| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E |

| COST (In Millions) | FY 2005 | FY2006 | FY2007 | FY 2008 | FY 2009 | FY 2010 | FY 2011 |
|---|---|---|---|---|---|---|---|
| Total Program Element (PE) Cost | 60.897 | 125.384 | 48.975 | 51.480 | 71.092 | 76.890 | 77.097 |
| Rapid Strike Force Technology LNW-01 | 3.334 | 34.584 | 38.925 | 51.480 | 71.092 | 76.890 | 77.097 |
| Future Combat Systems LNW-03 | 57.563 | 90.800 | 10.050 | 0.000 | 0.000 | 0.000 | 0.000 |

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

(U) his 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.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. This project is developing technologies that serve as force multipliers, enabling safe and effective operations in hostile environments. Revival of this project stems from the need to support the development of effective and adaptive weaponry, both lethal and non-lethal, for a variety of target suppression effects. Other technologies to be explored will include tele-operated systems, novel targeting and firing techniques, and advanced situational awareness and response systems.

(U) The U.S Army's Future Combat Systems (FCS) is envisioned to be a System of Systems (SoS), which will provide capabilities that strike an optimum balance between critical performance factors (e.g., operational and tactical mobility, lethality, survivability, and sustainability) and strategic responsiveness. The FCS program embraces an evolutionary acquisition, spiral development process. The first FCS SoS Unit of Action (UA), equipped with the eighteen (18) FCS Systems, plus the Network, will be initially fielded in 2014. The program allows for continuous capability upgrades through the introduction of new, enabling technologies throughout the development phase. This Joint DARPA/Army activity supports the FCS spiral process through the development of critical technology improvements for FCS platform variants and the Network. The resulting network-centric SoS will continue to provide the Unit of Action overwhelming lethality, strategic deployability, self-sustainment, and high survivability over other conventional ground forces.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E |

| (U) **Program Change Summary:** *(In Millions)* | **FY 2005** | **FY 2006** | **FY 2007** |
|---|---|---|---|
| Previous President's Budget | 62.546 | 139.100 | 66.900 |
| Current President's Budget | 60.897 | 125.384 | 48.975 |
| Total Adjustments | -1.649 | -13.716 | -17.925 |
| | | | |
| Congressional program reductions | -0.048 | -13.716 | |
| Congressional increases | 0.000 | | |
| Reprogrammings | 0.000 | | |
| SBIR/STTR transfer | -1.601 | | |

(U) **Change Summary Explanation:**

| | |
|---|---|
| FY 2005 | Decrease reflects the DOE transfer directed for P.L. 108-447 and the SBIR/STTR transfer. |
| FY 2006 | Decrease reflects congressional cuts to DPX-5 and C-130 STOL Demo, undistributed reductions for Section 8125 and the 1% reduction for Section 3801: Government-wide rescission. |
| FY 2007 | Decrease reflects repricing of efforts in Project LNW-01, Rapid Strike Force Technology, and reductions to Future Combat Systems technologies reflecting transitions of technologies and managerial control to the U.S. Army. |

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| **APPROPRIATION/BUDGET ACTIVITY** RDT&E, Defense-wide BA3 Advanced Technology Development | **R-1 ITEM NOMENCLATURE** Land Warfare Technology PE 0603764E, Project LNW-01 |

| COST (In Millions) | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | FY 2010 | FY 2011 |
|---|---|---|---|---|---|---|---|
| Rapid Strike Force Technology LNW-01 | 3.334 | 34.584 | 38.925 | 51.480 | 71.092 | 76.890 | 77.097 |

**(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, particularly in urban areas where both combatants and civilians are present. This project is developing technologies that serve as force multipliers, enabling safe and effective operations in hostile environments. Revival of this project stems from the need to support the development of effective and adaptive weaponry, both lethal and non-lethal, for a variety of target suppression effects. Other technologies to be explored will include tele-operated systems, novel targeting and firing techniques, and advanced situational awareness and response systems.

**(U) Program Accomplishments/Planned Programs:**

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Boomerang | 3.334 | 0.000 | 0.000 |

(U) The goal of the Boomerang program was to rapidly develop and demonstrate affordable and reliable acoustic gun shot detection and localization techniques. The program focused on enhancing the safety of vehicle convoys and increasing situational awareness. Based on previous acoustic shot detection work, Boomerang developed system hardware design and packaging, vehicle integration concepts, user interfaces and signal processing algorithms and software for prototype systems, as well as continued refinement of algorithms, hardware and software to improve system performance and accuracy. Acoustic sensors, mounted in an array at the top of a mast, are used to detect both supersonic shock and sound waves from muzzle blast and then identify the location of the shooter. Users receive simultaneous visual and auditory information about the point of fire from an LED display and speaker. Boomerang systems were tested by warfighters serving in Operation Iraqi Freedom (OIF). The systems were designed for ease of use, installation and field upgradeability. Shot data collected from a series of CONUS firing tests and from systems deployed to OIF demonstrated that Boomerang provides troops the ability to detect and locate supersonic shots for both moving platforms and stationary applications, thus providing increased force protection capabilities. Comments from deployed troops were collected and analyzed. As a result, an improved version of the Boomerang system with significantly smaller acoustic arrays (designed to reduce visual

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

footprint) was developed with enhanced crew display, increased detection range, ability to provide shooter's elevation, and improved electro-magnetic interference thresholds so as not to interfere with tactical combat radios used by Marine and Army units.

(U) Program Plans:
- Improved performance based on data from deployed systems, user feedback and evolving concepts of operations.
- Conducted extensive testing on the enhanced system to validate improved system performance, reliability, and robustness.
- Fabricated and delivered updated systems to deployed warfighters for field testing.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Multi-Modal Missile (M3) | 0.000 | 9.000 | 9.500 |

(U) The Multi Modal Missile (M3) program will explore the development of an integrated, man-portable weapon system capable of performing surface-to-surface, anti-armor, and surface-to-air anti-aircraft missions with an emphasis on extreme precision. The program will focus on delivering precision targeting accuracy to 1) enable light-weight munitions and thus deeper magazine and/or longer engagement ranges, 2) tailor categories of kill through subsystem targeting, and 3) provide lethal effects against targets otherwise beyond the reach of man-portable weapons. The objective M3 capability will integrate a variety of existing weapons-systems functions and provide the dismounted soldier with a compact system to engage vehicles, rotorcraft, and close air support aircraft. The effort will also explore additional mission concepts to include anti-personnel and breaching applications, beyond-line-of-sight functionality, air-to-ground capability, and ground vehicle mounting options. Critical characteristics of this weapon system concept include light weight, simple operation, and affordability. Technologies under consideration will include advanced imaging seekers and/or operator terminal guidance; low-cost, high-performance, solid-rocket engines; sensor-based fusing; and novel warhead concepts to support a wide range of engagement geometries with desired lethality effects against a range of targets.

(U) Program Plans:
- Perform initial system design analyses and trade off studies.
- Initiate critical technology, maturation efforts for seeker, propulsion, guidance and warhead.
- Develop, analyze and assess initial multi-modal missile system preliminary designs.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Non-Lethal Alternatives for Urban Operations | 0.000 | 8.000 | 4.500 |

(U) The Non-Lethal Alternatives for Urban Operations effort will explore system concepts and enabling technologies for non-lethal weapons in challenging urban and semi-urban environments. This effort will assess effects, targeting systems, delivery systems, and countermeasures, and will develop integrated less-lethal system options for application to urban warfighting. Effects to be investigated will include less-lethal projectiles, malodorants, entanglers, and marking agents. The effort will consider direct and indirect fire systems to counter personnel and to provide area effects against vehicles, crowds and groups of combatants. Operating scenarios to be explored will include force protection for fixed sites, force protection for mobile forces, situational control (including traction control), individual soldier weapons, border protection, and protection of extended infrastructure. The effort will pay particular attention to technologies that support application on autonomous and teleoperated unmanned ground robotic vehicles in urban environments at a sustained operational tempo. Transition organizations will be identified as efforts and systems are developed.

(U) Program Plans:

- Perform initial concept development and effects assessment.
- Develop initial urban less-than-lethal system design.
- Begin focused less-than-lethal technology maturation efforts to address and reduce system risk.
- Develop and demonstrate technologies in an end-to-end system.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Tactical Urban Operations (TURBO) program | 0.000 | 8.182 | 3.425 |

(U) One of the key reasons for the overwhelming effectiveness of U.S. forces in large scale warfare is the ability to perform reconnaissance and strike with impunity from the air, in coordination with ground forces. The Tactical Urban Operations (TURBO) program will extend this capability to low-level ground forces in urban (and other) settings by providing close integration of dismounts with information from low-level

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

airborne assets, such as the Micro Air Vehicle (MAV) or the Organic Air Vehicle (OAV), local intelligence sources, and responsive and improved fires / effects capable of acting on this information. Technologies to be explored include: aggregation of information from multiple MAVs and OAVs with that from other sources into an easy-to-use interface, improved techniques for detecting dismounted targets and distinguishing friend from foe, and improved methods for displaying information to dismounts and allowing them to direct operations without impeding their mission. These systems will be developed within the framework of both legacy forces and expected future forces. The result will be to provide dismounted soldiers with the ability to obtain greatly improved reconnaissance and “close air support” in urban settings. The program will be a multi-phase program with frequent user reviews to ensure that the resulting products are meaningful and affordable. The program will culminate with a series of prototype demonstrations of the capabilities in a surrogate urban combat environment.

(U) Program Plans:

- Define system architecture and constraints in conjunction with user group.
- Develop and demonstrate technologies and evaluate to determine system effectiveness.
- Initiate second phase to improve selected technologies and integrate them into the overall TURBO system.
- Perform live fire demonstration of soldier-level ground / air team and remote precision munitions to demonstrate improved situation awareness and responsive fly-in-the-foxhole and fly-in-the-window accuracies.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| PEO-Soldier/Exoskeleton Transition | 0.000 | 9.402 | 6.000 |

(U) The PEO-Soldier Exoskeleton Transition Program will employ novel mechanisms, information systems, and power management hardware and software to ultimately produce a wearable machine that will serve as an intuitively operated load carriage system for individuals. The goal of the program is to enable an individual soldier to lift and carry 150 pounds while feeling only a small part of the load, work for long periods of time, and to travel in difficult conditions. This ability for a single soldier to carry heavy loads could be leveraged in applications ranging from moving boxes of ammunition or supplies to enabling the carriage of significantly greater body armor than is presently possible. The Army envisions the Personal Combat Vehicle (PCV) to be a highly armored anthropomorphic vehicle for the individual soldier that can move through

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

rough and urban terrain without difficultly while providing the individual soldier with an unprecedented amount of ballistic protection. This program has transitioned from PE 0602715E, MBT-01, where the underlying smart materials and mechanism development was funded.

(U) Program Plans:

- Develop the enabling components and improve the overall system performance of the exoskeleton device against threshold requirements developed in an MOA with the Army (May 2005).
- Transition exoskeleton technology to the Army with cost share in FY 2006 and FY 2007 with complete transition by FY 2008.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Hyper-awareness Urban Force Multiplier (HYFORM) | 0.000 | 0.000 | 6.000 |

(U) The HYFORM program, an outgrowth of the Tactical Urban Operations (TURBO) program also budgeted in this project, will develop a lightweight and unobtrusive audio and visual interface with robust high-bandwidth communications allowing the soldier not only instant access to real-time ubiquitous sensor data (imaging, night vision, satellite/UAV data, etc.), but also act as the interface to an entire tactical intelligence center consisting of both automated and human-in-the-loop analysis. Techniques such as dynamic information encoding, multi layer waveforms and predictive routing that adapt across multiple layers will be developed. Thus a single soldier can have virtually unlimited real-time reach-back support while not incurring the enormous force protection and logistics cost. Key enabling technologies may include miniature heads-up-displays (HUDs), compact multimode communication receivers (e.g., RF, EO/IR, etc., to maintain link in urban canyon), retinal scanners, multidimensional surround sound, and voice activated computer interfaces for the embedded soldier, as well as knowledge aided and adaptive computing at the support center. HYFORM should have access to non-line-of-sight radar to see behind buildings and maintain track of mobile targets. This non-line-of-sight capability will develop new radar and electro-optic/infrared (EO/IR) integration to track vehicles over wide urban areas. Thus the output of the HYFORM program will be an extremely compact, lightweight acousto-optic interface with a robust communication link back to the computer/command center.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

(U) Program Plans:

- Architecture and sensor conceptual design for multi-sensor/multi-point operation.Communication and sensor sizing to determine operational requirements.
- Analysis to determine achievable qualitative performance.
- Develop techniques such as dynamic information encoding, multi-layer waveforms and predictive routing that reliably penetrate the urban infrastructure and cope with rapidly changing propagation.
- Develop candidate conceptual designs meeting objective system performance.
- Brassboard demo of basic penetration performance.
- Experimental field trials.
- Full prototype development and demonstration.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Standoff Explosives and Concealed Weapons Detection | 0.000 | 0.000 | 3.500 |

(U) The Standoff Explosives and Concealed Weapons Detection program will develop a standoff system for the detection of improvised explosive devices (IEDs), suicide bombs and vehicle bombs that have become weapons of havoc and destruction in current urban operations; as well as a low cost concealed weapons detection system. This program will explore various phenomenologies that may permit explosive detections. The first approach will examine chemical approaches such as spectrometry using IR photothermal signature of the explosive compounds, or standoff detection using molecular tags that change physical, electronic, or optical properties upon exposure to emitted vapors. These tags provide specific molecular information on the signature chemicals, thus enhancing specificity in the cluttered environment. They could be deployed as dust or chaff that can be dispersed in the air or sprayed on suspect vehicles, or into larger sensor structures that could be used to integrate the concentration of vapor over time. Yet another approach is the development of integrating, reactive collectors that can be broadly distributed and sensed remotely. Imaging based approaches will be developed that could allow stand-off detection of weapons or explosives on individuals. Integrated silicon-based antenna array receiver devices could produce whole radar arrays on a single die. Advanced front-end lens/reflector subsystems composed of lightweight, low cost materials must be developed in conjunction with highly sensitive receiver subsystems to extend the standoff range. High-performance, real-time image processing algorithms must be executed in real-time and would require the

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

development of a lightweight, low-power processor. This combined standoff concealed weapons detection system could result in a significant reduction in military and civilian casualties.

(U) Program Plans:
- Conceptual verification to determine qualitative performance achievable of chemical-based approaches and stand-off imaging.
- Develop candidate conceptual designs meeting objective system performance.
- Laboratory prototype demonstration.
- Brassboard demo of basic penetration performance.
- Experimental field trials.
- Transition to operational forces.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Urban Obscurants | 0.000 | 0.000 | 3.000 |

(U) The Urban Obscurants program will develop a system, inherently immune from countermeasure that obscures U.S. operations while maintaining visibility of the enemy. This system would potentially provide a new operational capability for conducting building raids, clearing facilities, and perhaps even masking convoy movement in the urban theatre.

(U) Key technical challenges are associated with developing a system intrinsically immune from countermeasures. Initial studies have shown optical analogs of secure digital communication hold great promise for providing a "coded" obscurant system. The optical properties of obscurant can be tailored such that they develop transparency at narrow, tunable wavelengths. This narrow band optical bleaching phenomena could be realized through optical threshold sensitive switching materials akin to some developed for laser protection goggles. The U.S. Army PM-Obscuration and Decontamination Systems will be the likely transition partner. This program is an outgrowth of the Non-Lethal Alternatives for Urban Operations program also budgeted in this project.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

(U) Program Plans:
- Develop and test particulate materials that are spectrally agile.
- Determine and enhance human safety of materials.
- Determine particulate loading that obscures vision of enemy while maintaining vision of allies.
- Develop and test particle dispersion methods.
- Integrate particulate materials with dispersion devices to produce urban obscurant system.
- Test integrated system and transition to operational forces.

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Urban Counter Mortars | 0.000 | 0.000 | 3.000 |

(U) The Urban Counter-Mortars (UCM) program will provide persistent surveillance and tracking of mortar launches. With precision sensor positional knowledge, the UCM will backtrack the mortar to within 0.5 meters of the insurgent location within seconds of the initial launch – enabling an automated counter-fire solution that will impact the insurgent location before they disappear while limiting collateral damage.

(U) To achieve these performance parameters, the UCM program will develop the precision multisensor network metrology necessary for extremely small angular resolution. The distributed sensor system requires precision knowledge of each sensor location within the urban coordinate system, sub-nanosecond shared system timing, extremely-fast Mid Wave Infrared (MWIR) and Long Range Infrared (LWIR) detectors, and the tracking algorithms to enable 0.5 meters Circular Error Probability (CEP) geolocation within ten seconds of the mortar launch. Competing system concepts include stereo-imaging and single-sensor with a LADAR. The UCM program will develop the competing systems in the context of ten year operational lifetimes, affordability, and applicability to providing guidance corrections to the counter-fire response. The final system design will transition to the U.S. Army for integration into the perimeter defense systems.

(U) Program Plans:
- Develop objective system concepts demonstrating persistence, accuracy, and speed.
- Develop high-fidelity physics-based urban background models; validate with data.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-01 |

- Develop precision individual and network sensor positional knowledge.
- Develop advanced knowledge-aided signal processing algorithms.
- Demonstrate 0.5 meters CEP calculations less than 10 sec post-launch.

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

- Not Applicable.

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| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

| COST (In Millions) | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 | FY 2010 | FY 2011 |
|---|---|---|---|---|---|---|---|
| Future Combat Systems LNW-03 | 57.563 | 90.800 | 10.050 | 0.000 | 0.000 | 0.000 | 0.000 |

**(U) Mission Description:**

(U) The Army's Future Combat Systems (FCS) is envisioned to be a System of Systems (SoS), which will provide capabilities that strike an optimum balance between critical performance factors (e.g., operational and tactical mobility, lethality, survivability, and sustainability) and strategic responsiveness. The FCS program embraces an evolutionary acquisition, spiral development process. The first FCS SoS Unit of Action (UA), equipped with the eighteen (18) FCS Systems, plus the Network, will be initially fielded in 2014. The program allows for continuous capability upgrades through the introduction of new, enabling technologies throughout the development phase. This Joint DARPA/Army activity supports the FCS spiral process through the development of critical technology improvements for FCS platform variants and the Network. The resulting network-centric SoS will continue to provide the Unit of Action overwhelming lethality, strategic deployability, self-sustainment, and high survivability over other conventional ground forces.

**(U) Program Accomplishments/Planned Programs:**

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| FCS Supporting Technologies | 57.563 | 90.800 | 10.050 |

(U) DARPA and the Army identified key areas where technology development is needed for potential pre-planned product improvements via the planned FCS Spirals: Class I, II and III unmanned air vehicles, robotic unmanned ground vehicles, UA and above command, control and communications, advanced radar sensor and EW systems, and advanced armament and missile systems.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

(U) The Unmanned Ground Combat Vehicle (UGCV) – Perception for Off-Road Robotics (PerceptOR) Integration (UPI) program is integrating and testing autonomous navigation algorithms with the Spinner platform to yield an unmanned ground vehicle (UGV) that operates reliably in obstacle-rich terrain. Spinners are being used as platforms to port and test methods for perception techniques to optimize autonomous performance. This integration of the best-of-class sensors and algorithms on a vehicle of Spinner's class represents a leap forward in UGV capability. Autonomous mobility is being further enhanced by the use of terrain data for path planning. The program's technologies will transfer to the FCS UGV Integrated Product Team activities to include System Development and Demonstration (SDD) efforts and potential early spirals into FCS anticipated to occur in FY 2008.

(U) The Future Combat Systems MultiCell and Dismounted Command and Control program enables experimentation with advanced command and control information technology. MultiCell emulates the functionality of an entire tactical combined arms force. The program incorporates both unmanned air and ground robotic platforms, headquarters working at the operational level, and human dismounts. MultiCell also provides commanders with recommended interface functions and workload allocations. MultiCell validates the understanding of the dynamics of complex warfighting organizations thus defining commander interface layouts, functions and displays for maximum flexibility and effectiveness. This program recommends capability enhancements supporting technology for the nomination of information sources and supports visualization of current and future operational states. MultiCell enables commanders to successfully prosecute future command and control operations with significantly reduced staff. DARPA established an MOA with the Army for this program in August 2003. The MultiCell Command and Control technology is planned for transition to the Army at the conclusion of Phase II, anticipated to be completed in FY 2006.

(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.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
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(U) Under the Maneuver $C^3$ program, the Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) project will pursue MIMO communication systems, which have the potential to increase data rates by 10-20 times above current systems. MIMO will use multipath to create parallel channels in the same frequency band thereby increasing spectral efficiency. This effort will demonstrate the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. This effort will undertake advanced MIMO technology development and perform field demonstrations of mobile ad hoc networks (MANETs). This effort will culminate in the development of a wideband form-factor (Joint Tactical Radio System (JTRS) cluster 1 size PC card) system. The MNM technology is planned for transition to the Army in FY 2008.

(U) Two autonomous air vehicle programs will provide reconnaissance and surveillance, and targeting information for small unit FCS direct and indirect fire weapons. The approach is to develop autonomous vehicles for operation at two levels; a company level vertical take off and landing unmanned air vehicle (VTOL UAV) program will develop a vehicle for carrying out airborne surveillance and targeting against ground targets; and a platoon level VTOL UAV for providing small units with an organic reconnaissance and surveillance capability. The company level UAV will be developed under the OAV-II program and the platoon level UAV will be developed under the Micro Air Vehicle (MAV) program.

(U) The Organic Air Vehicle – II program will develop lift augmented ducted fan vertical flight vehicles together with their associated flight controls, collision avoidance systems, non-line-of-sight communications systems and heavy fuel engines. Once the basic flight vehicle is proven, a reconnaissance, surveillance and target acquisition (RSTA) payload, which is being developed by the Army Night Vision & Electronic Sensors Directorate, will be integrated to demonstrate mission capability. The OAV-II program will leverage several programs in DARPA and the services including advanced communications, sensor developments, the MAV ACTD, and UAV command and control programs. The dry system weight (no fuel) of the OAV II will be no greater than 112 lbs. The program will transition to the Army at the end of Phase III, which is anticipated to be in FY 2009.

(U) The primary goal of the Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD) program is to further develop and integrate MAV technologies into militarily useful and affordable backpackable systems suitable for dismounted soldier, Marine, and Special Forces missions. The ACTD will focus on the development of lift augmented ducted fan MAVs to accomplish unique military missions, particularly the hover and stare capability in restricted environments. The objective of the MAV ACTD is to demonstrate a backpackable, affordable, easy-to-operate, and responsive reconnaissance and surveillance system. The system will provide the small unit with militarily useful real-time combat information of difficult to observe and/or distant areas or objects. The system will also be employable in a variety of war

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|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

fighting environments (for example: in complex topologies such as mountainous terrain, urban areas, and confined spaces). 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. The MAV ACTD program is intended to get DARPA-developed small, Vertical Take – Off and Landing (VTOL) UAVs rapidly into the hands of the users for evaluation and evolution of the technologies; to develop tactics, techniques and procedures; and to provide a residual operational capability to active duty forces. The FCS MAV technology is planned for transition to the Army during FY 2007.

(U) The FCS LADAR Support (JIGSAW Phase III) program is developing advanced laser radar (LADAR) sensor systems and technologies for foliage penetration. Jigsaw will enable warfighters to accomplish day/night target identification and verification in the most stressing environments at short range (<1km). Environments of interest include targets hidden by foliage and camouflage, and targets in urban settings, such as alleyways. Jigsaw technologies are designed to provide warfighters with reliable combat identification based on a LADAR sensor that will deliver a visual picture of the target scene. The JIGSAW technology is planned for transition to the Army, which is anticipated to be completed by FY 2007.

(U) The Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER) initiative supports the Future Combat Systems (FCS) and the U.S. Army Objective Force. The program is developing FOPEN Ground Moving Target Indication (GMTI) radar. This radar promises persistent, long-term detection and tracking of dismounted troops and vehicles moving under foliage and in the open. The technology allows Objective Force commanders to operate with confidence in forested areas. The FORESTER radar will also be able to detect low-flying aircraft such as helicopters and ultra-lights at ranges out to 75km. FORESTER is a UHF-band FOPEN GMTI radar designed to operate on rotary wing platforms such as the A-160 unmanned helicopter. For GMTI operation, the helicopter flies into the wind to maintain near-zero ground speed. The goal is to detect dismounted troops under foliage at 30 km range under calm to low surface wind speeds. The program employs adaptive processing and innovative radar waveforms to overcome radio frequency interference and electronic countermeasures in hostile electromagnetic environments. The FORESTER technology is planned for transition to the Army at the conclusion of Phase III anticipated to be completed by FY 2008.

(U) The goal of the AACER (Affordable Adaptive Conformal ESA Radar) Program is to develop a high performance radar and communication system for Class IV unmanned helicopters such as the A-160. The Ka-band radar will provide airborne, all-weather, day-night Synthetic Aperture Radar reconnaissance, wide area Ground Moving Target Indication (GMTI) surveillance, dismount detection, and target

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

acquisition and designation for precision fires. It will provide this information directly to the Unit of Action commander via an interleaved data link through the same antenna. The program will develop Electronically Scanned Array (ESA) technology in a small Ka-band antenna. The combination of platform and radar characteristics will provide for persistent surveillance including that in urban areas, with a minimum discernable velocity of 1 mph. The technologies being developed include: (1) affordable radar devices such as phase shifting elements and power amplifiers/combiners which operate at Ka band; (2) miniature receiver/exciter modules generating very broadband waveforms; (3) signal processing algorithms to support multiple functions simultaneously and detect and track dismounts. Use of existing signal and data processing hardware and software will allow an early flight demonstration of the entire system on an A-160 or surrogate aircraft. If successful, this program will provide a vastly improved intelligence and targeting capability for local commanders by providing a dedicated, rapidly taskable asset with surveillance of most of their battlespace, including areas inaccessible or obscured to larger airborne assets. DARPA negotiated an MOA with the Army for this program in August 2005, and the AACER technology is planned for transition to the Program Executive Office – Intelligence Electronic Warfare and Sensors (PEO-IEW&S) at the conclusion of Phase III in FY 2008.

(U) The electro-magnetic (EM) Mortar program will design and demonstrate EM guns (coilgun and railgun) capable of firing modified 120 mm mortar rounds with a velocity of 420 m/s. The second goal is to evaluate significant system “trade space issues” for implementation including: 1) ammunition integration and compatibility; 2) vehicle integration concerns; 3) system reliability metrics (barrel life, EM interference); 4) lethality change due to modification; and 5) system supportability metrics. Transition of developed capabilities will be accomplished through the Army FCS program, and is anticipated to occur in FY 2007.

(U) The goal of the DP-5X program was to provide a flight-ready, tactically transportable, vertical take-off and landing unmanned air vehicle (VTOL UAV) helicopter that integrated a JIGSAW sensor package and an EO/IR payload. The UAV was to be employable by a two person team and deployable in a single HMMWV. The DP-5X program was funded through FY 2005.

(U) The Future Combat Systems Studies, Analysis and Experimentation Project enables the continued Joint analysis and integration of enabling future land warfare concepts and technologies into the U.S. Army Future Combat System program. It enables the rapid analysis of opportunistic concepts and technologies, and provides support for Joint Force effectiveness modeling of DARPA enabling technologies by the TRADOC “Future’s Center.” The project has three initial focus areas: Air Assault Expeditionary Forces (AAEF), USMA Systems Engineering, and Directed Studies.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
| --- | --- |
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

(U) The objective of the FCS International Cooperation program is to establish and execute Science and Technology Project Agreements with the Republic of Singapore (SN) and the United Kingdom (UK) to identify new S&T initiatives. The program is in collaboration with the U.S. Army. The Singapore Project Agreement will initially support projects to investigate tactical command and control interoperability, explore the use of computer-based technology to mitigate differences between coalition partner planning processes and tools; investigate and assess the utility of various sensor packages on UAV/UGV platforms in dense jungle environments, urbanized terrain and littoral/maritime environments; and determine the applicability of quantum dot technology for developing multi-spectral optic systems. DARPA established an MOA with the Army for this program in April 2004. The agreement with the United Kingdom will initially support projects to: survey and assess international technologies applicable to the FCS program; compare and assess the coalition effects-based operations planning technologies available from the U.S. and U.K.; and, conduct an analysis of U.S./U.K. coalition interoperability. The FCS International Cooperation technology program is planned for transition to the Army by FY 2007.

(U) The Sensor Dart program will produce and demonstrate unattended ground sensors in an aerodynamic glider capable of covert delivery from a stand-off of at least 45 kilometers with a 50 meters or less circular error probability (CEP). Sensor Dart will leverage and integrate capabilities derived from prior small unmanned air vehicle demonstrator and unattended ground sensors projects. The basis for the Sensor Dart is a platform/sensor system that transitions from winged flight to earth-penetrating dart. The integration of glider and precision delivered sensor will provide a well-coupled seismic and acoustic sensing capability in support of the FCS Brigade Combat Team (BCT). The planned transition customer will be Unit of Action (UA) Product Manager Robotic and Unmanned Sensors (PM RUS) out of Fort Monmouth. Transition is scheduled to occur following program conclusion after FY 2007.

(U) The WolfPack program will further develop the initial capability for close approach electronic warfare. The overall effectiveness and efficiency of FCS will be improved by this effort through the development of an advanced, collaborative electronic warfare sensing and attack system. This will lead to improved situational awareness of the battlespace for other FCS platforms and will improve their survivability in a wide range of potential conflicts. The improved WolfPack system will be able to suppress enemy air defenses, RF communication systems, and networks either through sensing and passing back targeting information to other FCS weapon platforms for kinetic fire or by collaboratively jamming those systems and networks on its own. The WolfPack technology is planned for transition to the Army in FY 2007.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

(U) The C-130 Short Take-Off and Landing (STOL) demonstration modified an existing C-130 aircraft in order to demonstrate improvements in take-off and landing distances and maximum payload capability. This was accomplished by changing the standard 4-blade propellers to 8-blade propellers. The effort was funded with FY 2005 resources.

(U) Program Plans:

– UGCV – PerceptOR Integration (UPI)
  - -- Integrated perception on original Spinner.
  - -- Redesigned and constructed (2) Spinner vehicles.
  - -- Integrate Spinner payloads.
  - -- Commence testing of ported Learning Applied Ground Robots (LAGR) hardware on Spinner.
  - -- Conduct operational UPI testing of Spinners + Perception.
  - -- Complete testing of ported LAGR hardware on Spinner.

– MultiCell and Dismounted Command and Control
  - -- Develop prototype command and control interfaces for higher commanders, cell commanders and dismount commanders.
  - -- Conduct human-in-the-loop experiments with dismounts and higher headquarters, including joint feeds.
  - -- Develop supporting operational and systems architectural framework products.
  - -- Develop a supporting C4ISR simulation test-bed to assess the performance of the C2 prototype.

– 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); 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.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

- -- Conduct experiments in support of selected command and control functions for operations with manned/unmanned systems.
- -- Complete the development of an initial $C^2$ experimental demonstrator.
- -- Continue experiments of Unit Cell $C^2$ incorporating limited activities of the dismounted soldier.
- -- Extend $C^2$ architecture to handle inter-unit cell operations, and operations between unit cell and next higher level.
- -- 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.

– Multiple Networked Multiple-Input/Multiple Output (MIMO) (MNM)
- -- Validated the MNM concept with field demonstrations of the MIMO-based Mobile Ad Hoc Network (MANET) and custom wideband RF/signal processing designs.
- -- Design and demonstrate wideband antenna/RF hardware and the MIMO signal processing.
- -- Design and develop a frequency agile MNM showing dynamic spectral efficiency and agility in an operational form factor for use in an urban and rural setting with applications for military and military operations other than war scenarios.

– Organic Air Vehicle - II
- -- Complete Phase II of competitive contracts for system detailed design.
- -- Conduct critical design review to evaluate detailed designs and downselect to the best design.
- -- Complete risk reduction testing on critical vehicle subsystems.
- -- Initiate Phase IIIA to build and fly a ~ 112 lb (dry weight) flight vehicle and demonstrate robust flight stability.
- -- Demonstrate collision avoidance system performance.
- -- Integrate RSTA payload sensors and non line of sight communications with the flight vehicle.
- -- Demonstrate RSTA and target designation missions with the integrated system.

– Micro Air Vehicle
- -- Demonstrate an enhanced g-MAV (gasoline engine) in military operations in urban terrain exercises and conduct experiments with troops in field trials.
- -- Continue to develop small heavy fuel engines.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

-- Provide Army unit from 25th Infantry Division, 25 MAV systems (50 air Vehicles) as a residual operational capability.
-- Integrate a heavy fuel engine with engineering prototype vehicles.

– Jigsaw Phase III
  -- Demonstrated in a flight test campaign that Jigsaw could obtain high quality images of targets even when they were more than 95% obscured by foliage and camouflage netting.
  -- Develop a form, fit, & function Jigsaw Sensor for integration onto the DP-5X.
  -- Develop real-time on-board registration and processing capability.
  -- Perform initial flight tests and data collections to demonstrate the utility of the Jigsaw system using a UH-1.
  -- Perform flight tests and data collections using a DP-5X UAV.
  -- Advance the technologies to a Technical Readiness Level 6.

– Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER)
  -- Demonstrate detection of slowly moving ground targets in foliage by rotorcraft-mounted Ground Moving Target Indication (GMTI) radars through measurements, simulations and analyses.
  -- Design, assess, and evaluate a brassboard FORESTER hardware system.
  -- Design, assess, and evaluate a form-fit-and-function FORESTER hardware system for rotorcraft installation.
  -- Design, and fabricate a FORESTER radar and integrate it first on a Black Hawk helicopter and then on an A-160 helicopter.
  -- Conduct airborne flight-testing of the FORESTER first on a Black Hawk and then on an A-160 and demonstrate ability to do real-time detection of moving troops under foliage and in the open.

– Affordable Adaptive Conformal Electronically Steerable Array Radar (AACER)
  -- Demonstrate sub-array ESAs, 2.4 GHz waveform generator (= 3” resolution).
  -- Fabricate quadrant and full ESA array (6” x 24”) with ~ 50 W average power from 34 to 38 GHz.
  -- Integrate full array and radar system with existing processor and receiver hardware for lab testing.
  -- Develop software and demonstrate functionality in A-160 or surrogate flight platform.
  -- Train military operators and perform simulated military mission tests and evaluation.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

- EM Mortar
  - Conducted modeling and simulation to design the launcher, power supply, and projectile modifications for coupling to the launcher.
  - Designed launcher for mortar launch application and developed specifications for the power system coil and rail guns.
  - Fabricate coil and rail gun launchers.
  - Conduct laboratory testing of the launchers with capacitor-based power systems.
  - Assess large-scale manufacturing issues for capacitors and demonstrate operation in a full-size module.
  - Conduct ammunition and weapon system testing.

- DP-5X
  - Designed and fabricated air vehicles.
  - Integrated off-the-shelf gasoline engine on initial vehicle.
  - Conducted ground test of DP-5X rotor.
  - Complete integration of air vehicles with autonomous flight control.
  - Integrate and conduct flight tests of JIGSAW sensor package.

- Studies/Analysis/Experiments
  - Conduct systems engineering studies.
  - Conduct experiments with Air Assault Expeditionary Force.
  - Conduct FCS related directed studies and analysis.

- International Cooperation
  - Jointly explore and develop innovative mechanized air assault force concept of operations through enabling technologies for coalition command and control.
  - Evaluate the operational performance of DARPA Organic and Micro Air Vehicles and Unmanned Ground Vehicles in complex terrain environments, e.g. jungle and urban.
  - Evaluate the operational performance of DARPA advanced sensors and advanced sensor exploitation technologies against tactical targets in complex terrain environments, e.g. urban and jungle.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

-- Evaluate U.S., U.K. and Singapore Command Post of the Future (CPoF) like technologies for facilitating the exchange of information and investigate concepts for command and control and explore interoperable architectures demonstrating plug and operate capabilities.
-- Conduct interoperability wargaming.
-- Initiate development of novel quantum dot detector technology for new design concepts for micro-sensors.
-- Survey and assess the applicability of international technologies to the FCS program.
-- Compare and assess the coalition effects-based operations planning technologies available from the U.S. and U.K.
-- Analyze U.S./U.K. coalition interoperability of tactical command, control and communications systems.

– Sensor Dart
-- Developed initial design concept that addresses separate Sensor Dart versions for a FCS Brigade Combat Team (BCT) deployment.
-- Conducted detailed trade studies and systems analysis that will be performed to maximize system capabilities.
-- Generated designs detailing the glider, dart, sensor, electronics, and communications subsystems.
-- Integrate Sensor Dart subsystems for flight testing.
-- Develop and flight test prototype glider and dart system.

– Wolfpack
-- Demonstrated WolfPack performance in laboratory and field demonstration.
-- Reduce form factor size of initial WolfPack capability hardware to suit multiple delivery options under the FCS architecture.
-- Refine target set and mission roles to complement existing EW systems with unique WolfPack capabilities.
-- Optimize initial WolfPack power generation and management systems for longer endurance.

– C-130 Short Takeoff and Landing (STOL) Demonstration Program
-- Conducted wind tunnel tests of modified configuration.
-- Completed necessary aero modifications for low speed stability.
-- Installed and flight tested 8-bladed propellers.

| RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit) | DATE February 2006 |
|---|---|
| APPROPRIATION/BUDGET ACTIVITY<br>RDT&E, Defense-wide<br>BA3 Advanced Technology Development | R-1 ITEM NOMENCLATURE<br>Land Warfare Technology<br>PE 0603764E, Project LNW-03 |

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

| | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| PE 0603005A Army | 104.800 | 40.000 | 25.000 |