RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, R-1 #50

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	94.578	129.025	153.067	182.100	148.500	113.600	119.300	120.600	Continuing	Continuing
Rapid Strike Force Technology LNW-01	51.983	31.993	19.992	21.500	26.600	32.000	37.000	37.000	Continuing	Continuing
Small Unit Operations LNW-02	42.595	36.032	43.075	38.600	59.000	66.600	82.300	83.600	Continuing	Continuing
Future Combat Systems LNW-03	0.000	61.000	90.000	122.000	62.900	15.000	0.000	0.000	0.000	N/A

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

(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 Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. 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; 4) the pre-cursor efforts of the Future Ground Combat System program that will explore and develop technologies to be used by tactical commanders in situational awareness, communications and control; and 5) the Metal Storm program that will develop a system to pack, transport and fire at variable sequence rates.

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(U) The goal of the Small Unit Operations project is to develop critical technologies that will enable dispersed units to effectively perform warfighting operations traditionally requiring massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater and component sensor programs; automated ultra-miniature imaging and non-imaging sensors and the use of robotic technology to impact operations in urban areas.

(U) The Future Combat Systems project goal is to develop an effective, light-weight suite of inhabited and uninhabited ground based systems that strike an optimal balance among critical performance factors, including ground platform strategic, operational and tactical mobility, lethality, survivability and sustainability. Efforts will focus on creating a multi-functional, multi-mission, re-configurable group of systems that maximize joint interoperability, strategic transportability and commonality of mission roles. These efforts will concentrate in six areas: robotic perception; unmanned ground combat vehicles; maneuver command, control and communication; beyond line of sight fires; organic all weather air vehicles; and organic all weather targeting. Support programs will develop rapid response and lethality packages requiring fewer personnel, decreased logistical support and lower life-cycle costs while increasing survivability.

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

	FY2000	**FY 2001**	**FY 2002**
Previous President's Budget	96.320	134.249	157.667
Current Budget	94.578	129.025	153.067

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects SBIR reprogramming and minor program repricings.

FY 2001 Decrease reflects the Section 8086 reduction, the government-wide rescission and minor program repricing.

FY 2002 Decrease reflects the phase down of Tactical Sensors and Situational Awareness System efforts and completion of Advanced Sensing Technology work.

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COST *(In Millions)*	FY 2000	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	51.983	31.993	19.992	21.500	26.600	32.000	37.000	37.000	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; Metal Storm (MS); Combat Hybrid Power Systems (CHPS); and the pre-cursor efforts of the Future Ground Combat System (FCS). 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) ATD 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 Solar Blind Detectors program (formerly titled "Vehicle Self-Protection") will develop 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) The Metal Storm (MS) program will develop a unique 100 percent solid state system for tightly packing, storing, transporting and firing projectiles in multiple tubes with high or low pressures, in an electronically infinitely variable sequence rate with applications to small arms and crew served weapons. The program facilitates current U.S. force reduction and restructuring policies while increasing firepower. The program will demonstrate revolutions in weapon design and application that will far exceed the effectiveness and versatility of existing small arms and large munitions weaponry, and will primarily focus on developing, fabricating and testing two sniper rifle prototypes for Special Operations Forces (SOF) use. The design will incorporate a multi-barrel configuration allowing instant access to a variety of projectiles. Studies will be conducted to optimize propellants and projectiles; to examine electronic keying, silencing and underwater operations; and to investigate the physics of scaling from a small caliber, low-pressure design to a large caliber (40 and 81mm), modest barrel pressure (~60,000 psi) design. Through a Project Arrangement under the Deutsch Ayers Agreement between the U.S. and Australia, the Defence Science and Technology Office (DSTO) will perform work in the areas of scaling, modeling and simulation, and small arms live fire testing.

(U) The Combat Hybrid Power System (CHPS) program developed enabling technologies and conducted demonstrations of an integrated hybrid electric power system to provide power and energy management for all of the electric subsystems throughout future combat vehicles. Hybrid

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electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The program transitioned to the U.S. Army at the beginning of FY 2001 and the technologies developed will play a key role in the Future Combat System (FCS) program.

(U) The Future Combat Systems (FCS) program, an out-growth of the Mobile Tactical Operations Center, 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 integrated command and control capabilities with unsurpassed situational understanding for all levels of commanders. The FCS program is funded in project LNW-03, Future Combat Systems, within this Program Element (0603764E) in FY 2001 and subsequent fiscal years.

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

(U) <u>FY 2000 Accomplishments:</u>

- Combat Hybrid Power Systems (CHPS). ($ 10.074 Million) [Future Combat Systems – related = $10.074 million]
  - Installed engine and thermal management system in the Systems Integration Laboratory (SIL) and operated the system with various combinations of engine, flywheel and battery to determine performance baselines for notional concept vehicle (15 tons).
  - Completed advanced, high-risk hybrid electric power system components, including the high energy/high power CHPS Lithium Ion Battery and Silicon Carbide DC/DC converter.
  - Investigated alternative power system component technologies, including Ultra capacitors and in-wheel hub motors.
  - Initiated testing and evaluation of integrated hybrid electric power system and subsystems.
  - Developed a plan to systemically investigate and qualify benefits of hybrid electric power for future combat vehicles using SIL and hardware-in-the-loop virtual prototype.
  - Developed a coordinated research plan for continued effective utilization of CHPS SIL and virtual prototypes.
  - Completed transition of CHPS program to U.S. Army Tank-Automotive and Armaments Command (TACOM).

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 10.651 Million)
  - Performed wheel motor qualification tests.
  - Rolled out vehicles 1 and 2.

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- Tactical Mobile Robotics (TMR). ($ 15.699 Million)
  - Initiated development of fully functional tactical robotic prototypes.
  - Integrated enabling technologies into functional platforms.
  - Refined demonstration and transition plans commensurate with success in system design and multi-platform collaboration.
  - Conducted technical experiments in machine perception and autonomous navigation of indoor cluttered environments.

- Solar Blind Detectors Program. ($ 5.679 Million)
  - Demonstrated low defect epitaxial material compatible for photo detectors with high sensitivity operating in the solar-blind region of the spectrum (260-280 nm).

- Future Combat Systems (FCS). ($ 6.896 Million)
  - Awarded agreements to four industrial teams for FCS concept development.
  - Began formulation of force level concepts.
  - Initiated development of standard threat scenarios.
  - Initiated Integrated Development Environment (IDE).
  - Initiated independent validation, verification and accreditation effort.
  - Concept development teams performed initial technology surveys (DoD-wide activities) and initial force capabilities.

- Advanced Concepts Evaluation. ($ 2.984 Million)
  - Conducted technology assessment and feasibility testing of advanced rapid strike force concepts including precision guided munitions, force-on-force modeling, counter situational awareness, covert autonomous sensors and future unmanned vehicle systems.
  - Conducted studies to optimize the Metal Storm concept, research propellants and projectiles, and developed approaches to enhance accuracy. Established international agreement between the U.S. and Australia.

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

- Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 7.334 Million)
  - Participate in U.S. Marine Corps (USMC) Advanced Warfighting Experiment.

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- Integrate and demonstrate Survivability Suite.

• Tactical Mobile Robotics (TMR). ($ 10.432 Million)
- Complete initial prototype development.
- Complete initial design of Human Robot Interface for multi-robot control, heterogeneous platform collaboration and marsupial operations.
- Initiate tactical experiment plan with fully functional platforms to determine operational value baseline.
- Refine collective experimentation plan.

• Solar Blind Detectors Program. ($ 4.736 Million)
- Demonstrate solar-blind detector array with 256 x 256 pixels.

• Metal Storm (MS). ($ 9.491 Million)
- Finalize designs for main sniper rifle and targeting and electronic subsystems.
- Perform scaling analysis of Metal Storm technology to larger calibers.

(U) **FY 2002 Plans:**

• Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 3.242 Million)
- Demonstrate V-22 compatibility.
- Complete RST/ C^4I test.
- Deliver vehicles 1, 2, 3, and 4.
- Deliver final report.

• Metal Storm (MS). ($ 10.017 Million)
- Demonstrate a single-barrel model of the electronic sniper rifle.
- Initiate design and tradeoff analysis of a multi-barrel model.
- Conduct Critical Design Review of the multi-barrel model.

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- Demonstrate preliminary design firing.
- Conduct technology assessment and feasibility testing of smart projectile enhancements to Metal Storm for protection against Anti-Ship Cruise Missiles and point defense of high-value airborne and ground assets.

- Tactical Mobile Robotics (TMR). ($ 6.733 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.
  - Initiate transition to military departments.

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

	FY2000	FY2001	FY2002	FY2003
Reconnaissance, Surveillance and Targeting Vehicle (RST-V) PE 0603640M Marine Corps Advanced Technology Demonstration	2.150	2.750	2.990	1.000
Combat Hybrid Power System (CHPS) PE 0603005A Combat Vehicle and Automotive Advanced Tech	2.000	4.700	0.000	0.000
Future Combat Systems				
PE 0602601A Combat Vehicle and Automotive Technology	6.586	0.000	0.000	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Technology (FCS)	5.312	0.000	0.000	0.000

(U) Schedule Profile:

Plan	Milestones
Metal Storm (MS)	
Sep 01	MS: Complete physics of scaling study.

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Oct 01	MS: Demonstrate preliminary design firing.
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)

Jun 01	RST-V: Demonstrate RST-V system capabilities in Advanced Warfighting Experiment (AWE).
Nov 01	RST-V: Demonstrate V-22 compatibility.
Dec 01	RST-V: RST-V/ C^4I testing complete.
Apr 02	RST-V: Deliver vehicles 1, 2, 3, and 4.
May 02	RST-V: Final Report.

Tactical Mobile Robotics (TMR)

Jul 01	TMR: Complete operational demonstrations of Tactical Mobile Robotic systems. Initiate transition and technology transfer plans.
Dec 02	TMR: Complete transition and technology to military services.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development						**R-1 ITEM NOMENCLATURE** Land Warfare Technology PE 0603764E, Project LNW-02					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost	
Small Unit Operations LNW-02	42.595	36.032	43.075	38.600	59.000	66.600	82.300	83.600	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 fusion 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 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 and Advanced Sensing Technologies and Urban 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 US 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 permit vulnerability and access to the target signatures. This program completes 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 military can use general-purpose robots to perform tasks that may be onerous or dangerous to human personnel or that exceed the capacity of the current force structure. The Robotics program 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. In addition, power generation and actuation at efficiencies and scale compatibility with these systems will be developed and demonstrated. Geo-spatial information systems (GIS) data is currently in expanding use commercially for a variety of applications from agriculture to environmental to traffic studies. The Combat Geographic Information Systems for Robotics (CGIS-R) will leverage the existing GIS software infrastructure and develop automatic and efficient GIS plug-ins to generate appropriate resource allocation and planning maps for use by military commanders and robotic vehicle controllers. This data is also likely to be downloadable to robotic platforms to assist them in generating robust "understanding" of the environment along the routes of their deployment.

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

(U) <u>FY 2000 Accomplishments:</u>

- Situational Awareness System. ($ 31.157 Million) [Future Combat Systems – related = $17.900 Million]
  - Completed development of the Individual Warfighter Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile and Relay/Router/Beacon detailed hardware design, software modules and network protocols.

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- Completed Individual Warfighter/WTA software coding.
- Completed IWSAS, WTA-Base, WTA-Mobile, Relays and network code development and testing.
- Completed situation awareness (planning, tasking, sensor control, navigation and alerts) application software coding and testing.
- Completed brassboard fabrication of the major SAS elements (IWSAS, WTA and Relays).
- Conducted performance assessment of Phase 3 brassboard design.
- Verified that Individual Warfighting Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets Service objective.
- Verified geolocation accuracy and navigation performance in urban and field environments.
- Developed Wolfpack system architecture and conduct system level trades to develop subsystem requirements.
- Determined the optimum use of legacy systems for IPB and cueing, and potential modifications required for coordinated spectrum access.

• Tactical Sensors. ($ 8.604 Million)
  - Continued development of internetted remote control sensors to detect, localize and characterize targets.
  - Continued development of surveillance and targeting sensors systems for dispersed operations.
  - Developed mature application performance requirements for optical tags.
  - Developed optical tag performance prediction modeling capability.

• Advanced Sensing Technologies. ($ 2.834 Million)
  - Completed and tested breadboard sensor.
  - Initiated brassboard development.

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

• Situational Awareness System. ($ 13.691 Million)
  - Complete fabrication of Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) Mobile and Base, tactical sensors and tactical relays for test.
  - Integrate IWSAS, WTA-Mobile and Base with external legacy communications, data and sensor equipment.

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- – Test integrated system and conduct performance assessment of final Phase 3 design; measure IWSAS, WTA and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments.
- – Complete development of detailed demonstration scenarios to test and evaluate performance under operational conditions.

- Tactical Sensors. ($ 8.151 Million)
  - – Continue development of internetted remote control sensors and fusion algorithms to detect, localize and characterize targets.
  - – Continue development of surveillance and targeting sensors sytems for dispersed operations.

- Optical Tags. ($ 5.072 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. ($ 3.020 Million)
  - – Complete brassboard and initiate fieldable sensor development.

- Wolfpack. ($ 6.098 Million)
  - – Initiate system design and performance analysis.
  - – Conduct analysis for the applicability of distributed ground jammers to attack surface to air radar systems.
  - – Initiate development of networked, distributed jamming enabling technologies.

(U) **<u>FY 2002 Plans:</u>**

- Situational Awareness System. ($ 10.586 Million)
  - – Complete prototypes.
  - – Perform setup of field demonstration.
  - – Develop training materials and conduct soldier training for field demonstration.

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- Conduct field demonstration to verify communications performance in urban, forested and mountaneous terrain when operated by warfighters. Show the use of multiple organic sensors being operated by battalion and below warfighters.

• Optical Tags. ($ 10.586 Million)
- Verify basic tag prototype design in lab setting tests.
- Conduct engineering tests of improved tags for more stressing situations.

• Tactical Sensors. ($ 4.182 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 node.

• Wolfpack. ($ 12.721 Million)
- Continue development of enabling technologies.
- Complete system design and performance analysis.

• Robotics ($ 5.000 Million)
- Select and refine several robotic arm-and-grasp designs and test on a broad array of common manipulation tasks. Integrate each of these with a robotic vehicle and study the effect of manipulation on balance and power requirements. Demonstrate the physical feasibility and utility of manipulation for ground robots in the 4, 40, and 400 pound range.
- Initiate development of an integrated suite of sensors required for appropriate manipulator behavior.
- 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.
- Develop concepts for advanced power and actuation schemes for biomimetically inspired robots.
- Conduct high fidelity GIS data collection at military operational areas.
- Develop integrated software for operation on GIS data in the context of military robot behaviors.

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

- Not Applicable.

(U) <u>Schedule Profile:</u>

Plan	Milestones
Situational Awareness System:	
Jun 01	Complete SAS software coding.
Dec 01	SAS engineer development model fabricated.
Jun 02	SAS prototypes fabricated.
Sep 02	SAS final demonstration.
Tactical Sensors:	
Sep 01	Complete micro-UGS field demonstration tests.
Dec 01	Design review for deployment and C^2 architecture.
Jul 02	Participate in field exercise.
Optical Tags:	
Jun 01	Develop improved response tag requirements and predict performance.
Jul 01	Basic tag performance predicted.
Jan 02	Design and test basic tag prototype.
Jul 02	Test improved response tag prototype.
Sep 03	Basic tag system field test.
Advanced Sensing Technologies:	
Sep 01	Demonstrate final brassboard.

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Wolfpack:

Oct 01	Initial Technology Run and System Definition.
Apr 02	System Design/Technology Assessment Review.
Oct 02	Initial enabling technology demonstrations.
Aug 03	Initial jammer subsystems demonstrated in laboratory.
Sep 03	Final Enabling Technology Demonstrations.
Jul 04	Subsystem field-testing completion.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Future Combat Systems LNW-03	0.000	61.000	90.000	122.000	62.900	15.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(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 to evaluate competitive concepts. The FCS program 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; adverse-weather reconnaissance, surveillance, targeting and acquisition (RSTA).

(U) The Government run experiments will consist of a series of hardware, and simulation based, experiments. The objective of these experiments will be to test key assumptions about how key technologies and components within the FCS Unit Cell and/or Unit of Action will need to perform. These experiments will focus on hardware experiments with surrogates and modeling and simulation in the early stages and then evolve to actual hardware in the loop experiments as key components and systems become available. The goal will be to conduct a series of simple, rapid turnaround experiments, that maintain traceability to concrete FCS Unit Cell and /or Unit of Action mission desires.

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(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 air vehicles and organic all weather targeting.

(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.

(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 accommodating 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. Future operations involving FCS technologies and operational capabilities cannot be restricted by a less responsive C^2 architecture. 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. 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 will be developed and validation of the architecture and assessment of performance (e.g., command latencies) will be achieved by conducting a series of experiments with combined simulated and real operational units.

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(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 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 (<100 lbs) air vehicle that can fly autonomously in adverse weather. It will leverage DARPA Micro Air Vehicle program technologies and design a vehicle that is scalable to accommodate varying missions and payloads. For example, the OAV program will fly the Jigsaw LADAR (Laser Radar) sensor in 2003 to demonstrate its utility for the FCS concept.

(U) The Jigsaw program will develop advanced LADAR sensor systems and technologies for all weather 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 2000 Accomplishments:</u>

- This program was funded in FY 2000 from Project LNW-01, Rapid Strike Force Technology, within this same Program Element.

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(U) FY 2001 Plans:

- FCS Concept Development. ($ 15.000 Million)
  - Continue Concept Development Activities including the identification of key technologies, technology tradeoffs, and technology roadmaps.
  - Establish program Integrated Data Environment (IDE).
  - Develop detailed Program Acquisition Strategy.
  - Initiate Government Experiment activities to identify critical questions and understand the impacts of selected solutions.
  - Define program metrics and structure modeling and simulation activities to address those metrics.
  - Develop baseline operational documentation.
  - Identify the role of FCS as it relates to the Army's vision of an Objective Force.

- FCS Supporting Technologies. ($ 46.000 Million)
  - PerceptOR.
    - - - Develop unmanned maneuver algorithms that use a combination of on-board and off-board sensors and terrain data to maximize the level of autonomous operation.
    - - - Develop surrogate perception prototypes for testing in FY02.

  - Unmanned Ground Combat Vehicle (UGCV).
    - - - Complete Phase I study of UGCV design drivers. Highlight critical technologies for achieving higher mobility and endurance in configurations associated with both combat and support duty vehicles in the context of the FCS mission.
    - - - Initiate Phase II work on UGCV long lead critical technology testbeds with traceability to fieldable UGCV concepts.

  - Maneuver C^3.
    - - - Develop top-level system architecture for fully integrated C^2 system.
    - - - Initiate the design of the C^2 architecture for the lowest, integrated FCS echelon (“unit cell”).
    - - - Examine potential wireless communications network architectures.
    - - - Develop technologies for assured communications in a hostile environment using novel waveforms and beam steering antennas for low probability of detection and anti-jam.

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– Netfires.
  - - Continue system hardware and software development for missiles, container/launchers and command/control units.
  - - Complete critical component demonstrations for motor, seeker, navigation and data link.
  - - Plan and initiate preparations for flight test demonstrations.

– Organic All-Weather Targeting Vehicles.
  - - Determine requirements for organic air vehicles to be used as sensor platforms.
  - - Develop air vehicles capable of operating in adverse weather.
    - Define A160 systems for operating in adverse environments: rain, icing, sand/dust, salt spray, and turbulence.
    - Define A160 SAR/MTI radar sensors and design Radar/A160 interfaces.
    - Carry out A160 (30 kft) flight test.
    - Design and initiate fabrication of Organic Air Vehicle (OAV) capable of autonomous flight.
    - Conduct OAV integrated technology systems demonstration.

– Jigsaw: LADAR Sensing for Combat ID.
  - - Initiate development of technology that can identify hidden targets by combining multiple LADAR images penetrating holes in the foliage and obscuring material and integrating information from multiple infrared-based LADAR images.
  - - Conduct trade studies to determine best technological approach to LADAR sensing for FCS application, including lasing, detection, and data processing.
  - - Conduct preliminary design reviews for prototype LADAR sensors for airborne captive carry operation.

(U) <u>FY 2002 Plans:</u>

- FCS Concept Development. ($ 30.000 Million)
  – Evaluate team concepts via modeling, simulation and specialized analysis.
  – Prepare Phase II program plans.
  – Perform concept downselect to two options.
  – Transition from concept development effort to preliminary design.

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– Continue Government Experiments exploring and defining critical FCS Unit Cell and/or Unit of Action performance parameters using surrogates and modeling an simulation. These experiments will investigate issues including, but not limited to: work load associated with tasking and controlling multiple type and quantities of Unmanned Air Vehicles (UAVs), Unmanned Ground Vehicles (UGVs) and sensors, fusion of data from multiple sensor types, and communication.

- FCS Supporting Technologies. ($ 60.000 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).
- - Continue work on Phase II technology testbeds and complete initial testing.
- - Update operational concepts based on testbed fabrication and testing results.
- - Plan and initiate preparations for integrated UGCV testbeds use in operational exercises.
- - Conduct field-testing with upgraded surrogate.

– Maneuver C^3.
- - Develop simulations for the integrated "unit cell" C^2 architecture.
- - 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.

– Netfires.
- - Initiate ballistic test vehicle and controlled test vehicle demonstrations.
- - Complete pintle motor development and testing.

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– Organic All-Weather Targeting Vehicles.
  - - Select platform and sensory payload for detailed design and prototyping efforts.
  - - Initiate detailed design efforts.
  - - Ground test A160 anti-icing systems, sand/dust/salt protection systems, and precision flight systems.
  - - Integrate SAR/GMTI Radar on A160 vehicle.
  - - Complete fabrication of AV 003.
  - - 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 critical design reviews for alternative prototype LADAR sensors.
  - - Build prototype LADAR sensors, collect data, and conduct experiments.

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

	FY 2000	FY 2001	FY 2002
PE 0602601A Combat Vehicle and Automotive Technology	0.000	7.752	19.564
PE 0603005A Combat Vehicle and Automotive Advanced Technology	0.000	5.312	61.586

(U) **Schedule Profile:**

Plan	Milestones
Aug 01	End of concept development by contractors.
Sep 01	Complete Unmanned Ground Combat Vehicle (UGCV) early surrogate tests of high-risk/long-lead technologies.
Sep 01	Flight Test of A160.
Nov 01	Initiate FCS design Competition.
Dec 01	Demonstrate Organic Air Vehicle (OAV) gust stability and inner loop control.
Jan 02	PerceptOR: Conduct initial unrehearsed field-testing of robot perception system prototypes.

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Feb 02	Complete UGCV technology testbed data collection.
Mar 02	FCS Downselect (end of Phase I efforts).
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).
Apr 02	Complete FCS design competition.
May 02	Complete UGCV integrated testbed detailed design and procure long lead items for fabrication.
May 02	Award FCS Concept Design and Demonstration Agreements.
Jun 02	Complete A160 AV003.
Jun 02	Preliminary data collections using prototype Jigsaw LADAR sensors.
Sep 02	Rollout UGCV first integrated testbed baseline configuration.
Oct 02	SAR/GMTI Radar first flight on A160.
Nov 02	Validate OAV adverse weather flight capability.
Dec 02	Demonstration of capability to ID targets using LADAR data from prototype Jigsaw sensors, combining data from multiple views.
Jan 03	Anti-icing system first flight on A160.
Jan 03	PerceptOR: Conduct unrehearsed field-testing of improved perception system prototypes in extreme terrain and degraded conditions.
Jan 03	Demonstrate OAV waypoint flight with collision avoidance.
Feb 03	Initiate FCS Program Risk Reduction/Concept.
Mar 03	Army decision on FCS technology readiness levels.
May 03	Complete UGCV fabrication of all integrated testbed vehicles and prepare for field-testing.
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 Unmanned Ground Combat Vehicle (UGCV) contractor testing of all integrated testbeds to prepare for government testing in complete FCS environment.