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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2012 Office of Secretary Of Defense **DATE:** February 2011

<b>APPROPRIATION/BUDGET ACTIVITY</b>				<b>R-1 ITEM NOMENCLATURE</b>							
0400: <i>Research, Development, Test &amp; Evaluation, Defense-Wide</i> BA 3: <i>Advanced Technology Development (ATD)</i>				PE 0603711D8Z: <i>Joint Robotics Program/Autonomous Systems</i>							
<b>COST (\$ in Millions)</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012 Base</b>	<b>FY 2012 OCO</b>	<b>FY 2012 Total</b>	<b>FY 2013</b>	<b>FY 2014</b>	<b>FY 2015</b>	<b>FY 2016</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
Total Program Element	10.289	9.943	9.756	-	9.756	10.071	10.281	10.520	10.857	Continuing	Continuing
P710: <i>Joint Robotics Program/Autonomous Systems</i>	10.289	9.943	9.756	-	9.756	10.071	10.281	10.520	10.857	Continuing	Continuing

**A. Mission Description and Budget Item Justification**

This program supports the technology development activities of the Joint Ground Robotics Enterprise (JGRE) with a focus on the development of subsystems and components, and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in simulated environments. Projects deliver advanced technology with direct relevance to enhancing warfighters' capabilities that have been identified during operational assessments and field feedback of current unmanned systems. By exercising its oversight role through a Technology Advisory Board, O-6 Council and Senior Steering Group (Flag level), Joint Ground Robotics applies this program to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. The primary purpose of this program is to support efforts to overcome technology barriers in the thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Manipulation Technologies, Collaborative Operations, Interoperability, Man-portable Unmanned Ground Systems, and Technology Transition/Transformation. Development and integration of technologies within the thrust areas of unmanned ground system technologies will expedite technology transition from the laboratory to operational use. The technologies are generally at Technology Readiness Levels (TRL) of 3 or 4 with the intent to mature them through JGRE efforts to TRL 6.

<b>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012 Base</b>	<b>FY 2012 OCO</b>	<b>FY 2012 Total</b>
Previous President's Budget	9.110	9.943	11.048	-	11.048
Current President's Budget	10.289	9.943	9.756	-	9.756
Total Adjustments	1.179	-	-1.292	-	-1.292
• Congressional General Reductions		-			
• Congressional Directed Reductions		-			
• Congressional Rescissions	-	-			
• Congressional Adds		-			
• Congressional Directed Transfers		-			
• Reprogrammings	-0.500	-			
• SBIR/STTR Transfer	-0.217	-			
• Other Program Adjustments	1.896	-			
• Defense Efficiency - Report, Studies, Boards, and Commissions	-	-	-1.277	-	-1.277
• Economic Assumptions	-	-	-0.015	-	-0.015

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<b>APPROPRIATION/BUDGET ACTIVITY</b> 0400: <i>Research, Development, Test &amp; Evaluation, Defense-Wide</i> BA 3: <i>Advanced Technology Development (ATD)</i>	<b>R-1 ITEM NOMENCLATURE</b> PE 0603711D8Z: <i>Joint Robotics Program/Autonomous Systems</i>
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**Congressional Add Details (\$ in Millions, and Includes General Reductions)**

**Project:** P710: *Joint Robotics Program/Autonomous Systems*

Congressional Add: *Autonomous Control and Video Sensing for Robots*

Congressional Add: *Battle-Proven Packbot*

Congressional Add Subtotals for Project: P710

Congressional Add Totals for all Projects

	FY 2010	FY 2011
	0.800	-
	1.200	-
	2.000	-
	2.000	-

**Change Summary Explanation**

Defense Efficiency – Report, Studies, Boards and Commissions. As part of the Department of Defense reform agenda, reflects a reduction in the number and cost of reports, studies, DoD Boards and DoD Commissions below the aggregate level reported in previous budget submission.

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**Exhibit R-2A, RDT&E Project Justification:** PB 2012 Office of Secretary Of Defense **DATE:** February 2011

<b>APPROPRIATION/BUDGET ACTIVITY</b>				<b>R-1 ITEM NOMENCLATURE</b>				<b>PROJECT</b>			
0400: <i>Research, Development, Test &amp; Evaluation, Defense-Wide</i> BA 3: <i>Advanced Technology Development (ATD)</i>				PE 0603711D8Z: <i>Joint Robotics Program/ Autonomous Systems</i>				P710: <i>Joint Robotics Program/Autonomous Systems</i>			
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
P710: <i>Joint Robotics Program/ Autonomous Systems</i>	10.289	9.943	9.756	-	9.756	10.071	10.281	10.520	10.857	Continuing	Continuing

**A. Mission Description and Budget Item Justification**

This Joint Robotics Program/Autonomous Systems program supports the technology development activities of the Joint Ground Robotics Enterprise (JGRE) with a focus on the development of subsystems and components, and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in simulated environments. Projects deliver advanced technology with direct relevance to enhancing war fighters' capabilities that have been identified during operational assessments and field feedback of current unmanned systems. By exercising its oversight role through a Technology Advisory Board, O-6 Council and Senior Steering Group (Flag level), Joint Ground Robotics applies this program to enable coordination between the Services and places emphasis on interoperability and commonality among unmanned ground systems. The primary purpose of this program is to support efforts to overcome technology barriers in the thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Manipulation Technologies, Collaborative Operations, Interoperability, Man-portable Unmanned Ground Systems, and Technology Transition/Transformation. Development and integration of technologies within the thrust areas of unmanned ground system technologies will expedite technology transition from the laboratory to operational use. The technologies are generally at Technology Readiness Levels (TRL) of 3 or 4 with the intent to mature them through JGRE efforts to TRL 6.

**B. Accomplishments/Planned Programs (\$ in Millions)**

	FY 2010	FY 2011	FY 2012
<p><b>Title:</b> Autonomous &amp; Tactical Behaviors</p> <p><b>Description:</b> Development of vehicle onboard intelligence and tactical behaviors for greater autonomy. These technologies will increase the war fighters' ability to accomplish military tasks with greater effectiveness, while simultaneously reducing their risk to exposure and harm. Multiple projects for this area have been selected and are listed below.</p> <p><b>FY 2010 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>- Speech Signature Based Biometric Security delivers the capability to enable voice activated user authentication and unauthorized user rejection to a modified PackBot and modified Talon Unmanned Ground Vehicle (UGV). This technology adds an additional layer of security in UGVs. The accomplishments for this project were: completed text dependent security research; completed algorithm research; developed software application programming interface; developed feature extraction for in-ear speech; developed text dependent security implementation; and developed/acquired a Universal Serial Bus (USB) soundcard.</li> <li>- Long Range Vision for Obstacle Detection demonstrates the ability to reliably classify terrain out to 100m in both structured and unstructured outdoor terrain. Project will transition to PE 0603709D8Z as the TRL level matures. The accomplishments for this project were: began selection sensor solution, sensor processing algorithm development, early performance testing, and unmanned ground vehicle integration; and evaluated candidate sensor technologies.</li> </ul>	2.289	2.945	1.930

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>
<p>- Adaptive Navigation Systems develops and demonstrates an advanced modular and adaptive inertial navigation system for small unmanned ground vehicles. The accomplishments for this project were: integrated magnetometer; integrated heuristics; developed coding for real-time execution onboard Heuristics-enhanced Dead-reckoning (HEDR) computer; developed add-on odometry; built HEDR system; and performed end-of-year 1 demonstration.</p> <p>- Collision Prediction Utilizing Traversability Models develop, demonstrate, and deliver one integrated sensor system that will detect, classify, track, and predict the motion of objects from a moving vehicle. The prototypes include sensors, computing, power distribution, and software to sense the environment. In addition to the prototype system, the government will deliver government use rights for the hardware and software, a well documented C++ API with associated libraries developed under this project, and other third party libraries and relevant source code. Project will transfer to PE 0603709D8Z as the TRL level matures. The accomplishments for this project were: completed requirements development; completed algorithm sensor and platform research and analysis; prepared software architecture design and documentation; and completed Critical Design Review 1.</p> <p>- Real Time Detection and Tracking of Objects from a Moving Vehicle improves overall reliability in terms of detection rate and a reduced false alarm rate and thus provides the ability of a UGV to safely and autonomously navigate in crowded environments and among people. The accomplishments for this project were: developed hardware and software running on a CPU-GPU processing unit that uses an open software interface.</p> <p><b>FY 2011 Plans:</b></p> <p>- On-Board Robot Shock Tube Dispenser will allow the warfighter to stage a counter charge on-board a Small Unmanned Ground Vehicle (SUGV) prior to proceeding down range and will eliminate the requirement to be tethered to the command post. This will provide greater maneuverability and reduce the operator's time on target, provide a more robust search of the target area, and reduce the amount of shock tube that must be transported. The plans for this project are: prepare documentation and requirements; develop prototype; and perform system level testing on-board a SUGV.</p> <p><b>FY 2012 Plans:</b></p> <p>Projects for this research area will be selected in July 2011.</p>				
<b>Title:</b> Collaborative Operations		1.623	3.225	3.775
<b>Description:</b> Integrate communication, mission planning, interface technologies, and advanced intelligence capabilities to support collaborative operations between manned and unmanned systems. Develop and assess several strategies to enhance tele-operation of current Unmanned Ground Vehicles (UGV) and collaborative Unmanned Air Vehicles (UAV) teams. Development of these technologies will enable unmanned systems to support War fighter concepts of operation that are envisioning unmaned				

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>
<p>systems working in collaboration across domains (air, ground, and maritime) to execute tactical missions and complex military tasks. Multiple projects for this area have been selected and are listed below.</p> <p><b>FY 2010 Accomplishments:</b> - Counter Tunnel Exploitation develops and demonstrates a prototype robotic system for Counter Tunnel Exploitation, Mapping and Characterization. The Tunnel Exploitation and Reconnaissance Robotic Apparatus (TERRA) system will meet the technology gaps and needs for the counter tunnel mission. This mission is currently performed by CONUS Defense Support to Civil Authority missions supported by U.S. Northern Command (USNORTHCOM). The accomplishments for this project were: developed an unmanned ground vehicle (UGV) mobility platform capable of insertion through a maximum 8 inch diameter bore hole; demonstrated &amp; transitioned UGV mobility platform prototype; developed 1st generation sensor suite with 3D Simultaneous Localization and Mapping (SLAM) and modeling; Integrated a mobility platform and support apparatus into system; and completed 1st generation sensor suite and algorithms development.</p> <p><b>FY 2011 Plans:</b> - Counter Tunnel Exploitation, Mapping, &amp; Characterization will develop and demonstrate a prototype robotic system for Counter Tunnel Exploitation, Mapping and Characterization. The Tunnel Exploitation and Reconnaissance Robotic Apparatus (TERRA) system will meet the technology gaps and needs for the counter tunnel mission. Project transitions to PE 0604709D8Z as TRL level matures. The plans for this project are: complete mobility platform development; bore hole support apparatus prototype development; and begin 2nd generation sensor suite and algorithms development.</p> <p><b>FY 2012 Plans:</b> Projects for this research area will be selected in July 2011.</p>				
<p><b>Title:</b> Interoperability</p> <p><b>Description:</b> Software algorithms and interface technologies will facilitate sharing of data across unmanned platforms and domains, and with C2 systems as well as interchangeability of mission payloads and unmanned chassis. Such interoperability will enable collaborative operations between manned and unmanned systems as well as among unmanned systems in differing domains. Multiple projects for this area have been selected and are listed below.</p> <p><b>FY 2010 Accomplishments:</b> - Non-RF Comms for Small Unmanned Ground Vehicles (UGVs) design and develop a laser communication system for small UGVs to improve communications in CREW environments. The accomplishments for this project were: performed early system</p>		1.350	1.947	2.225

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>
<p>demonstrations; performed system analysis; completed software automation development; completed design and development; and completed design review.</p> <p><b>FY 2011 Plans:</b> - Non-RF Comms for Small Unmanned Ground Vehicles (UGVs) will improve communications of the operator control unit and the robotic vehicle by developing a laser interrogator for a free-space optical communication systems for UGVs. The plans for this project are: fabricate, test, and demonstrate an interrogator; and demonstrate Non-RF Communications systems.</p> <p>* Real-time Radio Modeling for Robotics will fix issues associated with losses of data in sending tactical messages across the battlefield experienced by war fighters. The planned accomplishments for this project are: Begin modeling effort with different types of materials; Begin antenna modeling.</p> <p><b>FY 2012 Plans:</b> - Real-time Radio Modeling for Robotics will fix issues associated with losses of data in sending tactical messages across the battlefield experienced by warfighters. Project will transition to PE 0603709D8Z when TRL level matures. The plans for this project are: complete modeling effort with different types of materials and complete antenna modeling.</p>				
<p><b>Title:</b> Man-Portable UGS Technologies</p> <p><b>Description:</b> Increase war fighter capability by transferring and developing technologies of immediate impact on man-portable robotic systems - e.g., obstacle detection/obstacle avoidance (ODOA) and collaborative behaviors for small vehicles. Certain missions and mission environments (urban, unimproved surface, mountainous, subterranean) require the use of man-portable robots in support of dismounted operations. Technologies that can be scaled to low size, weight, space, and power density will enable robotic solutions to capability needs in dismounted operation areas and challenging environments. Currently no projects for this reasearch have been selected.</p> <p><b>FY 2010 Accomplishments:</b> No projects are addressing this research area at this time.</p> <p><b>FY 2011 Plans:</b> No projects are addressing this research area at this time.</p> <p><b>FY 2012 Plans:</b> Projects for this research area will be selected in July 2011.</p>		-	-	-
<p><b>Title:</b> Manipulation Technologies</p>		1.747	-	-

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>
<p><b>Description:</b> Incorporate existing technologies, enable 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 and currently place war fighters in extremely vulnerable and dangerous situations. One project for this area has been selected and is listed below.</p> <p><b>FY 2010 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>- Highly Dexterous Manipulator for EOD Operators develops a 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 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 war fighter is increased performance and capability over the current state-of-the-art which will translate into reduced mission time. The accomplishments for this project were: began development of dexterous heavy lift hardware; began testing of feed-forward controls; began Human Machine Interface (HMI) Phase I.</li> </ul>				
<p><b>Title:</b> Technology Transition/Transformation</p> <p><b>Description:</b> Facilitate integration of technologies to ongoing programs: exploit best features of past and ongoing efforts, e.g., interface technologies (Human Robot Interaction) and autonomous operations. Robotics technologies are being matured with the express intent of transitioning them out of the laboratory to either development programs of record, licensing to industry to foster COTS solutions, or integration into fielded systems. Two projects for this area have been selected and are listed below.</p> <p><b>FY 2010 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>- Range Clearance Competition reduces the cost of range clearance, shortens the time required to clear the ranges, and takes people out of harm's way by moving from a manual process to a semi-autonomous robotic process. The accomplishments for this project were: developed rules for the competition.</li> </ul> <p><b>FY 2011 Plans:</b></p> <ul style="list-style-type: none"> <li>- Range Clearance Competition reduces the cost of range clearance, shortens the time required to clear the ranges, and takes people out of harm's way by moving from a manual process to a semi-autonomous robotic process. The plans for this project are: conduct competition pilot; conduct competitor in-process reviews; and hold competition.</li> <li>- Tip-over Prevention Behaviors will develop an autonomous controller with the stability feedback necessary to avoid a tip-over event. This will allow navigation of complex areas and larger payloads to be accomplished with prior stability behavior measures and changes to be made based on the data received. The plans for this project are: investigate, characterize, and adapt existing</li> </ul>		1.280	1.826	1.826

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	FY 2010	FY 2011	FY 2012
algorithms; implement operator alert for teleoperated robots nearing tip-over conditions; selection and integration of hardware; prediction & algorithm evaluation; and integration of IMU and GPS into the robot.  <b>FY 2012 Plans:</b> - Tip-over Prevention Behaviors project will continue. The planned accomplishments for this project are: develop reactive behaviors; begin definition of Robotics Standards Harmonization (JAUS) registration messages; demonstrate real time algorithm on robots; demonstrate operator warning of potential tip overs; and demonstrate real time behavior on steep slopes.			
<b>Accomplishments/Planned Programs Subtotals</b>	8.289	9.943	9.756

	FY 2010	FY 2011
<b>Congressional Add:</b> Autonomous Control and Video Sensing for Robots  <b>FY 2010 Accomplishments:</b> The project will demonstrate an open architecture adaptive digital video system for unmanned ground vehicles. The deliverables will include a reference architecture design and a physical demonstration of the proposed system. The system will include either modified COTS or custom digital cameras and video compression hardware adapted to utilize the SAE AS4 standard interface. The system will also demonstrate the ability to automatically vary the video bandwidth settings to adapt to real-time changes in the bandwidth available from the wireless networked radios.	0.800	-
<b>Congressional Add:</b> Battle-Proven Packbot  <b>FY 2010 Accomplishments:</b> The project will research an in-situ charging capability for the Packbot and various enhanced communication methods, to include longer range and operation in complex indoor environments. Prototypes implementing both capabilities will be produced.	1.200	-
<b>Congressional Adds Subtotals</b>	2.000	-

<b>C. Other Program Funding Summary (\$ in Millions)</b>											
Line Item	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
• (BA4) PE 0603709D8Z : <i>Joint Robotics Program</i>	15.072	9.878	9.710		9.710	12.206	11.509	11.169	12.990	Continuing	Continuing
	5.013	4.155	3.126		3.126	2.986	3.028	3.157	4.575	Continuing	Continuing

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**C. Other Program Funding Summary (\$ in Millions)**

<u>Line Item</u>	<u>FY 2010</u>	<u>FY 2011</u>	<u>FY 2012</u> <u>Base</u>	<u>FY 2012</u> <u>OCO</u>	<u>FY 2012</u> <u>Total</u>	<u>FY 2013</u>	<u>FY 2014</u>	<u>FY 2015</u>	<u>FY 2016</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
• (BA5) PE 0604709D8Z : <i>Joint Robotics Program</i>											

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

1. Technologies to be funded & developed are reviewed by Capabilitiy Area focused working groups to determine progress, transition plans, and relevance of each project.
2. Project plans are 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 is assessed during mid-year and end-of-year reviews.
4. Technologies developed by the Joint Robotics Ground Enterprises (JGRE) are tracked and documented using the DOD Technology 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.