

# OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

May 2009

APPROPRIATION/ BUDGET ACTIVITY  
**RDTE, Defense Wide BA# 4**

PE NUMBER AND TITLE  
**0603709D8Z - Joint Robotics Program**

COST (\$ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate				
P709 Joint Ground Robotics Enterprise (JGRE) ACD&P	23.251	11.782	11.803				

**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 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 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, Manipulation Technologies, Collaborative Operations, Interoperability, Man-portable Unmanned Ground System Technologies, and Technology Transition/Transformation. The purpose is to further the fielding of a family 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. 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 responses to advanced technology needs directed at enhancing the warfighter's capabilities identified during concept development, operational assessments and field feedback of current unmanned systems.

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<b><u>B. Program Change Summary</u></b>	FY 2008	FY 2009	FY 2010	
Previous President's Budget (FY 2008/2009)	23.654	11.847	12.005	
Current BES/President's Budget (FY 2010)	23.251	11.782	11.803	
Total Adjustments	-0.403	-0.065	-0.202	
Congressional Program Reductions				
Congressional Rescissions		-0.065		
Congressional Increases				
Reprogrammings	-0.039			
SBIR/STTR Transfer	-0.318			
Other	-0.046		-0.202	

<b><u>C. Other Program Funding Summary:</u></b>	FY 2008	FY 2009	FY 2010					
PE 0603711D8Z (BA3) Joint Robotics/Autonomous Systems	19.585	8.449	9.110					
PE 0604709D8Z (BA5) Joint Ground Robotics Enterprise (JGRE) SDD	6.851	5.725	5.127					

Comment:

**D. Acquisition Strategy:** Not applicable for this item.

**E. Performance Metrics:** Not Applicable.

# OSD RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

May 2009

APPROPRIATION/ BUDGET ACTIVITY <b>RDTE, Defense Wide BA# 4</b>		PE NUMBER AND TITLE <b>0603709D8Z - Joint Robotics Program</b>					PROJECT <b>P709</b>	
	COST (\$ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate				
P709	Joint Ground Robotics Enterprise (JGRE) ACD&P	23.251	11.782	11.803				

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All actions under this PE are within BA 4 and are identified with one project number.

**B. Accomplishments/Planned Program:**

<b><u>Accomplishments/Planned Program Title:</u></b>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>
(U) Autonomous & Tactical Behaviors and (U) Collaborative Operations	8.173	4.120	4.200

**FY 2008 Accomplishments:**

- \* Demonstrated Autonomous Geo-physical survey using Unmanned Ground Vehicles, decreasing time to survey and compile the data (Autonomous Range Clearance).
- \* Integrated the Robotic Intelligence Kernel (RIK) Kalman Filter for improved use of visual odometry in navigation.
- \* Integrated local world map for improved obstacle avoidance.
- \* Conducted user demonstrations of first-generation system for Automatic Payload Deployment System (APDS).
- \* Demonstrated robotic ground refueling of an aircraft via simulation and completed state-of-the-art market survey on aircraft ground refueling and robotic equipment and components for potential use in autonomous refueling.
- \* Selected platform for robotic firefighting proof of concept vehicle; defined requirements, selected firefighting system components and completed system design (Autonomous Firefighting).
- \* Designed marsupial platform using modified SEGWAY units as the foundation and the build of autonomous navigation payload (Marsupial for Autonomous perimeter Security and Unexploded Ordnance)

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APPROPRIATION/ BUDGET ACTIVITY  
**RDTE, Defense Wide BA# 4**

PE NUMBER AND TITLE  
**0603709D8Z - Joint Robotics Program**

PROJECT  
**P709**

- \* Identified most promising stereo-based solution proven for pedestrian detection and tracking.
- \* Completed technology assessment in areas of long range non line-of-sight communications, extended power duration fuel cells, hybrid engine systems, mobile platforms, and ISR sensors (Man-Portable ISR Robot).
- \* Developed JAUS software development kits to allow non-compliant hardware to more easily integrate into a JAUS compliant system.
- \* Developed a JAUS compliant Chemical Biological Radiological and Nuclear (CBRN) sensor package for any JAUS compliant robot platform (CBRN Package for Unmanned Ground & Aerial Vehicles).
- \* Produced second-generation Automatically Deployable Communications Relays (ADCR) systems.
- \* Selected JAUS compatible robot platform and CBRN sensor package that will be integrated (CBRN for UGV & UAS).
- \* Integrated JAUS into Simulation Systems for experimentation/validation.
- \* Initiated research to extend the dynamic discovery of JAUS, supporting UAV and UGV collaborations.
- \* Algorithm development, implementation and testing for precision landing of the Rotomotion UAV utilizing a NovAtel Differential Global Positioning System (DGPS).
- \* Initiated effort to integrate & fuse data from a variety of sensors, imagers, access control, robotic platforms and IFF systems to more effectively execute defensive battle space actions.
- \* Continue integration of JAUS into Simulation Systems for experimentation/validation.
- \* Continued efforts to determine and identify Mission Essential Modules to improve COTS system multi-mission capability.
- \* Demonstrated ability to extend Non-Line-of-Sight operator control of UGVs up to 20 miles through use of a communications repeater integrated onto a UAV
- \* Developed a Phase I user interface for UAV/UGV range extension operations that allow the operator to view optimal communications regions for uninterrupted telemetry and control
- \* Convoy following operations: Designed infrared targets to be placed on the lead vehicle ; fabricated 1st target prototypes; developed algorithm to determine the location of the lead vehicle relative to the follower based on the sensed infrared targets; Performed initial testing of system to evaluate the accuracy of the sensed lead vehicle location ; new target design initiated to improve tracking performance; Developed algorithm to determine the location of the lead vehicle relative to the follower based on the sensed infrared targets; Performed initial testing of system to evaluate the accuracy of the sensed lead vehicle location.

FY 2009-2010 Plans: Support the development of vehicle onboard intelligence and tactical behaviors to allow the fielding of advanced autonomous unmanned systems. Including integration and testing of specific tactical behaviors for fielded EOD robots. Improve performance of and reduce computational load for small UGVs by integration of reduced size and weight sensors. Baseline user identified mission scenarios to develop operational behaviors enabling unmanned operations within the conduct of mission tasks. Increase the warfighter's capability by transferring and developing technologies that will have an immediate impact on the autonomy and functional capabilities of current and future robotic systems. Enable transitioning of technologies appropriate for small robots from the technology transfer program to fielded systems. 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 UGVs and collaborative UAV teams, including unmanned system collaboration demonstrations. Collaborative and tactical behaviors include system convoying, teamed obstacle avoidance, area perception and relative position information sharing. Plans include:

- \* Autonomous Navigation for Small UGVs

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<b>APPROPRIATION/ BUDGET ACTIVITY</b> <b>RDTE, Defense Wide BA# 4</b>	<b>PE NUMBER AND TITLE</b> <b>0603709D8Z - Joint Robotics Program</b>	<b>PROJECT</b> <b>P709</b>
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- \* Automated Aircraft Refueling
- \* Mine Area Clearance Equipment Development/Autonomous Range Clearance
- \* Chemical Biological Radiological & Nuclear (CBRN) Package for Unmanned Ground & Aerial Vehicles
- \* Robotic Firefighting Technologies
- \* Automatic Payload Deployment System (APDS) - UGV
- \* Human Presence Detection (HPD)
- \* Convoy Active Safety Technologies (CAST)
- \* Joint Training and Experimentation Center (JTEC)
- \* Covert tracking robots/ sensors
- \* Marsupial (SEGWAY) for APS and UXO
- \* Automatically Deployed Communications Relays (ADCR)
- \* Joint Collaborative Technologies Experiment (JCTE)

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>	<u>FY 2011</u>
(U) Interoperability	4.829	2.628	2.500	2.570

FY 2008 Accomplishments:

- \* Demonstrated integrated capabilities in support of Force Protection Joint Experiments Integration Assessments (FPJEIA).
- \* Developed software required for payload operation, began assembling payload package; began payload and platform control development (Autonomous Firefighting).
- \* Continued to refine, maintain for and transition of documentation for Joint Architecture for Unmanned Systems (JAUS) to a Society of Automotive Engineers (SAE) standard.
- \* Completed transition of JAUS to a Society of Automotive Engineers (SAE) standard.
- \* Under the Automatic Payload Deployment System (APDS) conducted user demonstrations of first-generation system; generated feedback for further payload development.
- \* Under the Automatically Deployable Communications Relays (ADCR) effort, continued testing on complete system.

FY 2009-2010 Plans: Promote and guide technology development to meet joint requirements and promote ground as well as air unmanned systems interoperability. Support the bridging of currently incompatible robots and controllers from various manufacturers, using different communications channels and hardware. Optimize best features of prior/ongoing research efforts into a maturing, standardized system that can be easily ported to robotic platforms used DoD-wide. Plans include:

- \* Autonomous Control Development
- \* Networked Robotic Communication Solutions
- \* Robotic Systems Technical & Operational Metrics Correlation
- \* Covert Tracking Robots/Sensors

# OSD RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

May 2009

<b>APPROPRIATION/ BUDGET ACTIVITY</b> <b>RDTE, Defense Wide BA# 4</b>	<b>PE NUMBER AND TITLE</b> <b>0603709D8Z - Joint Robotics Program</b>	<b>PROJECT</b> <b>P709</b>
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- \* Autonomous Robotic Countermine (ARCS2)
- \* Convoy Active Safety Technologies (CAST)
- \* Joint Training and Experimentation Center (JTEC)

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>	<u>FY 2011</u>
(U) Man-Portable Unmanned Ground System Technologies and (U) Manipulation Technologies	5.584	3.785	3.900	3.946

**FY 2008 Accomplishments:**

- \* Investigated varying technology approaches for human presence detection capable of meeting the size, weight, and power constraints of man-portable platforms.
- \* Development/transition of technologies from Next Generation Explosive Ordnance Disposal Remote Control vehicle development.
- \* Technology assessment in areas of long range non line-of-site communications, extended power duration fuel cells, hybrid engine systems, mobile platforms, and ISR sensors (Man-Portable ISR Robot).
- \* Conducted Remote Ordnance Neutralization System (RONS) Continuous Improvement Program (CIP) projects.
- \* Continued EOD Cooperative Robotics developments.
- \* Continued automatically deployable communications relays (ADCR)efforts.
- \* Continued development, fielding and life cycle development of systems deployed for IED defeat missions.
- \* Investigated varying technology approaches for human presence detection capable of meeting the size, weight, and power constraints of man-portable platforms.
- \* Conducted Military Utility Assessment on a Mobile Under Vehicle Inspection
- \* Completed AEODRS Analysis of Alternatives Advanced EOD Robot System (AEODRS)/analysis of product family design requirements for the optimal EOD robot family/analysis for AEODRS control architecture state of the art.
- \* Continued support of field use and development purposes, procured off-the-shelf small robots for loan to government agencies, laboratories, and universities for the purpose of accelerating the spiral development process, more quickly improving future robotic platforms for the joint warfighter.
- \* Completed design, prototype development of General Mechanical interface to TAGS-CX (Battlefield Extraction - Assist Robot)
- \* Completed first phase of BEAR characterization and operational simulation assessments at Soldier Battle Lab.
- \* Supported limited objective experiments, feasibility demonstrations, and concept exploration projects.
- \* Supported capability development via the Joint Architecture for Unmanned Systems (JAUS) development process.

**FY 2009-2010 Plans:** Increase the warfighter's capability by transferring and developing technologies that will have an immediate impact on the functional capabilities of man-portable robotic systems. Enable transitioning of technologies appropriate for small robots from the technology transfer program to fielded systems. Specific technologies include obstacle detection/obstacle avoidance (ODOA) and collaborative behaviors for small vehicles. Incorporate existing technologies into systems representative to those in use, demonstrate ease of robotic manipulation, support the development of mobile manipulation, expedite the transition and integration of corresponding robotic technologies to enhance the current fielded systems with more functionalities, autonomy and state-of-the-art behavior with interface methods from the RTD&E environment. Plans include:

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- \* Man-Portable Intelligence, Surveillance, and Reconnaissance (ISR) Robot
- \* Advanced Control Schemes for EOD Robotics/Advanced EOD Robot System Technology Development/3D Visualization for EOD UGVs
- \* Automatically Deployable Communications Relays (ADCR)
- \* Autonomous Navigation for Small UGVs
- \* Joint Collaborative Technologies Experiment (JCTE)
- \* Integration of Access and Forced Entry Tools on Small UGV
- \* Autonomous Navigation for Small UGVs
- \* Highly Dexterous EOD Manipulator Development
- \* Joint Training and Experimentation Center (JTEC)

<b><u>Accomplishments/Planned Program Title:</u></b>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>	<u>FY 2011</u>
(U) Technology Transition/Transformation	4.665	1.249	1.203	1.282

**FY 2008 Accomplishments:**

- \* Integrated the Robotic Intelligence Kernel (RIK) Kalman Filter for improved use of visual odometry for navigation.
- \* Developed a Technology Transition Agreement (TTA) for detection on the move (DOTM) for Mobile Detection Assessment Response System (MDARS) (Human presence Detection).
- \* Continued to provide support to determine and identify Mission Essential Modules to improve COTS system multi-mission capability.
- \* Established baseline information on taxonomy of international ground robotics development thrusts and key performers
- \* Experimentation and testing of next-generation platform stabilization systems (Perfect Horizon)
- \* Continued refined optimization of Simultaneous Localization and Mapping (SLAM) capabilities for outdoor applications in GPS-denied areas.
- \* Supported development of mutiple size (75, 150, and 300 lbs) linear actuator version of the Perfect Horizon for stabilization of system payloads.
- \* Initiated technology transfer efforts as part of a joint experiment initiative leading to support of the Joint Force Protection Advanced Security System (JFPASS) JCTD.
- \* Continued transition of technologies from the NGEODRCV efforts.
- \* Refined, maintained and completed final transition of documentation for Joint Architecture for Unmanned Systems (JAUS) to a Society of Automotive Engineers (SAE) standard.
- \* Continued integrated experiment of ground and aerial platforms, continued development of automated ground targeting system and continued development of image feature extraction algorithms for UXO detection (Active Range Clearance).

FY 2009-2010 Plans: Facilitate integration of and ensure the ultimate transfer or transformation of technologies to ongoing programs. Including a Technology Demonstration for Advanced EOD Robot System (AEODRS). Exploit the best features of past and on-going efforts while supporting the development of technologies that have low risk to transition. Technologies of interest include: Interface Technologies (Human Robot Interaction), Autonomous Operations (Information Fusion, Perception, and Navigation), Autonomous Technologies (Positioning), and Platform Technologies. Plans include:

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PROJECT  
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- \* Investigating advances in technology that focuses on the COCOM Homeland Defense Community - mission analysis and requirements investigation to identify technology gaps for future leverage of technology.
- \* Continuing to pursue automatically deployed communications relays (ADCR) from unmanned ground vehicles.
- \* Convoy Active Safety Technologies (CAST)
- \* Automatic Sensor Deployment
- \* Advanced EOD Robot System Technology Development - transition to program of record (POR)
- \* Man-portable Robot Systems
- \* Automated Aircraft Refueling
- \* Autonomous Navigation for Small UGVs
- \* Autonomous Robotic Countermine (ARCS2)
- \* Joint Collaborative Technologies Experiment (JCTE)
- \* Integration of Access and Forced Entry Tools on Small UGV
- \* Joint Training and Experimentation Center (JTEC)

<b><u>C. Other Program Funding Summary:</u></b>	FY 2008	FY 2009	FY 2010					
PE 0603711D8Z (BA3) Joint Robotics/Autonomous Systems	18.734	9.198	9.110					
PE 0604709D8Z (BA5) Joint Ground Robotics Enterprise (JGRE) SDD	6.710	5.694	5.127					

Comment:

**D. Acquisition Strategy:** Not applicable for this item.

**E. Major Performers:** Not applicable for this item.

# OSD RDT&E COST ANALYSIS (R3)

BUDGET ACTIVITY			PE NUMBER AND TITLE							PROJECT				
<b>4 - Advanced Component Development and Prototypes (ACDP)</b>			<b>0603709D8Z - Joint Robotics Program</b>							<b>P709</b>				
I. Product Development	Contract Method & Type	Performing Activity & Location	Total PYs Cost	FY 2008 Cost	FY 2008 Award Date	FY 2009 Cost	FY 2009 Award Date	FY 2010 Cost	FY 2010 Award Date					
Joint Ground Robotics Enterprise			22651	23176	1-4Q	11682	1-4Q	11700	1-4Q					
Subtotal:			22651	23176		11682		11700						
Remarks:														
Funding value captures the total committed and obligated or planned for obligation across the PE. The Joint Ground Robotics Enterprise (JGRE) utilizes several contracting and management strategies to achieve its objectives: technology developemnt against the 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. This PE supports the need to integrate technologies into representative models or prototype systems in a high fidelity and realistic operating environment and expedite 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 responses to advanced technology needs directed at enhancing the warfighter's capabilities identified during concept development, operational assessments and field feedback of current unmanned systems.														
II. Support Costs	Contract Method & Type	Performing Activity & Location	Total PYs Cost	FY 2008 Cost	FY 2008 Award Date	FY 2009 Cost	FY 2009 Award Date	FY 2010 Cost	FY 2010 Award Date					
Subtotal:														
III. Test And Evaluation	Contract Method & Type	Performing Activity & Location	Total PYs Cost	FY 2008 Cost	FY 2008 Award Date	FY 2009 Cost	FY 2009 Award Date	FY 2010 Cost	FY 2010 Award Date					
Subtotal:														
IV. Management Services	Contract Method & Type	Performing Activity & Location	Total PYs Cost	FY 2008 Cost	FY 2008 Award Date	FY 2009 Cost	FY 2009 Award Date	FY 2010 Cost	FY 2010 Award Date					
Joint Ground Robotics Enterprise Support			324	75	1-4Q	100	1-4Q	103	1-4Q					
Subtotal:			324	75		100		103						
<b>Project Total Cost:</b>			<b>22975</b>	<b>23251</b>		<b>11782</b>		<b>11803</b>						

# Schedule Profile (R4 Exhibit)

May 2009

BUDGET ACTIVITY  
**4 - Advanced Component Development and Prototypes (ACDP)**

PE NUMBER AND TITLE  
**0603709D8Z - Joint Robotics Program**

PROJECT  
**P709**

Event Name	FY 08				FY 09				FY 10																							
	1	2	3	4	1	2	3	4	1	2	3	4																				
(1) Advanced EOD Robot System	▲ <sub>1</sub>																															
(2) Automated Aircraft Refueling	▲ <sub>2</sub>																															
(3) Autonomous Navigation for Small UGVs	▲ <sub>3</sub>																															
(4) Battlefield Extraction-Assist Robot (BEAR)	▲ <sub>4</sub>																															
(5) CBRN Package for UGVs & UAVs	▲ <sub>5</sub>																															
(6) Man-portable ISR Robot	▲ <sub>6</sub>																															
(7) Modeling and Simulation for EOD Robot Tactics Development	▲ <sub>7</sub>																															
(8) Tactical Behaviors for EOD Robots	▲ <sub>8</sub>																															
(9) PACOM Warfighter Experiment (Cobra Gold)	▲ <sub>9</sub>																															
(10) Robotic Standards of Harmonization (JAUS)	▲ <sub>10</sub>																															
(11) Joint Collaborative Tech. Experiment	▲ <sub>11</sub>																															
(12) Robotic Sys. Tech & Operational Metrics Correlation	▲ <sub>12</sub>																															
(13) Guernsey								▲ <sub>13</sub>																								



# Schedule Profile (R4a Exhibit)

May 2009

BUDGET ACTIVITY

**4 - Advanced Component Development and Prototypes (ACDP)**

PE NUMBER AND TITLE

**0603709D8Z - Joint Robotics Program**

PROJECT

**P709**

<u>Schedule Detail</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>					
Advanced EOD Robot System	1Q - 4Q	1Q - 4Q	1Q - 2Q					
Automated Aircraft Refueling	1Q - 4Q	1Q - 4Q	1Q - 4Q					
Autonomous Navigation for Small UGVs	1Q - 4Q	1Q - 4Q	1Q - 4Q					
Battlefield Extraction-Assist Robot (BEAR)	1Q - 4Q	1Q - 4Q	1Q - 4Q					
CBRN Package for UGVs & UAVs	1Q - 4Q	1Q - 4Q						
Man-portable ISR Robot	1Q - 4Q	1Q - 4Q						
Modeling and Simulation for EOD Robot Tactics Development	1Q - 4Q	1Q - 4Q						
Tactical Behaviors for EOD Robots	1Q - 4Q	1Q - 4Q	1Q - 4Q					
PACOM Warfighter Experiment (Cobra Gold)	1Q - 4Q	1Q - 4Q						
Robotic Standards of Harmonization (JAUS)	1Q - 4Q	1Q - 4Q	1Q - 4Q					
Joint Collaborative Tech. Experiment	1Q - 4Q	1Q - 4Q						
Robotic Sys. Tech & Operational Metrics Correlation	1Q - 4Q	1Q - 4Q	1Q - 2Q					
Guernsey		3Q - 4Q	1Q - 3Q					
Consortium TAB		3Q - 4Q	1Q - 3Q					
Consortium Support		3Q - 4Q	1Q - 3Q					

Events are based on multitechnology development efforts, executed within and across program elements and technology development priorities established through the JGRE Technology Advisory Board (TAB), O-6 Council and Senior Steering Group (SSG) in support of Joint Capability Areas (JCA). All efforts under this PE are identified with one project number.