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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, R-1 #51				
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	130.610	153.067	162.100	121.407	73.561	64.553	66.260	Continuing	Continuing
Rapid Strike Force Technology LNW-01	27.817	14.651	9.000	23.719	23.794	29.761	31.507	Continuing	Continuing
Small Unit Operations LNW-02	41.205	23.216	25.000	34.688	34.767	34.792	34.753	Continuing	Continuing
Future Combat Systems LNW-03	61.588	115.200	128.100	63.000	15.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Three broad efforts are being pursued in support of this objective: Rapid Strike Force Technology, Small Unit Operations and Future Combat Systems.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces. The Rapid Strike Force Technology project is developing the technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The primary thrusts of this project include: 1) the Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program that will design, develop, test and transition a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles to the Services; 2) the Solar Blind Detectors program that will develop technologies to enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles; 3) the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams of, mobile robots in complex terrain; and 4) the Metal Storm program that will develop a system to pack, transport and fire at variable sequence rates.

(U) The goal of the Small Unit Operations project is to develop critical technologies that will enable dispersed units to effectively perform warfighting operations at varying locations. The Services are pursuing new tactical concepts for employing small, easily deployed units as an

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early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat Systems (FCS) program was developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities. The FCS program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of an ensemble of manned and unmanned ground and air platforms. DARPA studies identified six key areas where technology development is needed to support the overall FCS system of systems design: robotic perception, unmanned ground combat vehicles, maneuver command control and communication (C^3), beyond line of sight fires, organic all weather targeting air vehicles and advanced laser radar sensor systems.

(U) **Program Change Summary:** (*In Millions*)

	FY 2001	FY 2002	FY 2003
FY02 Amended President's Budget	129.025	153.067	182.100
Current Budget	130.610	153.067	162.100

(U) **Change Summary Explanation:**

FY 2001 Increase reflects minor program repricing.

FY 2003 Decrease reflects completion of the situational awareness and urban robotics programs, and reprioritization of agency requirements.

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COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	27.817	14.651	9.000	23.719	23.794	29.761	31.507	Continuing	Continuing

(U) Mission Description:

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Reconnaissance, Surveillance and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Solar Blind Detectors; and Metal Storm (MS). These programs are closely coordinated with the U.S. Army, Navy and Marine Corps, and with DARPA's Small Unit Operations (LNW-02) project.

(U) The Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate and transition to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension. The vehicle will also host integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting (RST) sensor subsystems. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ACTD as well as address joint U.S. Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV), Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g., Capable Warrior).

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(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with a team of semi-intelligent, cooperating robot prototype platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: machine perception, autonomous operation and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz; and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction; and (b) traversal of rugged/complex terrain using one command per 100 meters of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to one meter per second over 25 cm steps and decimeter-scale rubble with open terrain sprint speeds of three meters per second.

(U) The Metal Storm program will demonstrate a revolutionary technique for firing tactically relevant projectiles at very high rates without the need for internal moving parts. The elimination of moving parts from the system should significantly reduce production and operation and support costs. It will also decrease the level of maintenance required in the field. The hardstand firing tests and demonstrations should set the stage for any service to scale and/or customize the technology for any number of current and future applications (vehicle self-defense, anti-personnel landmine replacement, ship self-defense, anti-materiel sniper rifles, etc). This effort utilizes innovative, multi-purpose, high-pressure sabot designs and projectiles for rifled barrels and will conduct a live-fire test fixture to demonstrate the following capabilities from a tactically relevant 0.40-0.50 cal. system: 1) Electronic sequential firing of three or more projectiles from a *single* barrel with the shortest possible time interval between rounds (i.e. dependent on internal projectile velocity and barrel length, tentatively 1.5msec = 40,000 rounds per minute/barrel). 2) Every projectile from a single barrel will penetrate 25.4 mm of rolled homogenous armor (RHA) at 1000 meters (0 degrees obliquity). 3) Maximum vertical spread of 1 1/2 minute of angle at 300 and 600 meters. Studies will be conducted to explore the feasibility and applicability of Metal Strom technology to other weapon systems, including vehicle self-defense, anti-personnel landmine replacement, and a naval self-defense system. Through a Project Arrangement under the Deutsch Ayers Agreement between the U.S. and Australia, the Defence Science & Technology Office (DSTO) will perform work in the areas of scaling, modeling and simulation, and small arms live fire testing.

(U) The Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD) program will build upon products from the MAV technology program (PE 0602702E, Project TT-07) and the Organic Air Vehicle program (Project LNW-03). It will focus on the development of MAVs to accomplish unique military missions, particularly with regard to flight operations in restricted environments. The mission areas are small

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unit reconnaissance and surveillance, and support of military operations in urban terrain. The resulting capability will be beneficial in varied warfighting environments such as complex topologies (i.e. mountainous terrain with caves), heavily forested areas/dense foliage/triple canopy jungle, confined spaces (often internal to buildings) and high concentrations of civilians where it may be critical to determine the neutral or hostile intent of a crowd. The initial MAV technology development program focused on the technologies and components required to enable flight at small scales, including flight control, power and propulsion, navigation and communications. It successfully demonstrated a new class of air vehicles, MAVs, which are at least an order of magnitude smaller (between 15 and 23 cm in diameter) than previously available flying systems. The MAV ACTD program will also leverage other DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, advanced electronic packaging technologies, and lightweight, efficient high-density power sources. The primary goal of the MAV ACTD program is to further develop and integrate MAV technologies into militarily useful and affordable systems suitable for dismounted soldier, marine, and special forces missions.

(U) The Solar Blind Detectors program (formerly titled "Vehicle Self-Protection") developed an ultraviolet (UV) solar blind, solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($6.894 Million)
  - Participated in the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ACTD.
  - Demonstrated V-22 compatibility.

- Tactical Mobile Robotics (TMR). ($10.214 Million)
  - Completed initial prototype development.
  - Completed initial design of Human Robot Interface for multi-robot control, heterogeneous platform collaboration and marsupial operations.
  - Initiated tactical experiment plan with fully functional platforms to determine operational value baseline.
  - Refined collective experimentation plan.

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- Solar Blind Detectors Program. ($3.673 Million)
  - Demonstrated solar-blind detector array with 256 x 256 pixels.

- Metal Storm (MS). ($7.036 Million)
  - Performed scaling analysis of Metal Storm technology to larger calibers.
  - Completed .45-caliber smooth bore proof-of-principle barrel/ammunition design.
  - Conducted studies to explore the feasibility and applicability of Metal Storm technology to other weapon systems.

(U) **FY 2002 Plans:**

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($5.314 Million)
  - Integrate and demonstrate Survivability Suite.
  - Complete RST/ C^4I test.
  - Rollout vehicles 3 and 4.
  - Continue development and integration of high packaging density electronics and control technologies to include battery power conversion, thermal management, and systems control.

- Metal Storm (MS). ($5.919 Million)
  - Conduct vented bomb tests.
  - Conduct preliminary smooth bore test firings with U.S. contractor and Australian government partner.
  - Perform a series of rifled bore proof-of-principle test firings with performance increasing to the minimum time interval between rounds and 1200 m/s muzzle velocity.
  - Demonstrate a preliminary reloading concept.

- Tactical Mobile Robotics (TMR). ($3.418 Million)
  - Complete final prototype modifications.
  - Initiate full team integration including multi-modal Human Robot Interface and collaborative platform system.
  - Conduct initial collective platform experiments in unscripted tactical vignettes.

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– Initiate transition to military departments.

(U) **FY 2003 Plans:**

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($3.000 Million)
  - Participate in Joint C^4I Enabler Advanced Concept Technology Demonstration.
  - Integrate mission-specific equipment.
  - Conduct Limited Technical Assessment at Yuma Proving Ground.
  - Deliver vehicles 1, 2, 3, and 4.
  - Deliver final report.

- Tactical Mobile Robotics (TMR). ($1.000 Million)
  - Complete transition to the services.
  - Conduct follow-on studies for perception and route planning systems.

- Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD). ($4.000 Million)
  - Demonstrate electric MAV in Military Operations in Urban Terrain (MOUT) exercises.
  - Conduct experiments with troops in field trials.
  - Evaluate lessons learned and design of internal combustion engine powered MAV.

- Metal Storm (MS). ($1.000 Million)
  - Design and simulate high performance, multi-barrel systems for launching 40-50 millimeter supersonic projectiles.
  - Conduct testing and assessment of critical system components.

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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 2001	FY 2002	FY 2003
Reconnaissance, Surveillance and Targeting Vehicle (RST-V)	2.750	2.990	1.000
PE 0603640M Marine Corps Advanced Technology Demonstration			
Micro Air Vehicles ACTD			
PE 0603001A Army	0.0	10.0	0.0
PE 0603750D OSD	0.0	1.0	3.5

(U) **Schedule Profile:**

Plan	Milestones
Metal Storm (MS):	
May 02	MS: Demonstrate single-barrel electronic sniper rifle.
Mar 03	MS: Multi-barrel electronic sniper rifle Critical Design Review.
Reconnaissance, Surveillance and Targeting Vehicle (RST-V):	
Mar 02	RST-V: Integrate and demonstrate Survivability Suite.
Jun 03	RST-V: Participate in Joint C^4I Enabler Advanced Concept Technology Demonstration.
Aug 03	RST-V: Final Report.
Sep 03	RST-V: Deliver Vehicles 1, 2, 3, and 4.
Tactical Mobile Robotics (TMR):	
Dec 02	TMR: Complete transition and technology to military services.
Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD):	
Jul 03	Demonstrate electric MAV in military operations in urban terrain exercises.

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COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Small Unit Operations LNW-02	41.205	23.216	25.000	34.688	34.767	34.792	34.753	Continuing	Continuing

(U) Mission Description:

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threats are located. The Services are developing lightweight communication and Global Positioning Systems (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator and Global Hawk have been developed to monitor the enemy's movements and characterize the battlespace. Under current configurations, these capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technologies are poorly configured to operate in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and is not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Small Unit Operations Project is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated aggregration and mining of information sources to provide a “bubble” of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and self-forming ad hoc networked communications that “glue” the components together, operate in any environment, are covert and resistant to interference. In addition, these technologies must not significantly increase the dismounted force’s mass and power burden. The programs that make up this project include the Situational Awareness System (SAS), Tactical Sensors, Optical Tags, Wolfpack, Advanced Sensing Technologies and Robotics.

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(U) The Situational Awareness System (SAS) will integrate a variety of communications, navigation and data processing technologies into an eventual 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The radio frequency module will be interoperable with the Army Land Warrior equipment and provide much greater functionality. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. This program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested and mountainous terrain. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the SAS functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises to provide independent validation of the SAS functionality.

(U) The Tactical Sensors program will develop unattended ground sensors, planning tools, deployment mechanisms, and the command and control that will provide the warfighter a capability to detect, track and classify mobile tactical targets. These systems provide a local, in-situ sensing capability deep in denied areas. Information provided by these systems can be fused with other assets to enhance the aggregate situational awareness of U.S. forces. Applications include surveillance, cueing, precision targeting, intelligence and battle damage assessment with respect to time critical mobile targets.

(U) The Optical Tags program will investigate optical technologies and innovative design and fabrication techniques for kilometer-range optical tag systems, which provide a quantum leap in tactics and operations in a wide variety of applications. The Optical Tags program will develop validated models to predict system performance in support of a selected set of applications for technology demonstration. The program will select a relatively mature application, such as marking or tagging, and a relatively immature application, such as precision strike. The applications will be selected based on their operational significance and user input. The Optical Tags program will perform system engineering to develop systems performance requirements for the applications and will demonstrate the systems in meaningful warfighter experiments.

(U) The Wolfpack program will develop technologies that would enable the U.S. to deny the enemy use of radio communications and radars throughout the battlespace. This will culminate in a networked system of autonomous, ground-based monitors/jammers linked together to cooperate and avoid disruption of friendly military and protected commercial radio communications and radars. The specific technologies to be developed include: (1) high efficiency sub-resonant antennas, (2) networking algorithms to allow coordinated access to the spectrum by communicators,

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jammers and SIGINT systems, (3) methods to easily deploy the systems in RF advantaged sites, and (4) algorithms to rapidly and autonomously detect, classify, identify and jam target signals with low power electronics.

(U) The Advanced Sensing Technologies program will develop a completely new class of sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, classification, cueing and bomb damage assessments at distances much greater than current capabilities. The sensors will use recent technical breakthroughs to exploit vulnerabilities and permit access to the target signatures. This program completed in FY 2001.

(U) While great progress has been made in robotic technology, practical military applications has been limited to specific niches such as explosive ordnance demolition including mine clearing. For the biggest military impact, general-purpose robots are needed. The Robotics effort will focus on using robotic technology to impact operations in urban areas: the insides of buildings, intricate distribution channels including sewers, sub-urban terrain of all types, and roads. This environment poses many difficulties for today's military and offers the hardest challenges for mobility, perception, and manipulation. This program will also focus on aspects of biological inspiration for generating new robotic platforms with maneuvering ability, sensing and autonomy compatible with combat, especially in urban terrains.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- Situational Awareness System. ($16.056 Million)
  - Completed fabrication of Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) Mobile and Base, tactical sensors and tactical relays for test.
  - Integrated IWSAS, WTA-Mobile and Base with external legacy communications, data and sensor equipment.
  - Tested integrated system and conducted performance assessment of final Phase 3 design; measured IWSAS, WTA and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments.
  - Completed development of detailed demonstration scenarios to test and evaluate performance under operational conditions.

- Tactical Sensors. ($11.702 Million)
  - Continued development of internetted remote control sensors and fusion algorithms to detect, localize and characterize targets.

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– Continued development of surveillance and targeting sensor systems for dispersed operations.

- Optical Tags. ($3.886 Million)
  – Fabricated appliqué-based optical tag with appropriate spectral response and demonstrated that it achieves desired performance over kilometer-class range.
  – Developed performance model in the mature (e.g. ground-to-ground) application, for both appliqué and random matrix tags, and predicted performance over a wide range of scenarios.

- Advanced Sensing Technologies. ($2.909 Million)
  – Completed brassboard and initiated fieldable sensor development.

- Wolfpack. ($6.652 Million)
  – Initiated system design and performance analysis.
  – Conducted analysis for the applicability of distributed ground jammers to attack surface to air radar systems.
  – Initiated development of networked, distributed jamming enabling technologies.

(U) FY 2002 Plans:

- Situational Awareness System. ($7.115 Million)
  – Complete prototypes.
  – Develop training materials and conduct soldier training for field demonstration.
  – Conduct field demonstration to verify communications performance in urban, forested and mountainous terrain when operated by warfighters. Show the use of multiple organic sensors being operated by battalion and below warfighters.

- Optical Tags. ($0.610 Million)
  – Design and test portable interrogator and detector system to support testing of the tags at ranges up to 1 Km in field environments.
  – Develop and test remote tag emplacement method.

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- Tactical Sensors. ($3.918 Million)
  – Complete development and field-test internetted remote control sensors to detect, localize and characterize targets.
  – Develop prototype planning tools and complete designs of deployment mechanisms.
  – Interface to operational command and control console.

- Wolfpack. ($11.073 Million)
  – Continue development of enabling technologies.
  – Complete system design and performance analysis.

- Robotics. ($0.500 Million)
  – Demonstrate mobility of legged vehicles superior to those of tracked and wheeled vehicles.
  – Demonstrate sensor systems based on biomimetic principles compatible with operations in urban terrain.

(U) **<u>FY 2003 Plans:</u>**

- Wolfpack. ($19.000 Million)
  – Complete enabling technology development.
  – Verify low duty cycle, low power jamming techniques with benchtop experiments.
  – Construct and lab test brassboard-jamming subsystems.
  – Conduct limited lab tests using brassboard equipment to attack several legacy type communication systems.

- Robotics. ($1.000 Million)
  – Develop concepts for autonomous control of robotic platforms.
  – Integrate mobility and sensor concepts into taskable and/or autonomous platforms.

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- Conduct field-testing of unmanned systems based on results generated in FY 2002 to validate models and update accordingly.

- Situational Awareness System. ($1.500 Million)
  - Complete transition to U.S. Army, U.S. Marine Corps and United States Special Operations Command (USSOCOM).

- Optical Tags. ($1.500 Million)
  - Develop an eye safe tagging and interrogator system.
  - Improve the response efficiency of the tags.
  - Demonstrate system operation at ranges up to 1 Km.

- Tactical Sensors. ($2.000 Million)
  - Fabricate and demonstrate four unattended ground sensor clusters in an end-to-end, turnkey system for Volcano system launch from a Blackhawk helicopter.
  - Demonstrate extremely high confidence levels of time critical target classification and precision target tracking.
  - Design, prototype, and evaluate the field performance of Volcano-compatible sensor nodes for detection and tracking of dismounted targets.
  - Conduct preliminary designs and concepts for the emplacement and utilization of nodes in urban environments.

(U) <u>Other Program Funding Summary Cost:</u>

	FY 2001	FY 2002	FY 2003
Wolfpack, Geolocation and Disruption of Terrorist Communications Defense Emergency Response Fund (DERF)	0.000	0.000	(8.000)

This emergency supplemental effort to the WolfPack program will enable near real time geolocation of terrorist radio communications using both military and commercial systems, and surgically deny usage of those communication systems through the use of a precise,

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coordinated response. As a Suppression of Enemy Air Defense asset, close proximity WolfPack systems will also permit non-lethal disruption of enemy radar systems, including possible terrorist reuse of civilian platforms.

(U) Schedule Profile:

Plan	Milestones
Situational Awareness System:	
Jun 02	SAS prototypes fabricated.
Sep 02	SAS final demonstration.
Tactical Sensors:	
Jul 02	Participate in field exercise.
Robotics:	
Sep 03	Field test of unmanned systems.
Wolfpack:	
May 02	System Design/Technology Assessment Review (Phase III).
Nov 02	Initial Enabling Technology Demonstrations (Phase II).
Sep 03	Final Enabling Technology Performance Review (Phase II).
Jun 04	Subsystem field-testing complete (Phase IV).
Optical Tags:	
May 02	Increased Range Field Demonstration.
Sep 02	System Design Review/Technology Assessment.
May 03	Demonstrate Eye Safe Tagging System.

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COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Future Combat Systems LNW-03	61.588	115.200	128.100	63.000	15.000	0.000	0.000	0.000	N/A

(U) <u>Mission Description:</u>

(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat Systems (FCS) program was developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities.

(U) The FCS program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of an ensemble of manned and unmanned ground and air platforms. The goal of the FCS program is to design such an ensemble that strikes an optimum balance between critical performance factors, including ground platform strategic, operational and tactical mobility; lethality; survivability; and sustainability. This system of systems design will be accomplished by using modeling, simulation and experimentation. The FCS unit will be capable of adjusting to a changing set of missions, ranging from warfighting to peacekeeping, as the deployment unfolds. An FCS-equipped force will be capable of providing mobile-networked command, control, communication and computer (C^4) functionalities; autonomous robotic systems; precision direct and indirect fires; airborne and ground organic sensor platforms; and adverse-weather reconnaissance, surveillance, targeting and acquisition (RSTA).

(U) DARPA studies identified six key areas where technology development is needed to support the overall FCS system of systems design: robotic perception, unmanned ground combat vehicles, maneuver command control and communication (C^3), beyond line of sight fires, organic all weather targeting air vehicles and advanced laser radar sensors.

(U) The Perception for Off-road Robotics (PerceptOR) program will identify and develop revolutionary unmanned vehicle perception prototypes. These perception systems will be flexible enough to operate in off-road environments and will be backed by extensive experimental test data in a variety of operationally relevant terrain and weather conditions. The resulting technology will be applicable to a variety of combat roles and will enable greater confidence in postulating the conditions under which unmanned off-road robotics should be used. The use of advanced remote imagery and small numbers of collective robots will be included in the approaches taken.

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(U) The Unmanned Ground Combat Vehicle program will develop vehicle prototypes exhibiting advanced performance in endurance, obstacle negotiation, and transportability (small size) based on novel designs unrestrained by the need to accommodate human crews. These prototypes may include unique mobility configurations (traditional wheeled/tracked to organic-mimicking, i.e. walking/crawling), exceptional drivetrains, advanced structures/composites, terrain/soil analysis, sensory exploitation and interaction with robotic control architectures.

(U) The Maneuver C^3 program will develop robust, assured and potentially high data rate connectivity for the Future Combat Systems (FCS) elements along with a command and control architecture to reduce the number of forward deployed Command and Control (C^2) operators. The communications component will develop an integrated architecture that provides for a seamless transition from line-of-sight to non-line-of-sight communications. To enable this functionality, development of new secure waveforms, directional antennas and mobile ad hoc networks will be initiated. The C^2 component will directly leverage the Army's investment in the automation of the Battlefield Functional Areas within the Army Battle Command System (ABCS). Because of the multitude of single aspect systems that feed information in ABCS, large amounts of data are made available to the commander, thus requiring a much larger staff of operators and workstation analysts to complete the fusion function of battlefield data into information for the commander to make decisions. Future operations involving FCS technologies and operational capabilities cannot be restricted by a less responsive C^2 architecture and large support staffs. The FCS C^2 program will attempt to integrate and compress selected Battlefield Functional Area functions in a scaled architecture to support the FCS Unit Cell operations. Through the use of advanced information technologies and knowledge base engineering, this program will attempt to develop an advanced method of command and control, which integrates the previous stove-piped Battlefield Functional Areas (BFAs) into a single integrated information environment (Commander's Support Environment, CSE) which will support the command and control of manned and unmanned systems. The technical approach is to use IT to facilitate the synthesis of information presented to an FCS Commander by moving as much of the information/data integration to a HW/SW environment thus allowing the Commander and Battle Managers to leverage existing operational opportunities by focusing on fewer unknowns, clearly visualize current and future operational end states and dictate the tempo of operations within a variety of environments, while being supported by a significantly reduced staff. The true compression and integration of these functions would provide the FCS commander with information for rapid decision making vice numerous data streams requiring analysis by a large battle staff. The compression of these selected functions would enable a reduction of personnel in the Unit Cell C^2 element, and facilitate anticipatory planning and adaptive execution by the FCS Commander. A top level C^2 architecture (systems and operational) will be developed and validation of the architecture and assessment of performance (e.g., command latencies) will be achieved by conducting a series of four experiments within a simulated environment.

(U) The Netfires (formerly Advanced Fire Support System) program will develop and test a containerized, platform-independent multi-mission weapon concept as an enabling technology element for FCS. NetFires will provide rapid response and lethality in packages requiring

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significantly fewer personnel, decreased logistical support and lower life-cycle costs, while increasing survivability compared to current direct fire gun and missile artillery. NetFires will allow FCS to defeat all known threats, will be air deployable in C-130 (and smaller) aircraft, and will enhance the situation awareness and survivability of FCS by providing standoff target acquisition and extended-range, non-line-of-sight engagements. The program will develop and demonstrate a highly flexible modular, multimission precision missile and a loitering attack missile that can be remotely commanded. Both missile types will have a self-locating launcher and a command and control system compatible with FCS.

(U) The Organic All-Weather Targeting Air Vehicle program provides FCS direct and indirect weapons system targeting under all operating conditions at the small unit level. The approach is to develop all weather vehicles for operation at two tiers; an upper tier for wide area coverage and a lower tier that allows a close-up view for positive target identification. For the higher tier, the A160 Vertical Take Off and Landing (VTOL) Unmanned Air Vehicle (UAV) program will develop a vehicle for carrying out airborne surveillance and targeting against ground targets. The A160 vehicle will further provide an airborne communications/data link relay between the various ground components and the command nodes and SATCOMs. In addition, the A160 will deploy unmanned ground sensors (UGS), unmanned ground vehicles (UGV), and Micro Air Vehicles (MAV) and provide a data link between them and the C^2 components. For the lower tier, the Organic Air Vehicle (OAV) program will develop a small (<75 lbs) air vehicle that can fly autonomously in adverse weather. It will leverage DARPA Micro Air Vehicle program technologies and design a ducted fan vehicle that is scalable between 9 and 29 inch outside diameter to accommodate varying missions and payloads.

(U) The Jigsaw program will develop advanced laser radar (LADAR) sensor systems and technologies for day/night target identification and verification in stressing environments. Stressing environments include targets hidden by foliage and camouflage, and targets in urban settings, such as alleyways and alcoves. The sensor systems and technologies developed under this project will support the needs of FCS and will enable human observers to perform combat identification reliably and confidently through a visualization of the target scene by the LADAR sensor(s).

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- FCS Concept Development. ($15.288 Million)
  - Identified key technologies, technology tradeoffs, and technology roadmaps.
  - Established program Integrated Data Environment (IDE).
  - Developed detailed Program Acquisition Strategy and evaluated alternative strategies to accelerate system fielding.

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- Initiated Government Experiment activities to identify critical questions and understand the impacts of selected solutions.
- Defined program metrics and structure modeling and simulation activities to address those metrics.
- Developed baseline operational documentation.
- Began to identify the role of FCS as it relates to the Army's vision of an Objective Force.

• FCS Supporting Technologies. ($46.300 Million)
- PerceptOR.
  - - Developed unmanned maneuver algorithms that use a combination of on-board and off-board sensors and terrain data to maximize the level of autonomous operation.
  - - Developed four surrogate perception prototypes for testing in FY 2002.
  - - Performed high resolution Lidar, visible, and multi-spectral imagery data collection from air platform over terrain containing several forms of forest, meadow, and pond areas in both winter and summer vegetation conditions.
  - - Analyzed these data sets to determine what size and type of features could be automatically detected for ground vehicle navigation improvement.
- Unmanned Ground Combat Vehicle (UGCV).
  - - Completed 11 Preliminary Designs for UGCV prototypes including finite element structural analysis, preliminary obstacle negotiation simulations, and endurance calculations to support the primary program metrics.
  - - Highlighted critical technologies for achieving higher mobility and endurance in configurations associated with payloads of both 150 kg (~330 lbs) and 1500 kg (3300 lbs) as representative of reconnaissance and weapons carrier vehicles respectively.
  - - Initiated procurement of Long Lead hardware for Phase 1B testing in FY 2002.
  - - Selected 4 designs for continued Critical Subsystem Testing and Detail Prototype Design (Phase 1B) in FY02.
- Maneuver C^3.
  - - Developed top-level architecture (operational and systems) for the FCS Unit Cell.
  - - Defined and initiated the development of the FCS Unit Cell Commander’s Support Environment (CSE).
  - - Established a C^2 laboratory environment to conduct applied research in C^2 for FCS.
  - - Initiated the design of the C^2 architecture for the lowest, integrated FCS echelon (“unit cell”).
  - - Conducted the first of four experiments in December 2001.
  - - Developed simulations for the integrated “unit cell” C^2 architecture.
  - - Examined potential wireless communications network architectures.

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- - Developed technologies for assured communications in a hostile environment using novel waveforms and beam steering antennas for low probability of detection and anti-jam.

– Netfires.
- - Continued system hardware and software development for missiles, container/launchers and command/control units.
- - Completed critical component demonstrations for motor, seeker, navigation and data link.
- - Planned and initiated preparations for flight-test demonstrations.

– Organic All-Weather Targeting Vehicles.
- - Determined requirements for organic air vehicles to be used as sensor platforms.
- - Developed air vehicles capable of operating in adverse weather.
  - Defined A160 systems for operating in adverse environments: rain, icing, sand/dust, salt spray, and turbulence.
  - Defined A160 Synthetic Aperture Radar/Moving Target Indicator (SAR/MTI) radar sensors and designed Radar/A160 interfaces.
  - Initiated ground and flight test phase of A160 air vehicle AV001.
  - Designed and initiated fabrication of Organic Air Vehicle (OAV) capable of autonomous flight.
  - Conducted OAV integrated technology systems demonstration.

– Jigsaw: LADAR Sensing for Combat ID.
- - Initiated development of technology that can identify hidden targets by poking through holes in foliage and camouflage and by combining 3-D images from multiple viewpoints to "see" through partial obscuration.
- - Conducted trade studies to determine best technological approach to LADAR sensing for FCS application, including lasing, detection, and data processing.

(U) **FY 2002 Plans:**

- FCS Concept Development. ($30.000 Million)
  – Carryout concept and technology demonstration (CTD) to support decision for transition to System Development and Demonstration (SDD) in 2003.
  – Select single Lead Systems Integrator (LSI) to carryout CTD program in partnership with the Government.

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- FCS Supporting Technologies. ($85.200 Million)
  - PerceptOR.
    - - - Conduct perception system prototype development testing in both laboratory and field.
    - - - Conduct unrehearsed evaluation experiments on early perception system prototypes in variety of terrain and environmental conditions.
    - - - Conduct algorithm development for advanced perception behavior.
  - Unmanned Ground Combat Vehicle (UGCV).
    - - - Complete critical subsystem testing and detailed prototype designs.
    - - - Select two designs for full prototype fabrication.
    - - - Initiate prototype fabrication.
    - - - Conduct initial UGCV surrogate tests.
  - Maneuver C^3.
    - - - Validate organic, self-contained approaches versus approaches that “reachback” to other systems for C^2.
    - - - Select wireless communications network architecture(s) for implementation.
    - - - Demonstrate sub-system components for assured communications in a hostile environment using novel waveforms and beam steering antennas for low probability of detection and anti-jam.
    - - - Refine Commander’s Support Environment (CSE) and expand CSE knowledge base and collective intelligence module.
    - - - Continue to refine and expand supporting simulation.
    - - - Collect and assess the insights of human-machine interface requirements for training prototypes with the assistance of Army Research Institute.
    - - - Conduct experiments #2 and #3 in support of selected command & control functions for operations with manned/unmanned systems.
  - Netfires.
    - - - Initiate ballistic test vehicle and controlled test vehicle demonstrations.
    - - - Complete pintle motor development and testing.
  - Organic All-Weather Targeting Vehicles.
    - - - Select platform and sensory payload for detailed design and prototyping efforts.
    - - - Complete flight testing of initial sizes for OAVs.

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- - Initiate detailed design efforts for different size Organic Air Vehicle to flight demonstrate the design code and scalability of the technology.
- - Ground test A160 anti-icing systems, sand/dust/salt protection systems, and precision flight systems.
- - Integrate SAR/GMTI Radar in A160 vehicle radome.
- - Demonstrate initial Organic Air Vehicle (OAV) gust stability and inner loop control.
- - Demonstrate second-generation OAV autonomous navigation and auto-landing capabilities.

– Jigsaw: LADAR Sensing for Combat ID.
- - Conduct preliminary design reviews for prototype LADAR sensors for airborne captive carry operation.
- - Conduct critical design reviews for alternative prototype LADAR sensors.
- - Build prototype LADAR sensors, collect data, and conduct experiments.

(U) <u>FY 2003 Plans:</u>

- FCS Concept Development. ($48.000 Million)
  - Complete concept and technology demonstration (CTD) phase.
  - Prepare for Technology Investment Decision Review.
  - Transition program from concept and technology development to system design and demonstration.
  - Initiate Force Development Testing and Evaluation (FDT&E) activities including limited man-in-the-loop testing.

- FCS Supporting Technologies. ($80.100 Million)
  - PerceptOR.
    - - Continue algorithm and supporting technology developments for unmanned maneuver.
    - - Update prototype algorithms and hardware based on supporting experimentation.
    - - Conduct unrehearsed field-testing of prototypes in extreme terrain and explore system implications of degraded component performance (communications constraints, sensor and other faults).

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– Unmanned Ground Combat Vehicle (UGCV).
  - - Complete UGCV prototype fabrication and rollout.
  - - Conduct initial testing of prototypes against mobility, endurance, and payload fraction metrics.
  - - Conduct resilience testing on prototypes and make reliability measurements.
  - - Update prototype hardware with late development technology and prepare for extreme testing conditions.
  - - Integrate PerceptOR technology onto a UGCV platform.

– Maneuver C^3.
  - - Complete the development of an initial FCS C^2 experimental demonstrator.
  - - Continue experiments of Unit Cell C^2 incorporating limited activities of the dismounted soldier.
  - - Document and finalize C^2 architecture for FCS unit cell.
  - - Provide an experimental test bed for future FCS developmental efforts using simulation.
  - - Demonstrate an integrated architecture that provides seamless transition from line-of-sight to non-line-of-sight communications via unmanned aerial vehicles and satellite communications.
  - - Demonstrate new secure communication waveforms and mobile ad hoc networks using directional antennas.

– Netfires.
  - - Complete controlled test vehicle demonstrations and initiate guided test vehicle demonstrations.
  - - Conduct critical design reviews.
  - - Investigate coordination of multiple Netfires missiles.

– Organic All-Weather Targeting Vehicles.
  - - Continue prototype platform development and sensory payload.
  - - Perform testing.
  - - Continue A160 anti-icing systems tests.
  - - Flight test A160 SAR/GMTI Radar.
  - - Complete A160 Satellite Communications (SATCOM) study.
  - - Complete A160 Survivability study.
  - - Complete A160 resupply study.
  - - Demonstrate third-generation Organic Air Vehicle (OAV) flight in rain, icing and adverse weather.

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- - Demonstrate OAV waypoint flight with collision avoidance in stressing environments.

– Jigsaw: LADAR Sensing for Combat ID.
  - - Conduct demonstration of Combat ID capabilities with LADAR sensing using prototype Jigsaw LADAR sensors against stressing targets.
  - - Develop a design for an objective LADAR sensor for FCS applications.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 2001	FY 2002	FY 2003
PE 0602601A Combat Vehicle and Automotive Technology	7.752	19.652	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Technology	5.312	87.586	122.000

(U) **Schedule Profile:**

Plan	Milestones
Feb 02	Conduct unrehearsed field-testing of robot perception systems in forest and meadow (Ft AP Hill).
Feb 02	Demonstrate mobile, wireless network operation with directional antennas below 3 GHz.
Mar 02	Complete FCS Phase I and select Lead Systems Integrator (LSI).
Mar 02	Critical design review of prototype Laser Radar (LADAR) sensors with processing method for Combat ID.
Apr 02	NetFires ballistic test vehicle firings.
Apr 02	Sensor breadboard testing (laboratory).
May 02	Complete UGCV integrated testbed detailed design and procure long lead items for fabrication.
May 02	Experiment #2 FCS C^2 “See, Move, Strike”.
May 02	Conduct unrehearsed field-testing in desert conditions for PreceptOR (Yuma).
Jun 02	Complete A160 AV003.
Jun 02	Preliminary data collections using prototype Jigsaw LADAR sensors.
Aug 02	Conduct unrehearsed field testing in mountain terrain for PreceptOR (California)
Aug 02	Complete UGCV technology testbed data collection.

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Sep 02	Demonstrate mobile, wireless network operation with directional antennas below and above 3 GHz.
Oct 02	SAR/GMTI Radar first flight on A160.
Oct 02	Experiment #3 FCS C^2 “See, Move, Strike, Sustain” (including limited functionality sub experiments of Future Warrior).
Nov 02	Validate OAV adverse weather flight capability with 2 different sized vehicles to demonstrate scalability.
Nov 02	Conduct unrehearsed field testing in wet terrain of PerceptOR (Florida)
Dec 02	Demonstration of capability to ID targets using LADAR data from prototype Jigsaw sensors, combining data from multiple views.
Dec 02	Rollout UGCV integrated prototypes.
Jan 03	Anti-icing system first flight on A160.
Jan 03	Demonstrate OAV waypoint flight with collision avoidance.
Jan 03	Demonstrate initial performance of UGCV Prototypes against obstacles and endurance goals.
Feb 03	Demonstrate assured, seamless, mobile, wireless network operation with directional antennas at multiple bands in a relevant operational and threat environment.
Feb 03	Experiment #4.
Feb 03	Conduct unrehearsed field-testing of improved PerceptOR perception system prototypes in extreme terrain and degraded conditions.
Mar 03	Army decision on FCS technology readiness levels.
May 03	Complete FCS Concept Design Preliminary Design Review.
Jun 03	Initiate FCS Detailed Design.
Jul 03	Sensor field tests.
Aug 03	Critical design review of objective LADAR sensors for FCS applications.
Sep 03	Complete initial Unmanned Ground Combat Vehicle (UGCV) contractor testing of all integrated testbeds to prepare for government testing in complete FCS environment.