Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Office of Secretary Of Defense											**DATE:** April 2013	
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*					**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*							
COST ($ in Millions)	**All Prior Years**	**FY 2012**	**FY 2013**#	**FY 2014 Base**	**FY 2014 OCO**##	**FY 2014 Total**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**Cost To Complete**	**Total Cost**
Total Program Element	-	10.932	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
P709: *Joint Robotics Program*	-	10.932	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 the focus of the robotic programs on operational requirements. Technologies in the PE support the continued development of technologies beyond Budget Activity 3 (PE 0603711D8Z) for technology transition and transformation to close warfighter requirement capability gaps. By exercising its oversight role through a technology advisory board, senior military Council and Senior Steering Group (Flag level), Joint Ground Robotics (JGRE) applies this PE to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. This PE funds efforts to overcome technology barriers in thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Collaborative Operations, Interoperability, Man-portable Unmanned Ground System Technologies, Manipulation Technologies, and Technology Transition/Transformation. This PE funds unmanned ground system technologies and 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 projects will continue the delivery of advanced technology directed at enhancing the warfighter's capabilities identified during new concept development, operational assessments and field feedback of current unmanned systems. The technologies are generally at TRL 4 or 5 with the intent to mature them through JGRE efforts to TRL 6.

B. Program Change Summary ($ in Millions)

	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	10.954	0.000	0.000	-	0.000
Current President's Budget	10.932	0.000	0.000	-	0.000
Total Adjustments	-0.022	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.022	-			
• SBIR/STTR Transfer	-	-			

PE 0603709D8Z: *Joint Robotics Program*
Office of Secretary Of Defense

Exhibit R-2A, RDT&E Project Justification: PB 2014 Office of Secretary Of Defense		DATE: April 2013

APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	R-1 ITEM NOMENCLATURE PE 0603709D8Z: *Joint Robotics Program*	PROJECT P709: *Joint Robotics Program*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
P709: *Joint Robotics Program*	-	10.932	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
Quantity of RDT&E Articles												

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 the focus of the robotic programs on operational requirements. Technologies in the PE supported the continued development of technologies beyond Budget Activity 3 (PE 0603711D8Z) for technology transition and transformation to close war fighter requirement capability gaps. By exercising its oversight role through a technology advisory board, senior military Council and Senior Steering Group (Flag level), Joint Ground Robotics (JGRE) applied this PE to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. This PE funded efforts to overcome technology barriers in thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Collaborative Operations, Interoperability, Man-portable Unmanned Ground System Technologies, Manipulation Technologies, and Technology Transition/Transformation. This PE funded unmanned ground system technologies and 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 projects continue the delivery of advanced technology directed at enhancing the war fighter's capabilities identified during new concept development, operational assessments and field feedback of current unmanned systems. The technologies are generally at TRL 4 or 5 with the intent to mature them through JGRE efforts to TRL 6.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2012	FY 2013	FY 2014
Title: Command, Communication & Control	1.609	0.000	0.000

Description: Development of data delivery, control and display, or task execution technologies enhanced unmanned ground vehicle operations, reduce operator loads and improve effectiveness. Development and integration of communication, mission planning, human-robot interface technologies, and advanced intelligence capabilities to support robotic operations.

FY 2012 Accomplishments:
1) Automated Mobile Communication Relay
- Integrated sensors and processing payload onto man-portable robots (both EOD and communications robots)
- Developed software components required to conduct automated relay mission
- Conducted experimental assessment system concept utilizing COTS components and radios to validate concept feasibility
- Terrain and road estimation module development
- Prediction moduel development

Exhibit R-2A, RDT&E Project Justification: PB 2014 Office of Secretary Of Defense		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	R-1 ITEM NOMENCLATURE PE 0603709D8Z: *Joint Robotics Program*	PROJECT P709: *Joint Robotics Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Prototype hardware development and construction - Performed prototype hardare validations and test - Technology demontstration 1 - Critical Design 2 4) Longe Range Vision for Obstacle Detection from a moving ground vehicle (LROD) project increased the capability of unmanned ground vehicles (UGVs) to respond to postiive, negative and moving obstacles. Project previously funded from PE 0603711D8Z - Early performance testing - Prototype development - Unmanned ground vehicle integration - Performed verification testing - Held final demonstration - Provided final report *FY 2013 Plans:* 1) Automated Mobile Communication Relay - Further develop system components, and conduct experimental assessment in a relevant environment			
Title: Interoperability *Description:* Promoted and guided technology development that met joint requirements and promoted ground as well as air unmanned systems interoperability. Supported the bridging of currently incompatible robots and controllers from various manufacturers, using different communications channels and hardware. Optimized best features of prior/ongoing research efforts into a maturing, standardized system that can be easily ported to robotic platforms used throughout the Department of Defense. *FY 2012 Accomplishments:* 1) Interoperability Challenges - Extended Interoperability Profile, Version 0 to autonomous systems, specifically those with Applique Kits. *FY 2013 Plans:* 1) Interoperability Challenges - Develop testing capability/environment associated with the Interoperability Profiles for autonomous systems. - Verify test environment/procedures, an Applique Kit prototype solution will be provided and tested.	1.134	0.000	0.000
Title: Mission/Platform Specific *Description:* Development of a technology that addressed the requirements of a particular mission and integrated with a specific platform.	5.656	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Office of Secretary Of Defense		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	R-1 ITEM NOMENCLATURE PE 0603709D8Z: *Joint Robotics Program*	PROJECT P709: *Joint Robotics Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: 1) Counter Tunnel Exploitation/Mapping - Developed Autonomy Architecture - Developed 3D Mapping Capability - Integrated 1st generation Sensor Suite - Miniaturized Sensor Suite - Conducted experiments of the bore hole apparatus and the Snakebot 2) Cargo Unmanned Ground Vehicle - Finalized system build for second MTVR as UGV - Conducted second Limited User Assessment - Conducted Limited Objective Experiment for Logistics Mission 3) Virtual Autonomous Navigation Environment - Completed the development of a high-impact, releasable version of the ANVEL - Developed scenario setup and mission plan assignment - Created runtime scene modifications for rapid scenario variations - Developed geo-specific environments for virtual UGV performance evaluations - Integrated sensor models for lower-fidelity desktop simulations - Implemented and verified high-fidelity vehicle terrain interface with deformable ground effects - Updated technical documentation and user guide *FY 2013 Plans:* 1) Counter Tunnel Exploitation/Mapping - Integrate sensor suite onto the platform - Conduct user assessment of the system - Finalize report on system progress and development			
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 2012 Accomplishments:* 1) Collision Prediction Utilizing Traversability - Advanced module development and hardware upgrades - Phase 2 validation and tests	2.533	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Office of Secretary Of Defense		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*	**PROJECT** P709: *Joint Robotics Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Technology demonstration and End User Support 2) Long Range Global Positioning System-Denied Localization - Completed study and evaluation of possible external data sources (aerial imagery, DTED, road/route networks, aerial lidar libraries, etc.). That study included a evaluation of how well those data sources can be match to a like set of multi-modal onboard sensors. An initial design was developed and implemented on a relevant UGV. Different combinations of external data sources and onboard sensors was evaluated to determine that best combination. 3) Autonomous Assisted Mobility for Small UGVs - Development of autonomy package and payload provided mobility assist functionalities during UGV operations. - Development and integration of onboard sensors and vision systems. - Development of behaviors such as auto CG adjustment, automatic flipper and manipulator configurations. 4) Tipover Prevention Behaviors - Reactive behavior software integrated on a robot with static payloads in rough and sloped terrain. *FY 2013 Plans:* 1) Long Range Global Positioning System-Denied Localization - Develop the algorithms to match the external data to the onboard sensor data - Reference design and software will be delivered with full Government rights and as open source so that the larger UGV community can make use of and build on it 2) Autonomous Assisted Mobility for Small UGVs - Combination of separate capabilities to enable autonomous reconfiguration of the platform to maximize the mobility performance of the UGV. - Technology demonstrations and assessments of the technology will be performed to examine utility of the technology in operational contexts. 3) Tipover Prevention Behaviors - Reactive behavior software integrated on a robot with dynamic payload in rough and sloped terrain. - Report recommending a JAUS message format for inertial and kinematic properties of robots and payloads. 4) Other projects for this area will be determined by 4QFY12			
Title: Perception *Description:* Development of post-processing software technologies (proprioceptive and/or exetroceptive) enhanced unmanned ground vehicle perception capabilities for navigation, manipulation, and general unmanned ground vehicle situational awareness in a wide range of environments and conditions. *FY 2012 Accomplishments:* 1) Real Time Radio Modeling	0.000	0.000	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Office of Secretary Of Defense		**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*	**PROJECT** P709: *Joint Robotics Program*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Integrated with Building Properties into the model - Integrated Building Properties with TARDEC IG - Integrated Building Properties with TARDEC UGV - Development of Urban Canyon Models - Built Clearing/Urban Canyon Comparison Analysis - Development of rain, snow, wind, and smoke models 2) Long Range Obstacle Detection - Finalized sensor processing algorithm development - Finalized prototype system development - Completed system integration onto UGV platform - Conducted performance verification testing - Conducted final demonstration - Compiled/delivered final report *FY 2013 Plans:* 1) Real Time Radio Modeling - Continue development of rain, snow, wind, and smoke models - Integration with TARDEC IG - Integration with TARDEC UGV - Weather Comparisons Analysis			
Title: Vision/Sensors *Description:* Development of technologies (hardware and software) enhanced 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 2012 Accomplishments:* 1) Very Low Cost Light Detection and Ranging System - Improved warfighter agility, survivability, lethality, and effectiveness which enabled lower-cost UGVs/SUGVs with superior situational awareness. - Integrated a set of existing technologies with minimal modification which realized a sensor package capable of generating 3D depth/image models of the environment.	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	10.932	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Office of Secretary Of Defense		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*	**PROJECT** P709: *Joint Robotics Program*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
• 0603711D8Z : *Autonomous*	9.481	0.000	0.000		0.000	0.000	0.000	0.000		Continuing	Continuing
• 0604709D8Z : *Robotics*	2.705	0.000	0.000		0.000	0.000	0.000	0.000		Continuing	Continuing

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

1. Technologies developed and reviewed by Joint Capability Area focused working groups. The Joint Staff Functional Capabilities Boards reviewed to determine progress, transition plans, and relevance of each project.
2. Project plans were submitted, evaluated and analyzed by the Joint Robotics Ground Enterprises management and technical staff for risk and progress.
3. Project progress toward goals and milestones were assessed during mid-year and end-of-year reviews.
4. Technologies developed by the Joint Robotics Ground Enterprises (JGRE) were 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-3, **RDT&E Project Cost Analysis:** PB 2014 Office of Secretary Of Defense				**DATE:** April 2013	

APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*	**PROJECT** P709: *Joint Robotics Program*

Support ($ in Millions)

Cost Category Item	Contract Method & Type	Performing Activity & Location	All Prior Years	FY 2012 Cost	FY 2012 Award Date	FY 2013 Cost	FY 2013 Award Date	FY 2014 Base Cost	FY 2014 Base Award Date	FY 2014 OCO Cost	FY 2014 OCO Award Date	FY 2014 Total Cost	Cost To Complete	Total Cost	Target Value of Contract
Robotics Technology Consortium	C/Various	Various:Various	-	10.932		0.000		-		-		-	Continuing	Continuing	
Subtotal			0.000	10.932		0.000		0.000		0.000		0.000			

	All Prior Years	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total	Cost To Complete	Total Cost	Target Value of Contract
Project Cost Totals	0.000	10.932	0.000	0.000	0.000	0.000			

Remarks

Exhibit R-4, **RDT&E Schedule Profile:** PB 2014 Office of Secretary Of Defense | **DATE:** April 2013

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*	PE 0603709D8Z: *Joint Robotics Program*	P709: *Joint Robotics Program*

	FY 2012				FY 2013				FY 2014				FY 2015				FY 2016				FY 2017				FY 2018			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Very Low Cost LADAR	█	█	█	█																								
Urban Environment Modeling	█																											
Miniature 3D Spatial Phase Sensors	█	█	█																									
High Speed Small Teleoperation Robotic Command and Control	█	█	█	█																								
Conformal End Effector	█	█	█	█																								
Collision Prediction Utilizing Traversability Models for Dynamic Environments	█	█	█																									
Maritime Interdiction Operations	█																											
Adaptive Navigation Systems	█	█	█	█																								
Urban Environment Exploration	█	█	█																									
HRI for EOD UGVs	█	█	█																									
Long Range Vision for Obstacle Detection	█	█	█	█	█																							
Cargo UGV	█	█	█	█																								
Robotic Range Clearance Competition	█	█	█	█																								
Autonomous Navigation for Small UGVs	█	█	█																									
Real Time Radio Marketing			█	█	█	█																						
Tipover Prevention Behaviors			█	█	█	█																						
Counter Tunnel (Mapping and Exploitation	█	█	█	█	█	█																						
Non-RF Communication for Small UGVs	█	█	█	█																								
Virtual Autonomous Navigation Environment (VANE)	█	█	█																									
UGV Interoperability Challenges			█	█	█	█																						
Automated Mobile Communications Relay		█	█	█	█																							
Autonomous Assisted Mobility for Small UGVs		█	█	█	█																							

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Exhibit R-4, RDT&E Schedule Profile: PB 2014 Office of Secretary Of Defense		DATE: April 2013

APPROPRIATION/BUDGET ACTIVITY 0400: Research, Development, Test & Evaluation, Defense-Wide BA 4: Advanced Component Development & Prototypes (ACD&P)	R-1 ITEM NOMENCLATURE PE 0603709D8Z: Joint Robotics Program	PROJECT P709: Joint Robotics Program

	FY 2012				FY 2013				FY 2014				FY 2015				FY 2016				FY 2017				FY 2018			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Long-Range GPS Denied Localization/ Navigation in Off-road Environments					███																							

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Exhibit R-4A, RDT&E Schedule Details: PB 2014 Office of Secretary Of Defense			DATE: April 2013	
APPROPRIATION/BUDGET ACTIVITY 0400: Research, Development, Test & Evaluation, Defense-Wide BA 4: Advanced Component Development & Prototypes (ACD&P)		R-1 ITEM NOMENCLATURE PE 0603709D8Z: Joint Robotics Program	PROJECT P709: Joint Robotics Program	

Schedule Details

Events	Start		End	
	Quarter	Year	Quarter	Year
Very Low Cost LADAR	1	2012	4	2012
Urban Environment Modeling	1	2012	1	2012
Miniature 3D Spatial Phase Sensors	1	2012	3	2012
High Speed Small Teleoperation Robotic Command and Control	1	2012	4	2012
Conformal End Effector	1	2012	4	2012
Collision Prediction Utilizing Traversability Models for Dynamic Environments	1	2012	3	2012
Maritime Interdiction Operations	1	2012	1	2012
Adaptive Navigation Systems	1	2012	4	2012
Urban Environment Exploration	1	2012	3	2012
HRI for EOD UGVs	1	2012	3	2012
Long Range Vision for Obstacle Detection	1	2012	1	2013
Cargo UGV	1	2012	4	2012
Robotic Range Clearance Competition	1	2012	4	2012
Autonomous Navigation for Small UGVs	1	2012	3	2012
Real Time Radio Marketing	3	2012	3	2013
Tipover Prevention Behaviors	3	2012	3	2013
Counter Tunnel (Mapping and Exploitation	1	2012	2	2013
Non-RF Communication for Small UGVs	1	2012	4	2012
Virtual Autonomous Navigation Environment (VANE)	1	2012	3	2012
UGV Interoperability Challenges	3	2012	3	2013
Automated Mobile Communications Relay	2	2012	2	2013
Autonomous Assisted Mobility for Small UGVs	2	2012	2	2013

Exhibit R-4A, **RDT&E Schedule Details:** PB 2014 Office of Secretary Of Defense				**DATE:** April 2013	
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 4: *Advanced Component Development & Prototypes (ACD&P)*		**R-1 ITEM NOMENCLATURE** PE 0603709D8Z: *Joint Robotics Program*		**PROJECT** P709: *Joint Robotics Program*	

Events	Start		End	
	Quarter	**Year**	**Quarter**	**Year**
Long-Range GPS Denied Localization/Navigation in Off-road Environments	2	2012	2	2013