

OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

May 2009

APPROPRIATION/ BUDGET ACTIVITY RDTE, Defense Wide BA# 5		PE NUMBER AND TITLE 0604709D8Z - Joint Robotics EMD						
COST (\$ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate					
P609 Joint Ground Robotics Enterprise (JGRE) SDD	6.710	5.694	5.127					

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 warfighter 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 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. Through application of funds against the thrust areas of unmanned ground system technologies, in execution 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 responses to advanced technology needs directed at enhancing the warfighters' capabilities identified during concept development, operational assessments and field feedback of current unmanned systems.

All actions under this PE are within BA 5 and are identified with one project number.

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<u>B. Program Change Summary</u>	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget (FY 2008/2009)	6.851	5.725	5.212	
Current BES/President's Budget (FY 2010)	6.710	5.694	5.127	
Total Adjustments	-0.141	-0.031	-0.085	
Congressional Program Reductions				
Congressional Rescissions		-0.031		
Congressional Increases				
Reprogrammings	-0.084			
SBIR/STTR Transfer	-0.044			
Other	-0.013		-0.085	

<u>C. Other Program Funding Summary:</u>	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
PE0603711D8Z (BA3) Joint Robotics Program/Autonomous Systems	18.734	9.198	9.110					
PE 0603709D8Z (BA4) Joint Ground Robotics Enterprise (JGRE) ACD&P	23.251	11.782	11.803					

Comment:

D. Acquisition Strategy:

The Joint Ground Robotics Enterprise (JGRE) utilizes several contracting and management strategies to achieve its objectives. JGR has established relationships with the several agencies to include the National Center for Defense Robotics (NCDR) and the Army's Rapid Equipping Force (REF) to support the rapid acquisition and evaluation of promising unmanned system technologies.

Funding is provided to Service lab partners and other developers to promote common technology solutions across platforms and Services. Execution of funding is against Technology Areas facilitated within technology projects which are selected and approved on an annual basis.

In FY08 JGRE began executing selected technology development efforts through a robotics technology consortium to broaden the research and development of robotic technologies with industry (traditional and non-traditional) and academia. Under the initiative, JGR will seek to deliberately mature specified emerging technologies to the point of demonstrating the technology in operationally relevant environments; improve the performance in reliability, range, speed, service life, and perception; achieve greater levels of tactical autonomy; develop and integrate platforms; and enable effective transition of the technology to programs of record via early consideration of life cycle support aspects (e.g., affordability, manufacturability, sustainment, training).

E. Performance Metrics:

FY	Strategic Goals Supported	Existing Baseline	Planned Performance Improvement / Requirement Goal	Actual Performance Improvement	Planned Performance Metric / Methods of Measurement	Actual Performance Metric / Methods of Measurement
08						

Comment:

Metrics for the Joint Ground Robotics Enterprise (JGRE) funded RDT&E technology development efforts are articulated in individual project plans and overview quad charts used to form the basis of funding justification and program assessments. Technology development effort decisions are supported by the JGRE Technology Advisory Board (TAB). The TAB provides matrix assessments of technologies against capabilities to inform funding decisions, provides input to unmanned system (UMS) roadmaps and ensures technology transitions. In all document sets, project descriptions include task schedules with associated milestones against which progress toward objectives and goals are measured. At the level of the performer, efforts are tracked using project technical and management milestones that have been appropriately defined and agreed upon in the project plans prior to execution. At the enterprise level, the JGRE governance structure and process tracks deliverables and examines the potential transition of technologies from the R&D performer to DoD programs. The JGRE governance structure and process includes mid-year and end-of-year in progress reviews (IPR), annual funding justification and prioritization, technology assessments, a senior military Council and a Senior Steering Group (SSG) overview. These DoD participant reviews include cost, schedule and technical progress assessment against technology area and project milestones. Metric evaluations for the funded actions include, where appropriate, controlled trials, demonstrations, quasi-experimental evaluations, and direct/indirect analysis.

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COST (\$ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate					
P609 Joint Ground Robotics Enterprise (JGRE) SDD	6.710	5.694	5.127					

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 warfighter 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 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. Through application of funds against the thrust areas of unmanned ground system technologies, in execution 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 responses to advanced technology needs directed at enhancing the warfighters' capabilities identified during concept development, operational assessments and field feedback of current unmanned systems.

All actions under this PE are within BA 5 and are identified with one project number.

B. Accomplishments/Planned Program:

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>	
(U) Autonomous & Tactical Behaviors and (U) Collaborative Operations	2.398	1.557	1.703	

FY2008 Accomplishments:

- * Refined, maintained and completed final transition of documentation for Joint Architecture for Unmanned Systems (JAUS) reference architecture to an industry standard via the Society of Automotive Engineers (SAE).
- * Automated functions necessary for activating robotic response to sensor stimuli: increase sensor data fusion for system automation and platform autonomy and reduce operator reaction requirements.
- * Continued effort to develop a Detection on the Move - capability for employment of ground robots in the defensive battle space: increase system autonomy and effectiveness and enhance the system situational awareness (SA).
- * Demonstrated UGV technology maturity for teleoperation, semi-autonomous operation and full autonomous operations for logistics support allowing unmanned on- and off-road reconnaissance, unmanned medical evacuations, or unmanned perimeter patrolling operations.
- * Continued development of advanced mission planning and programming via Robotics for Agile Combat Support.
- * Continued development of autonomous unmanned ground robotic vehicles via the 2008 Intelligent Ground Vehicle Competition (IGVC).
- * Developed UAV autonomous positioning algorithms for optimizing extended communications between the operator, UAV, and multiple UGVs

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- * Developed specifications for a standardized modeling and simulation (M&S) tool suite to support DoD robotics programs.
- * Demonstrated Convoy Active Safety Technologies (CAST).
- * Continued development of MDARS-Expeditionary as the Unmanned Ground Vehicle (UGV) for the Family of Rapid Response Equipment (FIRRE) - provide a semi-autonomous, high speed, cross-country, detection, persistent surveillance and response capability for forward deployed forces.
- * Initiated program to extend the JAUS world model message specification to incorporate true three dimensional information to enable UAV and UGV JAUS compliant collaborative capabilities.
- * Initiated research to extend the dynamic discovery of JAUS to support UAV and UGV collaborations.
- * Continued development and implementation of JAUS as a set of standardized messages suitable for controlling all types of unmanned systems, and becoming an Aerospace Standard of the Society of Automotive Engineers (SAE) via the 2008 Intelligent Ground Vehicle Competition (IGVC).
- * Integrated JAUS into Simulation Systems for experimentation/validation.
- * Completed design and off-board testing of automated Link Management System and precision UAS landings-refueling testing (JCTE).

FY 2009-2010 Plans: Support the development of vehicle onboard intelligence and tactical behaviors to allow the fielding of advanced autonomous unmanned systems. 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. Collaborative and tactical behaviors include system convoying, teamed obstacle avoidance, area perception and relative position information sharing. Plans include:

- * Human Presence and Detection
- * Covert Tracking Robots/Sensors
- * Tactical Behaviors for EOD Robots - Cooperative Robotics
- * Battlefield Extraction - Assist Robot (BEAR)
- * Autonomous Robotics Countermining Experiment 2 (ARC2)
- * Convoy Active Safety Technologies (CAST)
- * Decon II - Joint Forward Area Automated Decontamination (JDAAD)
- * Mobile Robot Knowledge Base (MRKB)
- * Joint Collaborative Technology Experiment (JCTE)

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>
(U) Interoperability	1.057	0.810	0.822

FY2008 Accomplishments:

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APPROPRIATION/ BUDGET ACTIVITY RDTE, Defense Wide BA# 5	PE NUMBER AND TITLE 0604709D8Z - Joint Robotics EMD	PROJECT P609
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- * Research and experimentation of unmanned vehicles, sensors, simulation, training, demonstration, and information distribution.
- * Developed autonomous collaborative behaviors between teamed unmanned ground robots in movement to observe, challenge and engage intruders into protected zones (JCTE).
- * Integrated BEAR robot with UGV TAGS-CX to demonstrate marsupial transport and collaborative operations.
- * BEAR - Continued design and development of stand-off casualty assessment and remote triage sensors.

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:

- * Advanced Control Schemes for EOD Robotics/Tactical Behaviors for EOD Robots
- * Mobile Robot Knowledge Base (MRKB)
- * Convoy Active Safety Tech. (CAST)
- * Decon II - Joint Forward Area Automated Decontamination (JDAAD)
- * Integration of Access and Forced Entry Tools on Small UGVs
- * Joint Collaborative Technology Experiment (JCTE)

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>
(U) Man-Portable Unmanned Ground System Technologies and (U) Manipulation Technologies	2.015	1.982	1.681

FY2008 Accomplishments:

- * Demonstrated semi-autonomous behaviors including guarded tele-operation, various forms of waypoint navigation with obstacle avoidance, and advanced visualization for teleportation techniques.
- * Analysis of Alternatives (AoA) for a Next Generation EOD Robotic System (NGEODRS) acquisition program - operational effectiveness, suitability, and life-cycle cost of alternatives/Supported development, fielding and life cycle development of systems deployed for IED defeat missions.
- * Testing on distributed communications system targeted for a Man-Portable Robotic System (MPRS).
- * Provided support to multiple joint acquisition programs, technology development and assessment programs, and COTS spiral fielding and assessment programs to support current military operations.
- * Continued concept exploration and demo and continuing technical and operational assessment for systems deployed.
- * Integration of manipulator and commercially available tools to automate the five stages of vehicular decontamination.
- * Continued development of manipulation and navigation maturity via the 2008 Intelligent Ground Vehicle Competition (IGVC).
- * Continued development the Joint Architecture Unmanned System (JAUS) manipulator capability beyond core capabilities to advanced manipulation control support via Robotics for Agile Combat Support.
- * Continued support for concept exploration and demo, and ongoing technical and operational assessment for systems deployed.

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- * Supported limited objective experiments, feasibility demonstrations, and concept exploration projects.
- * Continued robotic payload development.
- * Battlefield Extraction Assist Robot (BEAR) - Completed initial design and modeling of independently articulated lower tracked/wheeled limb combinations

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:

- * Robotic EOD Technologies/Advanced Control Schemes for EOD Robotics/Tactical Behaviors for EOD Robots
- * Robotic for Airbase Operations and Support
- * Warfighter Experimentation/Exercises
- * Mobile Robot Knowledge Base (MRKB)
- * Integration of Access and Forced Entry Tools on Small UGVs
- * MTRS Continuous Improvement Program
- * Autonomous Robotic Countermining System Capability (ARCS2)

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>
(U) Technology Transition/Transformation	1.240	1.345	0.921

- FY2008 Accomplishments:
- * Development and maintenance of the Robotic Systems Pool (RSP).
 - * Provided robotic platforms and technical support to leverage several research and development projects across DoD and supportive of unmanned system developments, including: EOD robot range extension; Automatically Deployed Communication Relay (ADCR); RedOwl sniper detection; JAUS software integration; PackBot health-monitoring and ultracell fuel-cell for small unmanned ground vehicles.
 - * Developed and implemented on-line knowledgebase/Web Portal for technology transfer.
 - * Provided robotic platforms to support Warfighter Experimentation and Concept Development including: RDECOM-TARDEC Dismounted Controller Experimentation and Product Manager, Force Protection Systems (PM-FPS) Family of Integrated Rapid Response Equipment (FIRRE) demonstration.
 - * Upgrades/improvements that focus on the capabilities of disruption, disposal, and render-safe procedures and nuclear, chemical, and biological agent detection.
 - * Supported the conduct of research to determine the feasibility of implementing robotics in military logistic systems and to explore potential applications for exploiting agile robotic technologies in military logistics.
 - * Supported continued development and implementation of JAUS compliance.

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* Continued technology development and transition efforts within industry and academia for sensors, artificial intelligence, processors, and human/computer interaction, and defining a strategy for early research and development.

* Provided support to joint acquisition programs, technology development and assessment programs, and COTS spiral fielding and assessment programs to support current military operations.

FY 2009-2010 Plans: Facilitate integration of and ensure the ultimate transfer or transformation of technologies to ongoing programs. Exploit the best features of past and ongoing 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:

- * Mobile Robot Knowledge Base (MRKB)
- * COCOM Ground Robotics Initiatives
- * Battlefield Extraction Assist Robot (BEAR)
- * Autonomous Robotic Countermining System Capability (ARCS2)
- * Man Transportable Robotic System (MTRS)
- * Convoy Active Safety Technologies (CAST)
- * Warfighter Experimentation/Exercises

<u>C. Other Program Funding Summary:</u>	FY 2008	FY 2009	FY 2010					
PE 0603711D8Z (BA3) Joint Robotics/Autonomous Systems	18.734	9.198	9.230					
PE 0603709D8Z (BA4) Joint Ground Robotics Enterprise (JGRE) ACD&P	23.251	11.782	11.955					

Comment:

D. Acquisition Strategy:

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E. Major Performers:

Category	Name	Location	Type of Work and Description	Award Date
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Labs/Centers:

	AFRL	Tyndall AFB, FL	Program Management, Systems Engineering. Air Force Research Laboratory (AFRL)	
	AMRDEC	Redstone Arsenal, AL	Program Management, Systems Engineering. U.S. Army Aviation and Missile Research, Engineering, and Development Center (AMRDEC).	
	JM&L LCMC	Picatinny Arsenal, NJ	Contract Management. U.S. Army Joint Munitions and Lethality Life Cycle Management Command (JM&L LCMC)	
	NAVEODTECH	Indian Head, MD	OSD Executive Agent for joint service EOD R&D. Program Management. Naval Explosive Ordnance Disposal Technology Division (NAVEODTECH).	
	SPAWAR	San Diego, CA	Program Management, Systems Engineering. Space and Naval Warfare [SPAWAR] Systems Center, San Diego (SSC San Diego).	
	TARDEC	Detroit, MI	Program Management, Systems Engineering. U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC)	

Contractors:

	National Center for Defense Robotics (NCDR)	Pittsburg, PA	Program Management.	
	L-3 Communications	Reston, VA	JGRE program management support.	
	BAH	Herndon, VA	JGRE program management support.Booz Allen Hamilton (BAH)	

Other:

	Program Manager Force Protection Systems (PM FPS)	Fort Belvoir, VA	Program Management, Systems Engineering.	
	Robotic Systems Joint Project Office (RS JPO)	Redstone Arsenal, AL	Joint Office Project Management.	

OSD RDT&E COST ANALYSIS (R3)

BUDGET ACTIVITY 5 - System Development and Demonstration (SDD)	PE NUMBER AND TITLE 0604709D8Z - Joint Robotics EMD	PROJECT P609
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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				5853	1-4Q	4844	1-4Q	4251	1-4Q					
Subtotal:				5853		4844		4251						

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 development 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					
Joint Group Robotics Enterprise Support			12146		1-4Q									
Subtotal:			12146											

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 Group Robotics Enterprise Support			2196	857	1-4Q	850	1-4Q	876	1-4Q					
Subtotal:			2196	857		850		876						

Project Total Cost:	14342	6710		5694		5127								
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Schedule Profile (R4 Exhibit)

May 2009

BUDGET ACTIVITY
5 - System Development and Demonstration (SDD)

PE NUMBER AND TITLE
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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	▲ ₁ Tech Demo																														
(2) Convoy Active Safety Technology (CAST)					▲ ₂ Tech Demo																										
(3) Autonomous Range Clearance	▲ ₃ Warfighter Experiment																														
(4) Robotic Firefighting	▲ ₄ Tech Demo																														
(5) Human Presence and Detection	▲ ₅ Tech Demo																														
(6) VANE					▲ ₆ Tech Demo																										
(7) JGRE Support					▲ ₇ Office Support																										

Schedule Profile (R4a Exhibit)

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BUDGET ACTIVITY 5 - System Development and Demonstration (SDD)		PE NUMBER AND TITLE 0604709D8Z - Joint Robotics EMD					PROJECT P609	
<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					
Convoy Active Safety Technology (CAST)		1Q - 4Q	1Q - 4Q					
Autonomous Range Clearance	1Q - 4Q	1Q - 4Q						
Robotic Firefighting	1Q - 4Q	1Q - 4Q						
Human Presence and Detection	1Q - 4Q	1Q - 4Q	1Q - 4Q					
VANE		1Q - 4Q	1Q - 4Q					
JGRE Support		1Q - 4Q	1Q					

Events are based on multiple technology 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.