardware-in-the-loop simulation is progressing. Efforts to reduce the noise level in the first sensor assembly are complete, and the assembly is now in the final stage of quality control. The second sensor assembly is being built up and should begin generating video by mid-March. Several new focal plane array devices have been selected and are in assembly.

Systems requirements reviews for the AGM-130, the GBU-24, and the Long Range Conventional Standoff Weapon (LRCSW) were conducted. Since LRCSW may not continue past the concept definition phase, emphasis was placed on cruise missile operational concepts and seeker requirements.

AGCW Planned Activity

Flight testing to be completed

Captive carry and free flight testing will begin in FY 1991 and finish in early FY 1992. Discussions will continue with the Navy and the Air Force concerning implementation in existing or developmental weapons.

FIBER OPTIC NAVAL WEAPONS (FOGW)

Operational Utility of FOGW

Eliminates shortcomings of RF data links

Experience with WALLEYE and GBU-15 has shown that precision guided munitions of this type can maximize target destruction while minimizing exposure of the launching and controlling aircraft to close-in and point surface air defenses. However, these weapons require a data link to a manned controller. Unsecure data links that employ radio frequency transmissions are vulnerable to jamming, the emitted signals can be exploited by enemy electronic support equipment, connectivity requires unobstructed line-of-sight, and the data link pod adversely affects aircraft performance. Replacing the RF data link with a fiber optic link avoids all these deficiencies. In addition, the bandwidth can be increased, allowing for higher data rates and the increased ability to use the data processing power available on the launch platform.

Reduces exposure, improves precision

Experience with laser guided bombs in Libya showed that tactical fighters maneuvering to avoid point defense threats can cause laser trackers to break lock and entirely miss the target. A fiber optic data link will eliminate this maneuvering restriction, plus increase the pinpoint accuracy of the weapon. Following weapon release, an aircraft can immediately turn away from the target while continuing to guide the weapon until impact.

Finally, aircraft video recording systems looking out the weapon nose through the optical fiber will permit better instant bomb damage assessment through more precise location of the impact point.

Technical Approach of FOGW

High speed payout of long fibers demonstrated

Funded as a program to develop a standoff naval weapon, FOGW is intended to demonstrate a hermetically sealed, dual spool fiber optic data link payout system suitable for air and surface launched precision guided weapons. The goal of the project is to demonstrate a low risk, cost effective, jam resistant, hermetically sealed, long length, high velocity payout system using advanced small diameter, high bandwidth fiber. A goal is to increase the range of fiber optic controlled weapons to at least 100 kilometers. Another goal is the development of an all-up-round so that fiber optic weapons can be adapted to aircraft delivery without modifying the aircraft.

Volumetrically efficient spooling techniques are being designed, developed, and tested to protect the fiber during storage and permit instantaneous payout when the weapon is released. Dual spool payout is necessary to accommodate the kinematics of post launch weapon and aircraft maneuverability, for high speed payout velocity, and for packaging the lengths of fiber needed for strike and interdiction weapons within reasonable size and weight constraints.

The primary technical challenges are high-speed fiber payout and system reliability. Technologies critical to meeting program objectives include:

- Optimized fiber adhesive for spooled fiber

- Transmitter/receiver electronics without repeaters for long fiber lengths
- Fiber/plume coupling
- Small orifice payout

The project is taking advantage of work done on the development of dual spooling techniques for air-launched weapons, the Army Fiber Optic Guided Missile (FOG-M) data link, and the airframe for the low-cost MK 82 Paveway II kit.

FOGW Progress to Date

Far exceeds Army FOG-M performance

The BTI fiber optic data link project demonstrated a four GHz data bandwidth over glass fiber being paid out of an A-3 aircraft. This wide bandwidth transmission capability and a newly demonstrated spooling and payout system make it practical to use these data links for target weapon and guidance even from tactical aircraft. These inexpensive data links are secure and jam proof, and they work in all kinds of weather, even over mountains and other obstructions.

Based on laboratory and field test results, the project determined that maximum use had been obtained from FOG-M technology hardware. The project has advanced beyond the limits of the Army FOG-M technology which is not suitable for high performance, medium and long range standoff systems.

Since the last BTI report to Congress, several laboratory tests, rocket plume sled tests, and flight tests have advanced toward all technical goals. Tests of fiber plume interaction indicate that the current design presents no serious burnthrough problems. No degradation of data link performance was noted as a result of interaction with the plume. The most serious problem is an increase in payout velocity if the fiber becomes entrapped in the plume. Tests of the aircraft modifications required by internal carriage of FOGW components revealed that the hardware and instrumentation will not interfere with normal bomb release. The project completed the design of a pylon which interfaces with existing avionics buses and provides volume for fiber optics spools and avionics.

Free flight tests

Following a series of captive carry tests, a bomb was dropped from an aircraft and guided by the aircrew to a target. This demonstration included retargeting the bomb while in flight. In other flight tests, up to 17 kilometers of optical fiber was paid out at velocities ranging from 250 knots to 512 knots at altitudes ranging from 500 feet to 22,800 feet.

Fiber-plume interaction

Rocket sled tests demonstrated that not only does fiber continue to perform well near a rocket motor plume, but also relatively short distance separation from the plume will eliminate excess fiber extraction by the higher speed exhaust. This also clears the way for implementation on existing weapons (e.g., AGM-130) and planned weapons with rocket motors.

Avionics partitioning

This task is determining the tradeoffs in removing expensive avionics from the weapon where they are destroyed and installing them in an "all-up-round pylon" on the launch aircraft where they can be reused. The first flight test passed a 4 GHz RF signal through fiber, virtually eliminating bandwidth as a design restriction. For practical purposes,

bandwidth between a fiber optic guided weapon and the aircraft is unlimited, opening up possibilities such as multiple seekers in the weapon with expensive image processing in the aircraft.

Linear payout systems

This task is developing the capability to transform the FOG-M spooled helical payout into a linear path that will pass through a one-quarter inch orifice. This will allow the fiber to be routed inside bomb bays on aircraft such as the F-117, B-1, B-2, and B-52 and inside rocket powered weapons such as Maverick where more separation from the plume is needed. For example, the fiber could be paid out from a hole in a fin. The small orifice will also reduce weapons signature while in flight.

FOGW Planned Activity

Transition to operable weapons systems

Near term efforts will concentrate on maturing the technology for transition into operable weapons systems. Maximum weapon range will be increased to 100 kilometers (60 miles) by increasing fiber carried using volumetrically efficient spooling techniques. In addition, several venders will be qualified to produce the fiber packages.

INFRARED COUNTERMEASURES TECHNOLOGY (IRCM)

Operational Utility of IRCM

Goal: An IRCM to defeat IR missile threat

The proliferation and increasing sophistication and counter-countermeasure capability of advanced infrared air-to-air and surface-to-air missiles present a major threat to fixed-wing and helicopter tactical air operations. Multi-engine SOF and airlift aircraft also operate in situations where shoulder-fired IR missiles present a threat. Existing countermeasure equipment. such as warning receivers used in combination with flare dispensers or modulated IR sources, are not able to provide high confidence avoidance of these missiles. The BTI IRCM project is addressing this deficiency by developing:

- An active laser source with precise pointing and tracking to produce damage or high confidence disruption of the guidance of current and advanced IR missiles.
- A prototype directional IRCM device for a helicopter which uses an active, incoherent flashlamp source to produce enhanced jamming and seeker performance degradation.

Technical Approach of IRCM

Laser IRCM for Fixed Wing Aircraft

This project will demonstrate a flyable prototype IRCM system intended for installation on a fighter-type aircraft. The system will satisfy size, weight, power, vibration, EMI, and thermal requirements. An existing Air Force/Martin Marietta LANTIRN pod will be modified in an attempt to meet as many operational requirements as possible at modest cost. The existing pointer/tracker device will be modified, and an existing parallel processor with

software provided by the Naval Research Laboratory will demonstrate operational performance at low cost. The Naval Research Laboratory threat warning algorithms, course track algorithms, and control functions will allow the system to operate in real time. Although the system is not required to meet all military specifications, care is being taken to achieve a valid demonstration of all critical countermeasure capabilities.

Incoherent Directional IRCM for Helicopters

A lower cost directional IRCM prototype is also being developed to protect helicopters from the newer, more sophisticated IR missiles. Maximum use is being made of off-the-shelf equipment. Hardware from previous development efforts is being used to integrate advanced optics, multiple IR flashlamps, and a more precise pointing mechanism with a modified IR warning receiver to achieve a high power, narrow focus, directional beam capable of 360-degree azimuth coverage.

IRCM Progress to Date

Component development and test

The effort began with work on missile warning system algorithms, laser measurements and testing, laser diode characterization, and potential systems effectiveness studies in FY 1989. The program activity increased with the start of the development of an aircraft IRCM prototype in FY 1990. A 40-watt countermeasure laser is being developed for an airborne demonstration in FY 1993. Concurrently, a mid-wavelength infrared laser that will meet operational requirements is also under development for laboratory demonstration.

Development of the directional IRCM prototype for helicopters was also started in FY 1990. The design is completed and components are being fabricated. The system includes a missile warning subsystem, a flashlamp modulation unit, and an electronic control unit. Generic jamming waveforms are being developed to cover a wide spectrum of threat missile seekers.

IRCM Planned Activity

Flight test in FY 1993

Pending successful completion of a critical design review in FY 1991, component fabrication and integration will begin to support ground and flight testing of the prototype system in FY 1993. The helicopter directional IRCM prototype device is scheduled to be field tested at the Sandia National Laboratory cable car facility in June and July 1991.

The Navy plans to incorporate the warning receiver into the F/A-18. A commitment to the entire system has been deferred until the BTI project reduces the risk associated with the laser.

LOW COST ANTI-ARMOR SUBMUNITION (LOCAAS)

Operational Utility of LOCAAS

Improve antiarmor capability at reduced cost per kill

Operational utility analyses of advanced weapons concepts usually show that these systems have utility and are cost effective when procured and deployed in sufficient numbers to make a difference. The problem has been that smart weapons are expensive, and their introduction into Service inventories has been constrained by cost. The objective of the LOCAAS project is to provide an anti-armor submunition at a cost low enough that the munitions will be bought in sufficient quantity to make a real difference. Fielding an antiarmor submunition that will meet Service performance and integration requirements and is effective against enemy armed vehicles including future battle tanks, yet can be provided at production costs on the order of $15,000 per submunition, would have a profound effect on the nature of conventional warfare.

The requirements for LOCAAS are based upon the Army ATACMS Block II, the Army Multiple Launch Rocket System, and the Air Force Standoff Attack Weapon requirements documents.

Technical Approach of LOCAAS

Modular integration of emerging technologies

The BTI approach to satisfying the requirements for low cost smart weapons is to develop and demonstrate submunition concepts that integrate emerging technologies. Modularity is one means being used to reduce the number of separate developments and overall costs. The LOCAAS concepts all have seekers with algorithms capable of autonomously finding targets; they have lifting airframes and control systems so they can fly to search for and then to reach a target; and they have warheads to destroy the target.

The seeker is a major technical challenge. The project will demonstrate performance and robustness against countermeasures throughout the mission profile of search, target acquisition, guidance and control, and warhead firing. The warhead design will be required to demonstrate penetration performance against specified targets.

LOCAAS Progress to Date

LOCAAS was a new project in FY 1990. The concept definition phase was completed with three contractors participating. Each of the contractors provided design definition and a production cost estimate for the submunition. The basic difference in the design definitions was in the seeker technology applied. One design used ladar, one used millimeter wave, and one used a combination of millimeter wave and infrared technologies. An extensive evaluation was conducted based on an analysis of effectiveness and performance, clarification of design-to-unit-production-cost goals, cost-per-kill trade studies, and identification of the high risk areas. This culminated in the selection of two submunition designs -- the one using ladar and the one using millimeter wave. The system and subsystem design phase has begun.

LOCAAS Planned Activity

The system and subsystem design phase will continue with planned completion in early FY 1992. Subsystem fabrication and test is planned for the second year of the three-year project. The final year will be devoted to integration, fabrication, and demonstration of the system on operational targets.

MILLIMETER WAVE SEEKER DEMONSTRATION (MMW)

Operational Utility of MMW

Autonomous standoff weapon

Current air launched standoff precision guided weapons require a man in the loop during weapons flight to ensure effectiveness. The purpose of this effort is to demonstrate the application of millimeter wave seeker technology to standoff air-to-ground weapons. This project will provide the Air Force with a candidate day/night, adverse weather, autonomous, lock-on-after-launch weapon for standoff delivery against fixed and mobile air defense units, moving and massed armor, and other mobile battlefield and second echelon targets. This project will integrate MMW seekers on AGM-65 Maverick airframes for flight testing through a competitive demonstration program.

Technical Approach of MMW

Demonstrate proof of concept

The technical goals to be achieved in this project include:

- Demonstrate MMW seeker maturity and readiness for full-scale engineering development
- Demonstrate the ability of the seeker to locate targets in clutter and discriminate targets by type
- Assess seeker susceptibility to countermeasures
- Integrate a MMW seeker with the Maverick center and aft sections
- Obtain multiple launches and kills per aircraft pass
- Unit production cost to be less than $110,000[11]

There are several key technical issues to be addressed by this effort. They include development and demonstration of algorithms to enable the seeker to discriminate air defense units from other targets, to reduce the number of false alarms, to operate in a countermeasures environment, and to terminally track and hit targets. Integration of the

[11] FY 1987 dollars for 10,000 units.

MMW seeker with the Maverick airframe to permit impact at less than normal speed is also a technical challenge.

MMW Progress to Date

Captive carry tests successful

Both of the contractors in this Congressional Special Interest program have tested brassboard seekers. Both seekers performed well in captive flight tests flown against realistic target arrays including the SA-6 air defense system simulator and a variety of tanks and other armored vehicles. Tests were conducted in both low clutter and high clutter environments. These seekers work especially well against moving vehicles and rotating antennas. The MMW seeker easily detected and tracked the target air defense unit. Moving targets are easily detected because of the moving-target-indicator design. The also work against arrays of stationary vehicles, but less capability is available with stationary targets. Hardware fabrication and software refinement continued in support of planned free flight missile tests. Hardware-in-the-loop testing continued. Special targets have been fabricated for the captive carry tests and planned missile launches.

MMW Planned Activity

Free flight testing planned

High speed captive carry and free flight testing will be conducted in FY 1991. The MMW Maverick program demonstration should be completed in early FY 1992 with FY 1991 funds. The operative Program Management Directive requires a Milestone II decision in FY 1993 and subsequent start of FSD. TAC is considering whether MMW Maverick will fulfill the need for an Advanced Attack Weapon under the terms of the approved Statement of Need 317-87.

SECTION VI
SPECIAL OPERATIONS/LOW INTENSITY CONFLICT THRUST AREA

The goal of the SO/LIC thrust area is to provide Special Operations Forces with an improved capability for covert and night operations. SO/LIC projects include:

- Swimmer Delivery Vehicle (SDV)
- Enhanced Aircraft Survivability
- Systems Applications for Uncooled Focal Plane Arrays (UCFPA)

The resources required for the SO/LIC thrust area are summarized in Table 8.

Table 8. SO/LIC Funding Requirements ($ millions)

FY 90 & Prior	FY 91	FY 92	FY 93	FY 94	Total
38.2	9.4	6.6	6.8		60.9

SWIMMER DELIVERY VEHICLE (SDV)

Operational Utility of SDV

Goal: Deliver forces ready to fight

Naval Special Warfare forces, Army Special Operations forces, and Air Force Combat Control Teams involved in special operations and conventional defense operations have a need for a capability to insert swimmers into operational areas from safe standoff distances. The advanced SDV will correct deficiencies identified in current systems and will possess classified operational characteristics required by special operations units.

Relative to the current swimmer delivery vehicle, the advanced swimmer delivery vehicle will provide increased standoff range and reduced vehicle signature, permit clandestine maneuver at very low speeds in confined harbors and estuaries, and provide the capability to deliver special forces personnel to the combat area in better condition to perform their mission ashore.

By integrating technology advances in several areas, this project will demonstrate the following improvements:

Three technology areas

- Increase internal payload volume by 50 percent while remaining within external volume constraints.
- Increase available stored energy for propulsion and life support by 75 percent. Improve battery cycle life ten-fold.
- Increase propulsion efficiency by 15 percent while providing for low speed maneuver and control below two knots.

Navy SDV program

The Navy is funding a separate effort to develop a Seal Delivery Vehicle for Naval Special Warfare. Due to cost and schedule constraints, the Navy project is taking a low-risk technical approach. The BTI project will parallel the Navy effort with technology demonstrations in time for use in full scale development of the Navy SDV. Success in the BTI program will have a direct effect on the Navy SDV design.

Technical Approach to the SDV

The two-year, BTI effort addresses technical issues in three separate but related areas: improved propulsion, hull materials and design, and energy storage.

Propulsion concept

The propulsion requirements will be met by an adaptation of the Stability Controlled Augmented Thruster (SCAT) that was developed as a 6.2 project for the submarine and Naval Special Warfare communities. SCAT is an advanced propulsion concept that improves maneuverability, efficiency, usable volume, and stability and reduces acoustic signature. The concept, a state-of-the-art brushless DC motor/controller, will be refined and integrated into an operational SDV prototype. Control mechanisms will be redesigned for improved operation, reliability, and maintainability.

Innovative hull design

Hull requirements will be met using an innovative composite monocoque structure. The hull is fabricated by spirally wrapping high pressure, carbon fiber gas storage hose into the desired configuration. The hose material, developed and tested under this program, is laminated between inner and outer composite skins to form a monocoque hull. This design significantly improves gas storage packing efficiency, provides a stronger, lower maintenance hull than the current welded aluminum, and provides excess buoyancy, permitting the inclusion of additional batteries. The increased hull strength will also make it possible to lift the vehicle by crane at sea.

Silver-iron batteries

Energy storage needs will be met using modular silver-iron batteries. Compared to existing technology, these developmental rechargeable batteries offer operational and logistical advantages:

- High energy density
- Improved cycle life (200 plus deep discharges)

- Recharge on board the SDV in less than eight hours with no cell monitoring
- Tolerant to abuse

This project will integrate the advances in these three technology areas with existing subsystems and perform a demonstration and validation of a prototype advanced technology SDV.

SDV Progress to Date

Demonstrated proof of concept

The David Taylor Research Center has conducted a proof of concept demonstration of SCAT. The results indicate that additional work is required under the BTI program to re-design and test the motor controller for the brushless motor/controller system. The David Taylor Research Center and the Massachusetts Institute of Technology are cooperating on the development of ducted cyclic pitch propeller hydrodynamics and associated duct/blade geometry. Two cyclic pitch mechanism concepts have been designed to improve reliability and are being evaluated. A selection of the preferred design will be based on tradeoff studies.

The Naval Coastal Systems Center has provided drawings of the composite hull design for preliminary stress analysis. The models are being refined to realistically reflect full-scale mid-body hull sections. Loads equivalent to 50,000 pounds have been applied to the finite element models and the structural responses are being studied. Technical specifications for the manufacture of the composite mid-body structure are under development. The high pressure gas hose design has been tested at five times operational pressures to validate analytical predictions. Preliminary material selection and trade off studies have been conducted.

Technology transfer issues identified

The Naval Coastal Systems Center has identified pertinent safety issues for the silver-iron batteries. These have been included in the test plan. Magnetic signature testing of the silver-iron cell has been completed. Technical specifications for safety and life-cycle testing are complete. The Naval Weapons Support Center, Crane, Indiana, is contracting for the fabrication of the modular batteries.

Issues related to the transition of technology from the BTI SDV project to the Navy SDV effort have been identified. The draft transition report will be refined in accordance with changes in the Navy program schedule.

SDV Planned Activity

Separate technology investigations

To improve the timeliness of technology development in parallel with the Navy SDV, the three technologies will be investigated separately during the demonstration and validation phase of the project. Separating the investigations minimizes the risk to the entire project by decoupling interdependent schedules. It also maximizes the probability of successful transition of each technology to the Navy SDV program. Separation allows the Department of the Navy Laboratories to work in the technology areas where they are best qualified.

Separation will also permit a complete and comprehensive evaluation of each technology based solely on its own merit, benefits, and deficiencies. The decision whether to demonstrate all the technologies on a single integrated platform will be deferred until after the Milestone II decision for the Navy SDV.

ENHANCED AIRCRAFT SURVIVABILITY

Operational Utility of Enhanced Aircraft Survivability

Reduced emission avionics development

It has become increasingly difficult to operate undetected in airspace covered by enemy air defense systems. Fighters, bombers, and special operations aircraft rely increasingly on low altitude flight and night operations to ensure survivability. This increases pilot workload and the risk of obstacle collision.

Active Service support

The Air Force is serving as the executive agent for the BTI project to enhance aircraft survivability. Air Force support for the BTI project was demonstrated by the addition of $2.5 million for risk reduction and schedule protection in FY 1989 and the provision of a B-1B radar system, inertial navigation units, computers, displays, global positioning system hardware, etc., at no cost to the program. The technology is being considered for use on the B-1B.

TECHNICAL APPROACH TO ENHANCED SURVIVABILITY

Goal: Demonstrate low altitude penetration without detection

This project develops and integrates aircraft subsystems to achieve high survivability of large aircraft that must penetrate defended airspace. The testbed is a C-130 aircraft, but the subsystems can be adapted to other large aircraft such as bombers, gunships, and special operations transports. The project is structured to obtain quick user evaluation of BTI-developed capabilities through a comprehensive set of laboratory and flight tests.

Progress to Date

Subsystem integration and demonstration completed

Efforts during FY 1990 concentrated on the integration and demonstration of subsystems. Phase I development and demonstrations are complete.

Planned Activity

Potential B-1B application

Project developments are directly applicable to MC-130 aircraft and other large aircraft used by special operations forces. The developments are also applicable to bomber and fighter aircraft, especially those that use low altitude flight to maximize survivability. Integration and aircraft simulation tasks continue into FY 1991. Flight demonstrations, data collection, and test results reporting will be completed in early FY 1991. The Combat Talon program has allocated funding for modifications to incorporate some of the technology.

The project will continue with the initiation of Phase II activity in third quarter FY 1991. (See Section 8.)

UNCOOLED FOCAL PLANE ARRAYS (UCFPA)

Earlier technology development programs at the Army's CCNVEO (formerly Night Vision Laboratory) and DARPA showed that practical uncooled infrared detector arrays could be made. The BTI project extends this technology to achieve greater sensitivity and demonstrates the use of the technology in several applications.

OPERATIONAL UTILITY OF UCFPA

Low cost night vision

Uncooled focal plane arrays can be used in a variety of devices, such as surveillance systems for perimeter defense, weapons sights, vehicle driving viewers, unmanned aerial vehicles, and weapons guidance systems. The devices will be useful to every branch of the Services in many applications.

Infrared sensors, particularly focal plane arrays, have contributed significantly to the efficiency and effectiveness of night operations in Operation Desert Storm. However, current long-wave infrared focal plane arrays must be cooled to cryogenic temperatures to work. The need for cooling to achieve adequate mid-range and long-range operation has contributed to the cost and complexity of these sensors. As a result, they have not been procured in the quantities desired. Use of advanced compound semiconductor materials to fabricate uncooled IR sensor arrays for short and mid-range applications, such as rifle sights, is expected to substantially reduce the cost of these systems and permit additional surveillance and munition sensor applications.

Simple, cheap, and effective IR seekers

Infrared imaging systems based on UCFPA devices offer particular advantages over current technology systems for Army and SO/LIC applications. The use of a staring focal plane array eliminates the need for mechanically complex scanning mechanisms. The resulting system is lighter, smaller, and less prone to malfunction. Current IR imagers use cryogenics to cool the detector material and reduce systems noise so that low contrast targets can be discerned. Uncooled detector technology eliminates the need for cryogenics, further reducing power requirements, complexity, and weight and improving reliability and availability. Because of its simplicity and low cost, uncooled detector technology can be used in moderate performance imagers and could be acquired in sufficient quantities to significantly expand the application of IR systems in troop operations. It will be possible to make lightweight systems that will operate on battery packs for a duration of more than 10 hours.

Technical Approach of UCFPA

This project will investigate two different technologies, bolometer and ferroelectric, and demonstrate their application in two areas.

- Individual weapon sights and area surveillance devices
- Man-in-the-loop and autonomous munitions seeker-sensors

Technical challenges

The key technical challenges are:

- Achieve the detector noise-equivalent temperature difference for medium range applications
- Obtain reproducible, large detector arrays with highly uniform response and few dead elements
- Develop small, low cost, low power electronics packages capable of operating in an operational environment .

UCFPA Progress to Date

Sensitivity and uniformity objectives being met

The UCFPA project was begun in January 1990 to complete DARPA uncooled FPA developments and to apply them to needed capabilities. The project has developed two infrared sensor technologies and has demonstrated the fabrication of large (200x400 pixels) long wave infrared focal plane arrays. Sensitivity and uniformity improvements needed for the advanced uncooled weapon sight and area surveillance applications are being approached.[12] Both have achieved an interim goal of 0.3 Kelvin NEDT and are making good progress toward the final goal of 0.1 Kelvin. Imaging systems are being demonstrated with both technologies. Breadboard and brassboard versions have been produced competitively by two contractors. One contractor has produced an easily carried surveillance system.

UCFPA Planned Activity

Fabricate prototypes and demonstrate performance

Performance achieved in this project is sufficient for surveillance devices, weapons sights, and driving devices. A weapon sight and a surveillance system will demonstrate short range applications based on the current level of performance; then missile and munitions seekers will demonstrate the higher level of performance achieved by the ongoing research.

12 NEDT of 0.10 to 0.15 degree Kelvin in the 8 to 12 micron band.

SECTION VII
HIGH POWER MICROWAVES THRUST AREA

Improve performance and develop hardening techniques

This thrust area differs in concept from the others. The FY 1990 appropriations bill included Congressional direction to the BTI program to demonstrate the utility of ultra wideband high power microwave technology for military applications. The goal is to find ways to exploit the perceived benefits of this technology. The Ultrawide Bandwidth High Power Microwave Project (UWB/HPM) was initiated with the following objectives:

- Investigate the phenomenology and performance of UWB radar system designs in comparison with conventional radar systems.
- Test the susceptibility of important types of U.S. and allied electronic systems to UWB/HPM radiation and conduct promising defensive and offensive prototype demonstrations.

The funding requirements for this thrust area are shown in Table 9.

Table 9. High Power Microwave Thrust Area Funding ($ millions)

FY 90	FY 91	FY 92	FY 93	FY 94	Total
1.9	4.6	10.0	10.0		(Note)

Note: Continuing program, total undefined

ULTRAWIDE BANDWIDTH HIGH POWER MICROWAVE PROJECT (UWB/HPM)

Operational Utility of UWB/HPM Technology

High payoff potential

The use of ultrawide bandwidth technology may permit the development of radars with extremely fine range resolution and may enable the detection of stealthy and camouflaged targets. Substantial performance improvements may be attained in a variety of application areas, including:

- Foliage penetration

- Point defense for ships and land vehicles
- Short range mine detection
- Short range surveillance and target recognition
- Short range structure penetration
- Missile seekers

Damage and disruption of important electronic systems such as radars, communications, missiles, and explosive detonators using UWB/HPM radiation may offer significant unconventional countermeasure capability during tactical operations. Enhanced survivability of U.S. electronic and weapons systems as well as substantial disruption of hostile systems may be possible with minimum cost and performance penalties.

Technical Approach of UWB Technology Project

Comparative testing

UWB radar utility is being investigated in two major tasks. Initially, the phenomenology, analysis and design methodology, and estimated performance associated with promising point designs are being established. Clutter performance, potential 3-D imaging, and other potentially important advantages will be examined. The performance of conventional radar versus time-domain UWB radar system designs will then be compared analytically and experimentally. Development of appropriate components and test bed prototypes will be accomplished as required to permit comparative field tests.

The susceptibility of systems to UWB/HPM radiation is being established in conjunction with the DOD High Power Microwave Program using standardized tri-service methodology. This approach is based on the analytical prediction of effects followed by low power characterization (disruption) tests. An initial assessment of susceptibility is made and then validated using high power characterization (damage) testing. Techniques for hardening existing and developmental electronic systems will be validated in the field using an instrumented test bed. Assessment of hardening techniques will also be conducted during field testing.

UWB Progress to Date

Potential applications being investigated

A preliminary study of the potential utility of UWB radiation focused on the potential advantages of UWB radar in tactical military operations. A number of systems applications were recommended for future development as listed above. The U.S. Army Harry Diamond Laboratory has initiated analytical and experimental investigation of an UWB foliage penetration synthetic aperture radar design. The Naval Research Laboratory is investigating an UWB point defense radar concept, and the Naval Ocean Systems Center is conducting UWB microwave clutter measurements and analysis projects. Industry participation has been initiated on a competitive basis to participate in the investigation of radar phenomenology and examination of promising point designs.

Narrowband conventional microwave radiation is effective in the laboratory in disrupting the normal functions of electronic systems. UWB radiation has not been investigated in similar detail. Limited experiments indicate that similar results may be obtained using simpler, cheaper sources that perform against a wider range of potential targets. A laboratory and field test program has been initiated to assess the susceptibility of radar, communications, missiles, and other electronic equipment to UWB effects and to validate hardening concepts. A widely proliferated U.S. tactical radar system was found to be susceptible to upset by microwave radiation within the passband of the radar receiver. On a different system, a previously unknown susceptibility to a modulated source was discovered as well. This information has been brought to the attention of system designers. Earlier, BTI published a design handbook on hardening electronic systems against microwave radiation.

UWB Planned Activity

Design, develop, and test prototypes

UWB radar phenomenological analyses and measurements will be completed during the second quarter of FY 1992. Point design of UWB systems and system experiments will be completed during the last quarter of FY 1992. Selection and development of promising prototype systems will be initiated in the first quarter of FY 1993 based on the results of the previous effort.

UWB/HPM laboratory tests on electronic equipment will be completed during FY 1992. Field test validation of selected assets will be conducted during FY 1993 and completed during FY 1994. Transfer of the results of effects testing will be made as they become available. Transfer of hardening concepts will be made upon the completion of field testing.

SECTION VIII
FUTURE PROJECTS

In this section we describe the efforts that are beginning in FY 1991, and we suggest some candidates for BTI projects in the outyears. In addition, we offer some ideas for pre-FSD prototype projects that could be undertaken with high potential payoff if the decision were made to increase the scope of the BTI program.

PROGRAMS PLANNED FOR FY 1991

The following projects are beginning in FY 1991:

Two new starts

- Multi-Mission Seeker (MMS)
- Advanced Tactical Radio Technology (Speakeasy)

In addition, there are three projects that begin new phases:

- Deep Battle Weapon
- Enhanced Aircraft Survivability Phase II
- Image Exploitation System Phase II

Multi-Mission Seeker (MMS)

The MMS effort is a FY 1991 new start in the Smart Weapons thrust area. Present weapons systems, both fielded and under development, are designed for specific missions and targets. This limits the potential broader utility of the weapons, increases weapons costs, and produces hardware that cannot be readily adapted to other missions and systems. The development of weapons such as missiles with the capability to handle ground and airborne targets and be launched from surface and airborne platforms will reduce the need to dedicate platforms to a specific target set, increase responsiveness to unexpected targets and targets of opportunity, and enhance overall battlefield effectiveness. A multi-mission seeker capability is essential to the feasibility of multi-mission precision guided weapons.

Improved weapons utility

MMS will demonstrate target engagements at a five- kilometer standoff range and top attack of targets in heavy clutter. The primary mode of operation will incorporate special processing of the infrared signal. When this cannot be done, the seeker will resort to basic IR guidance techniques. The special processing capability will permit acquisition and engagement of particular targets in clutter at standoff ranges greatly in excess of the current capability.

Overcome a serious clutter problem by a special processing technique

Potential applications of the MMS include crew served and vehicle mounted ground-to-ground systems, attack and armed reconnaissance helicopter munitions for air-to-air and air-to-ground engagements, close air support munitions, and as a technology insertion candidate for future ground-to-air and air-to-air missiles.

The project will utilize an instrument that has been developed in an earlier BTI project to capture and characterize phenomenology as needed to establish design parameters. The effort will take advantage of recent imaging technology developments, such as advances in infrared focal plane array technology, large throughput processing, and specialized algorithms. The Army will use this information to develop design specifications for the seeker platform and target options.

The award of a contract for the seeker development is anticipated in the third quarter of FY 1991. Seeker designs will be completed by the end of FY 1993. The test and evaluation phase will continue through FY 1994. Funding for the MMS project is shown in Table 10.

Advanced Tactical Radio Technology (Speakeasy)

Next generation combat radio

Speakeasy is a FY 1991 new start in the BM/C3I thrust area. A tri-service development program has been established to introduce emerging technology into the next generation of combat network radios. The project will demonstrate the technology required to provide an advanced multi-platform, multi-mode, multi-band tactical network radio. The common microprocessor-based architecture maximizes the use of digital microelectronic technology and permits flexible operation of HF to L-band radio links by insertion of appropriate internal components and antennas. This will result in unprecedented versatility in frequency, bandwidth, and waveform and should solve many of the current communications incompatibilities and vulnerabilities.

Development of an ECM-resistant programmable signal processor (PSP) which implements the modular architecture is a key factor in successful demonstration of the capability. A relatively low risk microprocessor and other existing digital/analog technologies were planned before BTI entered the process. However, the size, weight, and power requirements resulting from the use of this technology may limit many of the envisioned airborne and ground tactical applications. BTI has initiated coordinated development and insertion of selected key advanced technologies including wafer-scale microelectronic integration; MMIC, microstrip, and advanced antenna technologies; gallium arsenide residue number processing; and advanced analog filters. These will provide a more efficient architecture, improved performance, reduced power requirements and physical parameters, and an expanded user network.

Demonstration of Speakeasy is planned during FY 1993. Coordinated demonstration of the advanced PSP is expected to permit greatly reduced production costs and a four-year reduction in the overall network radio development schedule.

Deep Battle Weapon

Counterforce ATBM capability

Recent events confirm that finding and destroying mobile missile launchers is a very difficult task. The means to locate the launchers must be coupled with a weapon that can search a rather large area and reacquire the launcher even if it is camouflaged or partially obscured. The Deep Battle Weapon is a BTI submunition that can perform the search and then destroy the launcher.

The purpose of this project is to develop and demonstrate a wide-area-search, sensor-fuzed submunition capable of delivery by tactical surface-to-surface missiles such as MLRS and ATACMS. In addition to surface-to-surface missile launchers, the target set includes enemy command and control centers and mobile command posts.

An earlier effort was started in FY 1987, but it was unfunded in FY 1990. In FY 1990 we considered expanding the requirements to include those of LOCAAS. However, other approaches were chosen for LOCAAS, so funding has been restored in FY 1991 to enable the earlier project to meet only its original purpose. The Deep Battle Weapon will be managed for BTI by DARPA with technical support from the Army Armament Research, Development, and Engineering Center (ARDEC).

The concept envisions dispensing three sub-munitions from the MLRS missile and 18 from ATACMS. The submunition descends on a parafoil device which permits search of an area as large as 260,000 square meters during descent. A dual-mode sensor and automatic target recognition algorithms will provide a robust target acquisition and classification capability reducing precision delivery requirements and the number of rounds needed to negate the chosen target class.

The principal technical challenges to be addressed in the project are finding targets in clutter, transitioning from parafoil flight to a spin-stabilized end-game engagement, developing multisensor algorithms, and optimizing the performance of the fragmenting warhead. Demonstration of submunition performance is planned to occur in FY 1993.

Enhanced Aircraft Survivability Phase II

As a result of the success achieved in Phase I, planning for a Phase II effort has been approved.

Image Exploitation System Phase II

Improve accuracy and reduce time

The second development cycle of the IES project will be initiated in FY 1991. The project will continue to develop and evolve functional system capabilities required to improve system accuracy, reduce processing times, and extend the operational applications to handle different threat types. The goal is to reduce the exploitation time for a ten nautical mile

square area to ten minutes at 80 percent accuracy.[13] This should be accomplished in a field demonstration in FY 1991.

Specifically, the IES will extend the system to handle the full spectrum of Southwest Asian contingencies and will add an initial Combined Forces Europe (CFE) Treaty verification capability. In early 1992, IES will deploy an operational system at the U.S. Army Intelligence Center and School (USAICS). This deployment will support both user testing and introduce the next generation of image analysts produced at USAICS to automated technology so that they become comfortable and confident using the capability.

Funding Requirements

The funding required for the five new start or Phase II efforts planned for FY 1991 is shown in Table 10.

IDENTIFICATION OF POTENTIAL PROJECTS

Candidate BTI projects identified

Language in the FY 1991 Authorization Conference Report requires the identification of other programs that should be considered for inclusion in the BTI program.[14] Approximately 50 potential projects were defined and evaluated as part of the process of selecting the FY 1991 new start projects. The two highest ranking candidates, Speakeasy and the Multi Mission Seeker, were selected. Other candidate projects that offer promise are described in paragraphs 1 through 4 below.

Table 10. Funding Requirements for FY 1991 New and Extended Efforts ($ millions)

FY 91	FY 92	FY 93	FY 94	Total
23.3	37.6	39.6	5.3	105.8

Opportunities in an expanded BTI program

We have also given thought to the types of projects that BTI might undertake if the current constraints were relaxed to permit larger projects. This review led to a list of projects that are carried further toward the Milestone II Decision. In other words, these projects develop pre-FSD prototypes.

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13 The current demonstrated performance is 15 minutes at 75 percent accuracy.

14 Appropriations Conference Report for FY 1990, Section 211, Report 101-331, November 7, 1989.

Pre-FSD projects identified

The eight projects suggested for pre-FSD prototypes (projects 5 through 12 below) are larger than those now in the BTI program. Each would require between $50 million and $120 million. Current BTI projects are funded at between $20 million and $60 million. Project duration would typically be three to five years, but this could be shortened to two to four years if streamlined procurement procedures were authorized. In any case where a subsequent Service program is intended, the Service would be expected to define requirements and the concept of operations, perform comparisons with alternative ways to meet the need, and prepare for the appropriate Milestone Decision points.

1. High Power Microwave Demonstration

Application of BTI results

This project would exploit the progress made in the basic BTI project in UWB/HPM susceptibility investigations. That work is developing susceptibility data on electronic systems as well as developing HPM source technology. The suggested demonstration would build a fieldable prototype of an offensive/defensive HPM source to counter the electronic systems in radars, guidance, aircraft, and communications applications.

2. Aviation Fiber Optic Guided Missile

Low cost precision guidance applied

This project would be an extension of the work being done in the FOGW project. A light weight (70 lb), soft-launched, fiber optic guided weapon that could be launched from helicopters and fixed wing aircraft would be useful against bunkers, fighting vehicles, and helicopters. Fiber optic guidance would permit man-in-the-loop selection of the target and reduce the possibility of fratricide due to "friendly fire." It would also permit indirect fire to improve survivability of the launch platform.

Advanced technology image processing is needed to quickly recognize the target and select the aimpoint. The weapon will automatically guide to the aimpoint. Like other fiber optic guided weapons, cost can be kept low because the image processing and much of the guidance processing will be performed by a computer on the launch platform rather than on the missile.

3. Terminal Defense Munition

Alternative to CIWS

The Terminal Defense Munition is a guided round for the naval 5-inch gun to provide ship defense against sea-skimming missiles. For many naval vessels this might be a less expensive, more capable replacement for the Close-In Weapon System (CIWS). If successful, the current BTI project, Navy ET Gun, will satisfy this mission requirement on ships that are equipped with CIWS.

4. CL-20

CL-20 is a new energetic material for explosives, ammunition propellant, and missile propellant that is both more energetic and safer to use than current materials. It is important because of its potential for wide application and for the additional margin of safety

provided. The Navy has a program to characterize CL-20 and scale up the production process. BTI could support projects to apply this material to warheads and rocket motors.

5. Variable Flow Ducted Rocket (VFDR)

Enhanced AMRAAM performance

The VFDR is a solid propellant, air breathing propulsion system with a variable throttle fuel gas generator. A solid rocket booster is integral with the VFDR combuster. The VFDR uses several advanced technologies -- consumable closures, nozzleless boosters, etc., that have not yet been applied to an integrated missile system. The VFDR airframe would be demonstrated with an AMRAAM seeker and would extend the "no escape zone" by a factor of two or three.

6. Submarine Torpedo Defense

Active torpedo defense

This project would demonstrate an anti-torpedo torpedo for close-in self protection of submarines. It would include the detection, classification, and localization needed to employ the defensive weapon. This project was started in BTI, but it was terminated because of funding limitations. The Navy planned to continue development upon completion of the BTI project, but they were unable to pick up on the work that BTI abandoned. The Navy plans to resume the program on a protracted schedule. If the project were resumed as a BTI pre-FSD effort, the schedule could be shortened from six years to three years, and the Navy would budget for the follow-on FSD.

7. X-Rod All-Up-Round

As described in the basic BTI project, X-Rod is a guided hypervelocity 120mm round for tank main guns. This effort would extend the BTI X-Rod project to a pre-FSD prototype with testing of two concepts adequate to support a Milestone II decision. Each contractor would produce and test about 30 all-up-rounds after extensive component, subsystem, and captive carry testing.

8. Guided Multiple Launch Rocket System

Guided weapon for MLRS

The accuracy of the MLRS can be improved by a factor of six or more by the inclusion of a low cost inertial measurement unit (IMU) for projectile guidance. The payoff for conventional warfighting is great, particularly when the MLRS carries smart submunitions. The project would first use an available IMU, then would transition to a micromechanical IMU currently in development to obtain a low-cost guided round. The only exotic technology involved is the micromechanical IMU, currently funded by SDI.

9. Light Fighting Vehicle (Light Tank)

This project would develop a prototype of a vehicle using composite hull and chassis, an advanced engine, and gun or missile armament to satisfy the low weight required by the Marine Corps for deployability and transportability. Add-on armor would be provided to

meet the needs of the Army. The technologies needed for such a vehicle are reasonably mature. The project would produce prototypes for testing prior to a Milestone II decision.

10. Land Mine Detect and Clear

This project incorporates several basic BTI developments. An ultrawide bandwidth radar would be used to detect buried mines, and a high power microwave source and a gun would be used to clear the mines. The basic experiments and measurements needed to reduce the risk and assure systems effectiveness are underway in the BTI UWB/HPM project.

11. Air-to-Surface Standoff Weapon

Improved munitions effectiveness and platform survivability

This prototype project would apply conformable carriage and advanced shaping, materials, and construction technologies to achieve a low-drag, low-observable, versatile 2000-lb standoff weapon for destruction of shelters, command posts, and other hard targets. It would employ an imaging seeker and a boosted warhead. The project would be coordinated with the Navy 1000-lb cluster Advanced Interdiction Weapon System.

12. Air Launched Conventional Attack Missile

This project would develop a pre-FSD prototype of a 200-km precision guided missile for strategic bombers to provide a world-wide, quick reaction capability. Two classes of missions would be supported:

- With a data terminal on the launch aircraft to receive targeting data and with the appropriate submunitions the system would be effective against mobile targets, artillery companies, missile launchers, and tank companies.
- With an autonomous precision guidance system and a hard-cased warhead, the system would be effective against fixed targets such as buried command posts, hardened shelters, and power plants.

The project would use the Army Tactical Missile System (ATACMS) airframe that is now in production. A B-52 could carry at least 12 missiles, and each could be launched against a different target.