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**Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification** **DATE:** May 2009

<b>APPROPRIATION/BUDGET ACTIVITY</b>					<b>R-1 ITEM NOMENCLATURE</b>					
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)					PE 0603768E GUIDANCE TECHNOLOGY					
<b>COST (\$ in Millions)</b>	<b>FY 2008 Actual</b>	<b>FY 2009 Estimate</b>	<b>FY 2010 Estimate</b>	<b>FY 2011 Estimate</b>	<b>FY 2012 Estimate</b>	<b>FY 2013 Estimate</b>	<b>FY 2014 Estimate</b>	<b>FY 2015 Estimate</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
Total Program Element	114.752	107.979	37.040						Continuing	Continuing
GT-01: GUIDANCE TECHNOLOGY	35.526	32.771	17.235						Continuing	Continuing
GT-CLS: CLASSIFIED	79.226	75.208	19.805						Continuing	Continuing

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

(U) The Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing system oriented technologies that will improve our ability to navigate weapon systems with more precision and increase the capability to meet current and emerging threats. Consequently, this program element will merge with the Sensors Technology program element in FY 2011. Many of the guidance programs have ended eliminating the need for such a specific program element.

(U) The Guidance Technology project increases the ability of Global Positioning System (GPS) users to operate effectively in the presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

**B. Program Change Summary (\$ in Millions)**

	<u>FY 2008</u>	<u>FY 2009</u>	<u>FY 2010</u>	<u>FY 2011</u>
Previous President's Budget	124.974	110.572	80.238	
Current BES/President's Budget	114.752	107.979	37.040	
Total Adjustments	-10.222	-2.593	-43.198	
Congressional Program Reductions	0.000	-2.593		
Congressional Rescissions	-3.000	0.000		
Total Congressional Increases	0.000	0.000		
Total Reprogrammings	-3.800	0.000		
SBIR/STTR Transfer	-3.422	0.000		
TotalOtherAdjustments			-43.198	

**Change Summary Explanation**

FY 2008

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<p>Decrease reflects a below threshold reprogramming action, SBIR/STTR transfer, and the Section 8042 rescission.</p> <p>FY 2009 Decrease reflects reductions for Section 8101 Economic Assumptions and new starts.</p> <p>FY 2010 Decrease reflects completion of Guidance Technology programs and relocation of programs to the Sensor Technology Program Element.</p>		

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<b>APPROPRIATION/BUDGET ACTIVITY</b> 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)				<b>R-1 ITEM NOMENCLATURE</b> PE 0603768E GUIDANCE TECHNOLOGY					<b>PROJECT NUMBER</b> GT-01	
<b>COST (\$ in Millions)</b>	<b>FY 2008 Actual</b>	<b>FY 2009 Estimate</b>	<b>FY 2010 Estimate</b>	<b>FY 2011 Estimate</b>	<b>FY 2012 Estimate</b>	<b>FY 2013 Estimate</b>	<b>FY 2014 Estimate</b>	<b>FY 2015 Estimate</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
GT-01: GUIDANCE TECHNOLOGY	35.526	32.771	17.235						Continuing	Continuing

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

(U) Fire-and-forget stand-off weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: 1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; 2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and 3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. Thrusts are included in this project to improve our ability to navigate when the Global Positioning System (GPS) is jammed or otherwise unavailable; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

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

	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
Multifunctional Electro-Optics for Defense of U.S. Aircraft (MEDUSA)	10.856	8.615	5.892	
<p>(U) The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program will develop the technologies and systems to give the U.S. air dominance at low altitude and at night. This program will develop the technologies to leap-frog reactive end-game countermeasures and enable increased threat warning times, denial of launch, and put Electro Optical-Infrared (EO-IR) air defense threats at risk. MEDUSA is a three-part technology program: 1) conduct phenomenological measurements and develop countermeasures and target classification/identification techniques; 2) develop critical component technologies such as high-power IR laser sources, advanced IR detectors, and fibers for high-power IR transmission; and 3) develop and demonstrate an end-to-end MEDUSA system. The MEDUSA technology is planned for transition to the Air Force and Army at the conclusion of technology development and flight demonstration.</p> <p><i>FY 2008 Accomplishments:</i></p> <ul style="list-style-type: none"> <li>- Fabricated first fully integrated large format 128x128 Near/Mid-Wave Infrared (NMIR) focal plane arrays (FPA) integrated with a low-power, high-speed Read-Out Integrated Circuit (ROIC), demonstrating high-</li> </ul>				

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<b>B. Accomplishments/Planned Program (\$ in Millions)</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
<p>sensitivity and high-gain (&gt;300) performance in an integrated FPA/ROIC compact camera cryo-cooler package.</p> <ul style="list-style-type: none"> <li>- Fabricated final Long-Wave Infrared (LWIR) ROIC prior to hybridization with FPA.</li> </ul> <p><i>FY 2009 Plans:</i></p> <ul style="list-style-type: none"> <li>- Complete testing of 128x128 NMIR FPA and initiate designs for fabrication of 256x256 arrays.</li> <li>- Complete fabrication of first fully integrated large format 128x128 LWIR FPA integrated with a low-power, high-speed ROIC, demonstrating high-sensitivity large format heterodyne receiver performance in an integrated FPA/ROIC compact camera cryo-cooler package.</li> </ul> <p><i>FY 2010 Plans:</i></p> <ul style="list-style-type: none"> <li>- Conduct integration and system testing.</li> <li>- Complete fabrication and testing of 256x256 arrays.</li> <li>- Conduct integrated airborne proactive Infrared Counter Measure (IRCM) demonstration.</li> </ul>				
<p>Robust Surface Navigation (RSN)*</p> <p>*Formerly Robust Surface and Sub Surface Navigation (RSN/SSN).</p> <p>(U) The Robust Surface Navigation (RSN) program will provide the U.S. warfighter with the ability to navigate effectively when the Global Positioning System (GPS) is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The RSN program will use Signals of Opportunity (SoOP) from a variety of ground, air, and space-based sources, and augmented by judiciously placed RF beacons; these will be received on the Warfighter's forthcoming software defined radios and use specially tailored algorithms to determine position. The greater strength and diversity of these signals will provide coverage when GPS is denied due to lack of penetration into buildings, and when severe multipath is a problem. This is a two-part program: (1) cataloging and assessing potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation, and; (2) designing, testing, and demonstrating a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the SoOP. The RSN technology is planned for transition to the U.S. Special Operations Command and the U.S. Army with specific elements of the program transitioning to the U.S. Navy and U.S. Air Force.</p>	5.330	5.508	4.000	

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<b>B. Accomplishments/Planned Program (\$ in Millions)</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
<p><i>FY 2008 Accomplishments:</i></p> <ul style="list-style-type: none"> <li>- Completed concept design of RSN systems.</li> <li>- Conducted end-to-end performance modeling of the RSN system for stationary, walking, driving, and flying users, in urban, forested, and open environments.</li> </ul> <p><i>FY 2009 Plans:</i></p> <ul style="list-style-type: none"> <li>- Complete fabrication of RSN prototype system and conduct field test in urban environment.</li> <li>- Perform RSN technical risk mitigation experiments and analysis.</li> </ul> <p><i>FY 2010 Plans:</i></p> <ul style="list-style-type: none"> <li>- Conduct field test and demonstrate the functional RSN prototype in forested, jungle and open environments, and for airborne users.</li> <li>- Demonstrate total system readiness.</li> <li>- Transition RSN technology.</li> </ul>				
<p>Sub-Surface Navigation (SsN)</p> <p>(U) Building on technologies developed under the RSN program, the Sub-Surface Navigation (SsN) program will provide the U.S. warfighter with the ability to navigate effectively underground, when the Global Positioning System (GPS) is unavailable. SsN will also enable long endurance or covert underground missions where alternative navigation aids like inertial measurement units (IMUs) or inertial navigation units (INUs) are unsuitable. The SsN program will use Signals of Opportunity (SoOP) and will develop specialized low frequency RF beacons and specially tailored algorithms to provide three-dimensional navigation of personnel and mobile platforms underground. SoOP include global lightning events, which are abundant, propagate over very long distances, and are essentially non-deniable signals. The greater strength and diversity of these signals will provide coverage when GPS is denied due to lack of penetration through the earth. This is a two part program: (1) analysis and performance modeling and hardware-based concept validation of beacon-based signals, and experimental verification that SoOP have propagated (and dispersed) through various geological overburdens and can be correlated with sufficient accuracy to achieve desired geolocation resolution; and (2) designing, testing, and demonstrating a (non-</p>	3.340	2.948	1.343	

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<b>B. Accomplishments/Planned Program (\$ in Millions)</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
<p>form-fit) prototype receiver(s) and algorithms for geolocation using both beacons and SoOP. The SsN beacon technology is planned for transition to U.S. Special Operations Command.</p> <p><i>FY 2008 Accomplishments:</i></p> <ul style="list-style-type: none"> <li>- Designed prototype beacon-based SsN system, including subsystem development and testing.</li> <li>- Isolated and quantified the primary sources of error in the beacon antenna and identified approaches for reducing these in the Phase II design.</li> <li>- Initiated development of electromagnetic modeling capability to predict beacon-based system performance.</li> <li>- Initiated development of next generation, small form-factor beacons.</li> </ul> <p><i>FY 2009 Plans:</i></p> <ul style="list-style-type: none"> <li>- Continue design and development of prototype system with improved beacons and receivers.</li> <li>- Continue development of next generation, small form-factor beacon antenna design.</li> <li>- Develop hardware and software for a blended solution to use when operating the beacon-based in the infrastructure transition zone between improved and unimproved underground environments.</li> <li>- Develop electromagnetic modeling capability to predict beacon-based system performance.</li> <li>- Test functional prototype beacon-based system for underground use; demonstrate system in multiple representative environments.</li> </ul> <p><i>FY 2010 Plans:</i></p> <ul style="list-style-type: none"> <li>- Complete transition of SoOP technology to U.S. Special Operations Command (SOCOM).</li> </ul>				
<p>Precision Inertial Navigation Systems (PINS)</p> <p>(U) The Precision Inertial Navigation Systems (PINS) program will develop an entirely new class of inertial navigation instruments using atomic inertial force sensors. These sensors utilize the quantum-mechanical wave-like nature of atoms in the atomic analogue of an optical interferometer to provide unprecedented sensitivity to accelerations and rotations. The atomic sensors will further be used to measure the local gravitational field gradient to ensure that instrument alignment is properly maintained throughout vehicle maneuver, thus mitigating gravity-induced navigation errors. Initial program efforts</p>	6.000	4.000	6.000	

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<b>B. Accomplishments/Planned Program (\$ in Millions)</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
<p>will focus on developing fundamental technology components upon which future systems would be constructed. The PINS technology is planned for transition to the Navy at the conclusion of Phase III.</p> <p><i>FY 2008 Accomplishments:</i></p> <ul style="list-style-type: none"> <li>- Demonstrated single sensor integrating single axis high-performance accelerometer, gyroscope, and gravity gradiometer.</li> <li>- Completed open-ocean test campaign with combat swimmers demonstrating fifty meter per hour submerged navigation error.</li> </ul> <p><i>FY 2009 Plans:</i></p> <ul style="list-style-type: none"> <li>- Design and build six degree-of-freedom atom-based inertial measurement unit and multi-axis gravity gradiometer for extended laboratory testing.</li> <li>- Design and construct pre-production prototype for final evaluation by Marine Corps combat swimmers.</li> </ul> <p><i>FY 2010 Plans:</i></p> <ul style="list-style-type: none"> <li>- Complete laboratory testing of six degree-of-freedom atom-based inertial measurement unit and multi-axis gravity gradiometer, demonstrating less than 500 meters accumulated error after 100 hours of testing.</li> <li>- Transition atom interferometer-based navigation system to Navy Strategic Submarine Program Office.</li> </ul>				
<p>Navigation-Grade MEMS Inertial Measurement Unit (IMU)</p> <p>(U) The Navigation-Grade MEMS Inertial Measurement Unit (IMU) program will develop micro-scale accelerometers and gyros with navigation-grade performance that use only milli-watts of power. The program will transcend traditional single mass-spring methods for navigation sensing and will explore alternative approaches, such as multiple, interconnected mass-spring systems, micro-levitated spinning structures, micro-optical readout mechanisms, atomic interferometric readout mechanisms, and fluidic contortions. This program will transition to industrial performers by developing wearable inertial measurement units (IMUs) for dismounted warfighters capable of GPS-denied navigation for lengthy periods; small IMUs for unmanned air and underwater vehicles, and for guidance of small, long-range munitions—all of which will go into DoD systems.</p>	10.000	11.700	0.000	

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<b>B. Accomplishments/Planned Program (\$ in Millions)</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
<p><i>FY 2008 Accomplishments:</i></p> <ul style="list-style-type: none"> <li>- Developed levitation methods.</li> <li>- Developed fluid contortion sensing.</li> </ul> <p><i>FY 2009 Plans:</i></p> <ul style="list-style-type: none"> <li>- Develop micro-environmental control.</li> <li>- Control electronics integration.</li> </ul>				
<b>C. Other Program Funding Summary (\$ in Millions)</b>				
N/A				
<b>D. Acquisition Strategy</b>				
N/A				
<b>E. Performance Metrics</b>				
Specific programmatic performance metrics are listed above in the program accomplishments and plans section.				

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<b>COST (\$ in Millions)</b>	<b>FY 2008 Actual</b>	<b>FY 2009 Estimate</b>	<b>FY 2010 Estimate</b>	<b>FY 2011 Estimate</b>	<b>FY 2012 Estimate</b>	<b>FY 2013 Estimate</b>	<b>FY 2014 Estimate</b>	<b>FY 2015 Estimate</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
GT-CLS: CLASSIFIED	79.226	75.208	19.805						Continuing	Continuing
<b>A. Mission Description and Budget Item Justification</b> This project funds Classified DARPA Programs. Details of this submission are classified.										
<b>B. Accomplishments/Planned Program (\$ in Millions)</b>							<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified.  <i>FY 2008 Accomplishments:</i> Details will be provided under separate cover.  <i>FY 2009 Plans:</i> Details will be provided under separate cover.  <i>FY 2010 Plans:</i> Details will be provided under separate cover.							79.226	75.208	19.805	
<b>C. Other Program Funding Summary (\$ in Millions)</b> N/A										
<b>D. Acquisition Strategy</b> N/A										
<b>E. Performance Metrics</b> Details will be provided under separate cover.										

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