Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Office of Secretary Of Defense	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 5: *Development & Demonstration (SDD)*	R-1 ITEM NOMENCLATURE PE 0604709D8Z: *Joint Robotics EMD*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	4.049	2.715	-	-	-	-	-	-	-	Continuing	Continuing
609: *Joint Robotics EMD*	4.049	2.715	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This Program Element (PE) was established in response to Congressional guidance to consolidate DOD robotic programs on unmanned ground systems and related robotic technologies in order to increase focus of the Services' robotic programs on operational requirements. Technologies in the PE support the continued development of technologies in Budget Activity 3 and 4 (PEs 0603711D8Z and 0603709D8Z) for technology transitions and transformations and closing war fighter requirement capability gaps. By exercising its oversight role through a technology advisory board, O-6 Council and Senior Steering Group (Flag level), Joint Ground Robotics applies this PE to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. This PE supports the effort to overcome technology barriers in thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Manipulation Technologies, Collaborative Operations, Interoperability, Man-portable Unmanned Ground System Technologies, and Technology Transition/ Transformation. The purpose is to further the development and fielding of affordable and effective mobile ground robotic systems, develop and transition technologies necessary to meet evolving user requirements, and serve as a catalyst for insertion of robotic systems and technologies into the force structure. Through application of funds against the thrust areas of unmanned ground system technologies, this PE supports the integration of technologies into representative models or prototype systems in a high fidelity and realistic operating environment and expedites technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Within this PE, funded efforts will continue the delivery of advanced technology needs directed at enhancing the war fighters' capabilities identified during concept development, operational assessments and field feedback of current unmanned systems.

B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	4.155	2.715	2.564	-	2.564
Current President's Budget	4.049	2.715	-	-	-
Total Adjustments	-0.106	-	-2.564	-	-2.564
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.069	-			
• Economic Assumptions	-0.021	-	-	-	-
• FFRDC	-0.014	-	-	-	-
• Other Adjustments	-0.002	-	-2.564	-	-2.564

Exhibit R-2A, RDT&E Project Justification: PB 2013 Office of Secretary Of Defense			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 5: *Development & Demonstration (SDD)*	R-1 ITEM NOMENCLATURE PE 0604709D8Z: *Joint Robotics EMD*	PROJECT 609: *Joint Robotics EMD*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
609: *Joint Robotics EMD*	4.049	2.715	-	-	-	-	-	-	-	Continuing	Continuing
Quantity of RDT&E Articles											

A. Mission Description and Budget Item Justification

This Program Element (PE) was established in response to Congressional guidance to consolidate DoD unmanned ground systems and related robotic technologies in order to increase focus of the Services' robotic programs on operational requirements. Technologies in this PE support the continued development of technologies in Budget Activity 3 and 4 (PEs 0603711D8Z and 0603709D8Z) to fulfill Warfighter requirement capability gaps. By exercising its oversight role through a Technology Advisory Board, O-6 Council and Senior Steering Group (Flag level), the Joint Ground Robotics Enterprise applies this PE to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. This PE supports the effort to overcome technology barriers in thrust areas of unmanned ground system technologies to include: Navigation; Perception; Vision/Sensors; Manipulation; Command, Communication & Control; Mission/ Platform Specific; Interoperability; and Outreach & Harmonization. The purpose is to further the development and fielding of affordable and effective mobile ground robotic systems, develop and transition technologies necessary to meet evolving user requirements, and serve as a catalyst for insertion of robotic systems and technologies into the force structure. Through application of funds against the thrust areas of unmanned ground system technologies, this PE supports the integration of technologies into representative models or prototype systems in a high fidelity and realistic operating environment and expedites technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Within this PE, funded efforts will continue the delivery of advanced technology needs directed at enhancing the Warfighters' capabilities identified during concept development, operational assessments and theater feedback of current unmanned systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Manipulation	0.375	1.319	-
Description: Incorporation of new or existing technologies to enable a greater range of robotic manipulation, support the development of mobile manipulation, and improve manipulator performance. Development of these technologies will enable unmanned systems to conduct highly dexterous tasks that today are accomplished manually, but currently place war fighters in extremely vulnerable and dangerous situations.			
FY 2011 Accomplishments: 1) Highly Dexterous Manipulators for Explosive Ordnance Disposal Robots - The purpose of this project is to develop a Highly Dexterous Manipulator that approaches the dexterity of a human and is targeted for use on a small EOD UGV with a total vehicle weight (including the manipulator) of 164 pounds. The manipulator is to be capable of performing bimanual tasks as required in the Capability Development Document (CDD) for Advanced Explosive Ordnance Disposal Robotic System (AEODRS). The direct benefit to the Warfighter is increased performance and capability over the current state-of-the-art which will translate into reduced mission time.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Dexterous heavy lift hardware and technical documentation package - Feed-forward controls development - Human-machine interfaces phase 1 development and report - End effector interface family technical data package and hardware - Human-machine interface phase II development and report - Operator haptic interface - System integration and testing 2) Advanced Hydraulic Actuation - The purpose of this project is to design and build a technology demonstrator of an advanced hydraulic manipulator suitable for use on a 164 pound AEODRS Tactical class UGV. The intent of the AHA project is to demonstrate the theory that a hydraulic powered manipulator with a high power density, capable of both strength and speed, can be packaged in a way suitable for Tactical class UGVs. - Integration of arm and power unit and corresponding report - Arm operator control unit development and report - Fully integrates arm and power supply and report - Final report ***FY 2012 Plans:*** 1) Highly Dexterous Manipulators for Explosive Ordnance Disposal Robots - Development and complete integration of Haptic feedback - System integration (arm, end effector interface and end effector) and system testing - Dexterous hardware support - Make improvements to autonomous system and the OCU based on lessons learned during LTA 1 and LOE 1 - Conduct LTA 2. - Perform a four week LOE for Marines to assess the net military utility and determine the poetential for deploying for an Extended Evaluation. ***FY 2013 Plans:*** 1) Projects for this area will be determined by 4Q FY 2012			
Title: Mission/Platform Specific ***Description:*** Development of a technology to address the requirements of a particular mission or to be integrated with a specific platform. ***FY 2011 Accomplishments:***	1.125	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
1) Remote Checkpoint - The purpose of this project is to develop and demonstrate a prototype unmanned ground vehicle (UGV) system with semiautonomous capabilities to support operations at remote security checkpoints. The proposed solution will be a sensor-fused approach to integrate the Talon UGV with Idaho National Lab's robotics intelligence kernel (RIK) Iris recognition and personnel identification and explosives detection. This integrated sensor approach will enable the Talon to semi-autonomously perform several remote checkpoint tasks yet allow operator intervention when needed, especially to employ systems to delay or deny hostile personnel. The project will result in a capstone demonstration as well as a final report. - Finalized and delivered system design drawings - Delivered complete user's manual - Conducted Capstone Demonstration - Delivered final report with results of the overall project as well as the results from the Demonstration 2) Man-Portable ISR Robot - A current challenge for military ground forces is providing sustained intelligence gathering, surveillance, and reconnaissance (ISR) in remote, ungoverned, denied, and/or isolated environments. Highlighting the importance of this high-priority need, the Department of Defense Joint Requirements Oversight Counsel has identified "provide persistent surveillance in ungoverned/denied areas" as the second item on its current list of most pressing military issues. This need is of particular relevance in relation to the IED problem in Iraq, but is also a global requirement to support the War on Terrorism, as well as counter-narcotic and boundary enforcement operations in multiple areas of responsibility. The purpose of this project is to develop and evaluate a prototype unmanned system capable of providing sustained reconnaissance and surveillance in remote and/or denied areas. This project will develop a prototype UGV with enhanced capabilities that specifically support persistent surveillance and reconnaissance applications. It will have a power system to support 72-hour endurance, communication to support long-range operation, an integrated sensor suite, and low light color cameras to perform night surveillance. - Integrated new EMCCD cameras - Integrated new pan and tilt unit - Integrated Velodyne LIDAR - Conducted military user trials 3) Cargo Unmanned Ground Vehicle - The goal of this project is to determine the feasibility of reducing the exposure of Marines to lethal attacks by replacing a portion of the manned vehicles in logistics convoys with unmanned vehicles. Two Medium Tactical Vehicle Replacements (MTVRs) will be autonomized, and a third MTVR will be equipped with an Operator Control Unit (OCU). This project is advancing the current state of robotics through the development of its perception technology (including methods of sensor data fusion and object classification) and methods of GPS-denied navigation. - Completed system build for initial MTVR as a UGV - Completed system build for initial MTVR with Operator Control Unit			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conducted Limited User Assessment - Conducted Limited Objective Experiment - Initiated system build for second MTVR as UGV ***FY 2012 Plans:*** 1) Cargo Unmanned Ground Vehicle - Finalize system build for second MTVR as UGV - Conduct second Limited User Assessment - Conduct Limited Objective Experiment for Logistics Mission ***FY 2013 Plans:*** 1) Projects for this area will be determined by 4Q FY 2012			
Title: Navigation ***Description:*** Development of reliable motion planning, path planning, obstacle detection/obstacle avoidance, characterization, and decision analysis capabilities based on the perceived environment and specific missions outlined for the robot. ***FY 2011 Accomplishments:*** 1) Autonomous Navigation for Small Unmanned Ground Vehicles - The ANSU program focuses on moving technologies from the laboratory to a realistic operational environment, specifically technologies that will advance the autonomy of small systems in a practical and robust manner. Specific technologies to be addressed include obstacle detection/obstacle avoidance (OD/OA), autonomous navigation, retro-traverse, non-GPS waypoint navigation, guarded tele-operation and other tactical behaviors for small vehicles. - Developed algorithm to stitch successive 3D lidar scans - Developed algorithm for enhanced obstacles detection - Fused stereo vision data with lidar data - Developed algorithm for enhanced obstacle avoidance - Developed and integrate illuminator - Developed algorithm for vegetation classification - Refined control and behavior algorithms - Demonstrated enhanced behaviors 2) Collision Prediction Utilizing Traversability - The purpose of this project is to develop, demonstrate, and deliver two (2) prototype systems to detect, classify, track, and predict the motion of objects from a moving vehicle. The prototypes will include sensors, computing, power distribution, and software to sense the environment and generate predictions as to the expected path	0.849	0.410	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
of the sense objects of to 10 seconds into the future. This project is advancing the state of robots by developing predictive tools to track objects based on only on object dynamics but also on the environment around the objects. - Algorithm design and created software architecture - Software Development - Algorithm hardening and hardware selection review - Test readiness Review - System Qualification Review - Technology demonstration ***FY 2012 Plans:*** 1) Collision Prediction Utilizing Traversability - Advanced module development and hardware upgrades - Phase 2 validation and tests - Technology demonstration and End User Support ***FY 2013 Plans:*** 1) Projects for this area will be determined by 4Q FY 2012			
Title: Perception ***Description:*** Development of post-processing software technologies (proprioceptive and/or exetroceptive) which will enhance unmanned ground vehicle perception capabilities for navigation, manipulation, and general unmanned ground vehicle situational awareness in a wide range of environments and conditions. ***FY 2011 Accomplishments:*** Project will be determined in June FY 2011 ***FY 2012 Plans:*** 1) Long Range Obstacle Detection - Finalize sensor processing algorithm development - Finalize prototype system development - Complete system integration onto UGV platform - Conduct performance verification testing - Conduct final demonstration - Compile/deliver final report ***FY 2013 Plans:***	0.201	0.986	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
1) Projects for this area will be determined by 4Q FY 2012			
Title: Vision/Sensors	1.499	-	-
Description: Development of technologies (hardware and software) which will enhance unmanned ground vehicle sensory (visual, audible and/or tactile) capabilities for navigation, manipulation, and general unmanned ground vehicle situational awareness in a wide range of environments and conditions. ***FY 2011 Accomplishments:*** 1) 3D Visualization for Explosive Ordnance Disposal Robots - Develop, demonstrate, and transition technologies that will provide the EOD UGV operators with an improved situational awareness and visualization capability for manipulation. Provide a high-resolution 3D model of the object of interest and the position of the UGV and manipulator relative to the object in real-time. The 3D model of the object as well as models of the UGV and manipulator will be presented to the operator in a virtual view that accurately reflects the real system. This will allow the operator view the object and the UGV/manipulator from any viewpoint. - Procured the same hardware to replicate original the UNC system - Integrated system onto a Packbot. - Integrated software revisions - Developed 3D Modeling. - Integrate software onto the hardware - Test software on the Packbot MKI - Procured duplicate hardware for local integration and testing with a UGV - Designed a ground truth object that can be used to test the accuracy of the 3D models generated by the UNC pipeline ***FY 2012 Plans:*** 1) Projects for this area will be determined by 1Q FY 2012 ***FY 2013 Plans:*** 1) Projects for this area will be determined by 4Q FY 2012			
Accomplishments/Planned Programs Subtotals	4.049	2.715	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• 0603709D8Z: *Joint Robotics Program*	9.673	11.129	0.000		0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

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C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• 0603711D8Z: *Joint Robotics Program/Autonomous Systems*	9.567	9.756	0.000		0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

E. Performance Metrics

1. Technologies to be funded & developed are reviewed by Joint Capability Area focused working groups and the Joint Staff Functional Capabilities Boards to determine progress, transition plans, and relevance of each project.
2. Project plans are submitted, evaluated and analyzed by the Joint Robotics Ground Enterprise (JGRE) management and technical staff for risk and progress.
3. Project progress toward goals and milestones is assessed during mid-year and end-of-year reviews.
4. Technologies developed by the JGRE are tracked and documented using the DOD Technical Readiness Level (TRL) scale for developing TRL 3 or 4 technologies to TRL 6 and adhering to the integrated baselines with regard to cost and schedule.

Exhibit R-4, RDT&E Schedule Profile: PB 2013 Office of Secretary Of Defense		DATE: February 2012
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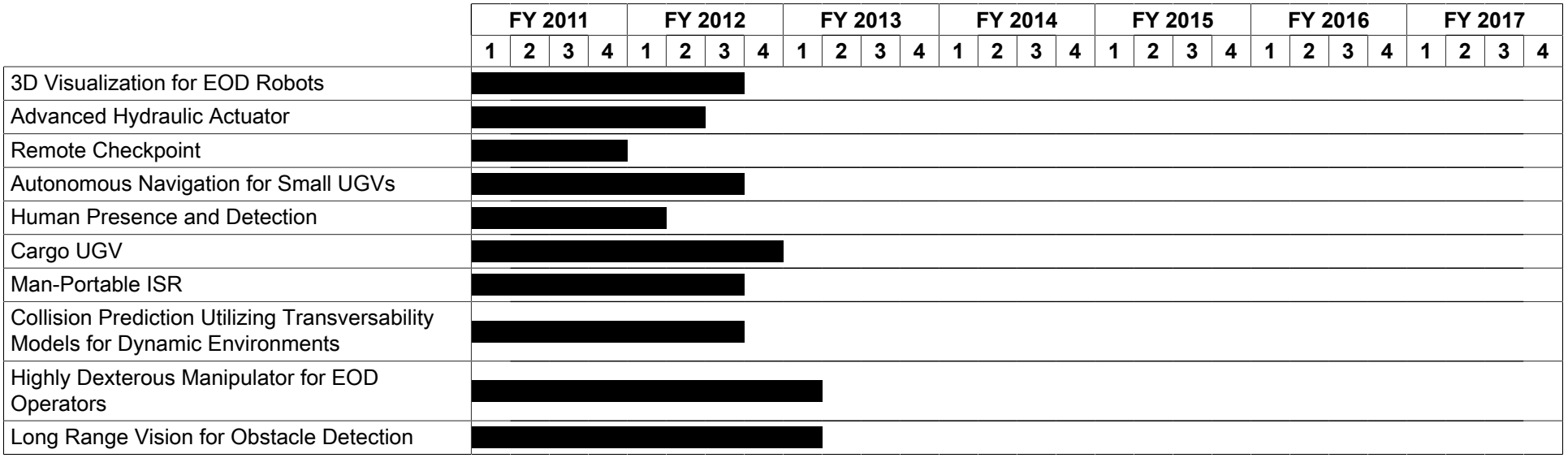

Exhibit R-4A, RDT&E Schedule Details: PB 2013 Office of Secretary Of Defense		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 5: *Development & Demonstration (SDD)*	R-1 ITEM NOMENCLATURE PE 0604709D8Z: *Joint Robotics EMD*	PROJECT 609: *Joint Robotics EMD*

Schedule Details

	Start		End	
Events	**Quarter**	**Year**	**Quarter**	**Year**
3D Visualization for EOD Robots	1	2011	3	2012
Advanced Hydraulic Actuator	1	2011	2	2012
Remote Checkpoint	1	2011	4	2011
Autonomous Navigation for Small UGVs	1	2011	3	2012
Human Presence and Detection	1	2011	1	2012
Cargo UGV	1	2011	4	2012
Man-Portable ISR	1	2011	3	2012
Collision Prediction Utilizing Transversability Models for Dynamic Environments	1	2011	3	2012
Highly Dexterous Manipulator for EOD Operators	1	2011	1	2013
Long Range Vision for Obstacle Detection	1	2011	1	2013