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Exhibit R-2, RDT&E Budget Item Justification							February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense Wide (0400), Budget Activity 3			R-1 ITEM NOMENCLATURE 0603941D8Z Test & Evaluation/Science and Technology (T&E/S&T)					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
PE 0603941D8Z	22.615	39.710	62.889	94.855	97.274	98.852	100.394	101.942
High Speed/Hypersonic Test	4.439	9.425	14.846	23.114	23.361	22.904	23.200	23.715
Spectrum Efficient Technology	3.493	3.585	0.650	2.217	4.428	5.713	5.802	5.891
Multi-Spectral Test	4.371	5.372	8.641	11.930	11.720	11.823	12.006	12.189
Non-Intrusive Instrumentation	3.229	5.094	8.379	10.915	10.721	10.798	10.965	11.132
Directed Energy Test	5.093	8.828	14.575	23.067	23.069	22.945	23.287	23.415
Netcentric Systems Test	1.852	5.373	11.547	17.977	18.339	18.950	19.310	19.671
Unmanned and Autonomous System Test	0.138	2.033	4.251	5.635	5.636	5.719	5.824	5.929

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A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

The T&E/S&T program seeks out and develops test technologies to pace evolving weapons technology. This program is critical to ensuring that the Department of Defense (DoD) has the capability to adequately test the advanced systems that will be fielded in the future. To meet this objective, the T&E/S&T program:

- Exploits new technologies and processes to meet important T&E requirements.
- Expedites the transition of new technologies from the laboratory environment to the T&E community.
- Leverages commercial equipment, modeling and simulation (M&S), and networking innovations to support T&E.

Additionally, the program examines emerging test requirements derived from transformation initiatives to identify needed technology areas and develop a long-range roadmap for technology insertion. This program leverages and employs applicable 6.2 applied research from the highly-developed technology base in the DoD laboratories and test centers, other government agencies, industry, and academia to accelerate the development of new test capabilities. This PE also provides funds to perform travel to carry out oversight of the T&E/S&T program, special studies, analyses, and strategic planning related to test capabilities and infrastructure.

This program is funded within the Advanced Technology Development Budget Activity because it develops and demonstrates high payoff technologies for current and future DoD test capabilities.

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B. (U) PROGRAM CHANGE SUMMARY

	<u>FY 2006</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
Previous President's Budget:	27.371	39.939	64.988	97.456
Current President's Budget:	22.615	39.710	62.889	94.855
Total Adjustments:	(4.756)	(0.229)	(2.099)	(2.601)
Congressional Program Reductions:				
Congressional Rescissions:				
Congressional Increases:				
SBIR/STTR Transfer:				
Other Program Adjustments:	(4.756)	(0.229)	(2.099)	(2.601)

Change Summary Explanation:

FY 2006: FY 2006 Defense Appropriations Act erroneously added \$4.2 million for "Advanced Unmanned Vehicle Systems Development" to Program Element 0603941D8Z, Test and Evaluation Science and Technology. Funds were reprogrammed to PE 0603709D8Z, Joint Robotics Program.

C. (U) OTHER PROGRAM FUNDING SUMMARY NA

D. (U) ACQUISITION STRATEGY NA

E. (U) PERFORMANCE METRICS

Percentage of T&E/S&T projects progressing satisfactorily toward technical, financial, schedule, and risk mitigation goals.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			HIGH SPEED/HYPERSONIC TEST					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
High Speed/Hypersonic Test	4.439	9.425	14.846	23.114	23.361	22.904	23.200	23.715

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

This test technology focus area is renamed from Hypersonic Test to High Speed/Hypersonic Test to more accurately communicate the nature of the test technologies required for future aerospace developments. The DoD is developing air-breathing weapons, advanced aircraft, and access to space platforms to operate at high speeds (Mach 3-5) and in the hypersonic speed regimes Mach 5 and higher. High speed/hypersonic systems to be developed by DoD will require T&E capabilities in numerous areas ranging from ground testing (wind tunnels, sled tracks, installed-system test facilities, and modeling and simulation (including computational fluid dynamics)) through flight testing. At high and hypersonic speeds, flight testing will challenge existing ground instrumentation systems (e.g., tracking system slew rate limitations, telemetry dropouts due to ionization) and range safety decision making. High speed/hypersonic weapon systems will depend on several new technological thrusts in areas such as propulsion and engines, structures and materials, guidance and control, seekers and sensors, warheads and payloads, and weapons delivery techniques and end-game dynamics - each requiring supporting T&E capabilities to determine performance, effectiveness, suitability, survivability, and responsiveness to Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems. Service improvement and modernization programs are addressing some basic test facility upgrades using off-the-shelf technologies. However, T&E of high speed/hypersonic systems will require technologies not yet developed or available for T&E purposes. The Department must have adequate T&E capabilities in place in time to meet current development, and ultimately, acquisition program schedules. The purpose of this T&E/S&T focus area is to address these T&E technology issues.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
High Speed/Hypersonic Test	4.439	9.425	14.846	23.114

FY 2006 Accomplishments:

Continued efforts initiated in prior fiscal years. Highlights of these efforts included:

- Completed Heat Flux Sensor Development for Aerothermal Measurements by successfully calibrating miniaturized heat flux sensors at high temperatures. These heat flux sensors were used in the successful wind tunnel tests on the Missile Defense Agency (MDA) Kinetic Energy Interceptor (KEI) at Arnold Engineering Development Center (AEDC). These heat flux sensors can be embedded in hypersonic vehicles to support wind tunnel and flight testing.
- Completed In-Situ Pressure Measurements for Hypersonic Vehicles efforts to develop an advanced prototype pressure sensor. This embedded sensor completed long duration testing in a flight representative hypersonic combustor. These sensors will allow for improved accuracy pressure measurements during long-duration flight and ground testing.
- Continued Test Media Effects development and demonstration of diagnostic tools to simultaneously measure chemical species, temperature and velocities in hypersonic flows. Efforts continued in the development of improved Computational Fluid Dynamics (CFD) algorithms to model the effects of vitiates in hypersonic vehicle propulsion systems. These tools will enable the measurement and prediction of vitiate effects to support hypersonic engine test and evaluation.
- Continued Clean Air Heater Test Technology efforts to evaluate material properties through static-testing and initiated design of the heater element.
- Continued In-flight Combustion Gas Analysis efforts to develop tunable diode laser sensor system for measurement of H₂O, CO, CO₂ and O₂ and temperature with two dimensional spatial resolution. This system was used to support the Robust SCRAMJET test at AeroJet test facilities.
- Continued High Heat Flux Sensor efforts to analyze alternative high temperature heat flux measurement methods and to conduct thermal conductivity and convective heat transfer finite element analysis modeling of candidate sensors to support the design of the model sensor for use in the extreme temperature environment of hypersonic aeropropulsion test facilities.
- Continued with Microelectromechanical System (MEMS) Shear Stress Sensors efforts to test and characterize the brassboard sensor performance and operation in supersonic flow conditions.

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- Continued Pulsed Electron Beam Spectroscopy efforts to design, fabricate and test pulsed e-beam spectroscopy in AEDC lab-scale shock tunnel for temperature and species measurements.
- Initiated new research efforts into Regenerative Storage Heater, Plug Nozzle Study, Hypersonic Engine/Facility Interaction, Modeling and Simulation for Hypersonic T&E and High Pressure Arc Heater.

FY 2007 Plans:

Continue efforts initiated in prior years. These efforts to include:

- Complete In-Flight Combustion Gas Analysis efforts to fabricate and ground test a non-intrusive laser spectroscopy diagnostic sensor suitable for in-flight test and evaluation of hypersonic propulsion systems. This diagnostic will provide an improved capability to evaluate the performance of hypersonic combustors in true flight conditions, and support the validation of CFD codes.
- Complete Pulsed Electron Beam Spectroscopy efforts to develop and demonstrate a non-intrusive sensor technology for temperature and gas concentration measurements in the flow field of hypersonic ground test facilities. This will provide the ability to determine temperature, gas species and concentration of combustion products in the flow field.
- Complete High Heat Flux Sensor efforts to develop and demonstrate high heat flux sensors that can provide accurate heat flux measurements in the extreme temperature environment of hypersonic aeropropulsion test facilities. The High Heat Flux Sensor project extends the developments of the Heat Flux Sensor project to make these sensors survive at higher temperatures (1500 degrees Fahrenheit vs. 700 degrees Fahrenheit). These high heat flux sensors will allow sensor measurements in hypersonic propulsion systems and in vitiated test environments.
- Complete MEMS Shear Stress Sensor efforts to develop and demonstrate a Silicon Carbide based MEMS sensor that is capable of measuring two-dimensional shear stress environments on the surface of hypersonic vehicles.
- Complete Plug Nozzle Study efforts to assess the feasibility of using an axisymmetric plug nozzle to create variable Mach number test conditions in the AEDC Aeropropulsion Test Unit (APTU) facility to determine uniformity of flow conditions downstream of the plug centerbody in the nozzle to support variable Mach number high speed/hypersonic testing.
- Continue Hypersonic Clean Air Heater Test Technology efforts to fabricate and test a sub-scale clean air heater system. This will provide the basis for the development of a full-scale heater system for use in hypersonic aeropropulsion testing.
- Continue Test Media Effects efforts to model effects of vitiated on hypersonic combustion engines to allow prediction of engine performance in clean air flight conditions.
- Continue Regenerative Storage Heater efforts to conduct comprehensive material testing for selecting core brick structural material for Storage Heater.
- Continue with Hypersonic Engine/Facility Interaction efforts to test a scramjet engine in test facilities and to conduct

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- CFD modeling of a scramjet engine in air, hydrogen and hydrocarbon vitiation conditions.
 - Continue Modeling and Simulation for High Speed Hypersonic T&E efforts to demonstrate accuracy of US Wind Code for scramjet and ramjet engine test. Efforts continue to improve combustion modeling to include capabilities such as liquid phase chemical kinetics for hydrocarbon-air combustion model, multiphase spray models for liquid injection model and turbulent heat and mass transfer model.
 - Continue High Pressure Arc Heater efforts to develop an arc characteristics monitoring system to determine effects of heater configuration changes on arc behavior to develop an analysis tool to determine the propensity of arcing to or between segments. These efforts will provide knowledge to reduce the arcing events, which cause severe damage to facilities.
- Initiate future investigations to address T&E technology challenges in this focus area for:
- Instrumentation for hypersonic flight testing of hot structures including sensor and sensor integration techniques for in-flight measurement of temperature, pressures, heat flux, strain and deformation.
 - Ground test technologies to simulate material ablation/erosion at high velocities.
 - Techniques to achieve a variable mach, free-jet test capability for ground testing a complete hypersonic propulsion system wherein the Mach number is varied to match anticipated flight profiles during a continuous facility run.
 - Measurement and computational modeling of hypersonic facility flow parameters to accurately predict behavior of the test article in different hypersonic facility flows and correlate experimental results between different ground test facilities.
 - High speed stores separation measurement technology for accurate store/vehicle separation data in hypersonic flight conditions.
 - Experimentally calibrated computational methodology to investigate the coupled fluid-thermal-structural effects generated in turbine nozzles during variable Mach number hypersonic tests.
 - Methodology for instantaneous optimized nozzle wall contour via closed loop control algorithm and actuators design.
- Initiate a Broad Agency Announcement (BAA) in FY 2007 to select efforts for FY 2008 award.

FY 2008 Plans:

Continue efforts initiated in prior years:

- Complete Test Media Effects efforts to incorporate the effects of vitiation into computational fluid dynamics codes to predict flame holding within hypersonic vehicle combustors used in hypersonic combustion engine testing.

This effort will result in the ability to characterize the performance of a hypersonic vehicle in a wind tunnel using vitiated air and use those results to predict the vehicle's flight performance. This effort will also advance the state of

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the art in ground test instrumentation to characterize the test environment.

- Complete High Pressure Arc Heater efforts to extend the operating regime for arc heater facilities to the Mach 8 – 12 regimes. This will provide true air operating conditions to support testing of thermal protection systems and hypersonic combustion systems.
- Complete Hypersonic Engine/Facility Interaction efforts to resolve ground test issues related to vitiate effects at various test facilities using different combustion heater fuels. This will provide an empirical understanding of the effects of vitiated air on hypersonic scramjet engines and support analysis of ground test performance at different test facilities.
- Continue Regenerative Storage Heater efforts to finalize pilot heater system design.
- Continue Modeling and Simulation for high speed/hypersonic T&E efforts to improve mode transition modeling to include capabilities to conduct numerical simulation of time independent mode transition and to simulate ram to scram mode transition.
- Continue Clean Air Heater Test Technology efforts to design and fabricate a high-pressure elevated temperature air flow system and heater control elements required for testing of heater element in a flow field.

Initiate additional investigations as a result of the BAA process to address critical T&E technology issues such as:

- Survivable command destruct package to allow safe and reliable termination of hypersonic flight tests.
- Technology to transmit effects and dynamics of Mach 7 + engagements to support weapon system performance evaluation.
- Advanced distributed simulation capabilities for Mach 7 + engagements to allow analysis of hypersonic system performance between test centers and system developers.
- Continuous and survivable instrumentation and communications to provide system performance (including time-space position and attitude information) and allow test system command and control throughout the hypersonic regime.

Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Continue efforts initiated in prior years: These efforts to include:

- Complete Regenerative Storage Heater efforts to develop a brick storage heater based on novel cored brick materials. This will provide a technique to produce non-vitiated air for ground testing hypersonic propulsion systems in a true flight environment.
- Complete Modeling and Simulation for high speed/hypersonic T&E efforts to develop enhanced modeling and simulation tools to support integrated test article and facility effects modeling. This will allow detailed analysis of hypersonic system testing prior to physical testing to reduce risk and cost of ground test events.

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- Complete Clean Air Heater efforts to develop and demonstrate a sub-scale resistive element clean air heater system. This technology will support development of a full-scale wind-tunnel heater system that can provide continuous clean air flow for use in hypersonic aeropropulsion testing.

Initiate additional investigations as a result of the BAA process to address critical T&E technology issues such as:

- Flight vehicle static structural testing to support ground testing of integrated hypersonic vehicles prior to flight testing
- Control jet interaction and flow separation control methodologies to ensure high Mach number testing accurately represents in-flight test conditions.
- Methods for electron-beam energy addition to create high temperature flows required to emulate Mach 8 and above flight conditions.
- Transient modeling techniques to simulate in-flight transients (e.g. boundary layer effects) to support “fly the mission” ground tests.

Initiate a BAA in FY 2009 to select efforts for FY 2010 award.

C. (U) OTHER PROGRAM FUNDING SUMMARY NA

D. (U) ACQUISITION STRATEGY NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			SPECTRUM EFFICIENT TECHNOLOGY					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Spectrum Efficient Technology	3.493	3.585	0.650	2.217	4.428	5.713	5.802	5.891

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

The Test Resource Management Center is realigning this program to perform risk reduction and advanced technology development for Central Test and Evaluation Investment Program (CTEIP) projects. Accordingly the Spectrum Efficient Technology (SET) Focus Area is being structured to provide advanced technology developments needed by CTEIP's integrated Network Enhanced Telemetry (iNET) project. The iNET study has developed an architectural concept for a Telemetry Network System (TmNS) that addresses the needs of the test and evaluation and training communities. However, the iNET architecture is not yet sufficiently defined to guide the selection and funding of SET projects. Accordingly, SET will temporarily phase out and stand up again in FY09 when iNET is better defined. SET will complete its current, ongoing projects: 10 in FY07 and 3 in FY08. No new starts will be funded until the iNET architecture is defined and advanced technology developments required to support iNET are clear.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Spectrum Efficient Technology	3.493	3.585	0.650	2.217

FY 2006 Accomplishments:

Continued efforts initiated in prior fiscal years. Highlights for these projects included:

- Completed X-band Tracking of a rocket in flight. This effort demonstrated the technology necessary to modify

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existing telemetry assets to support operation in the SHF band.

- Completed Steerable Beam directional antenna concepts ground and flight demonstration of a prototype steerable beam system with closed loop capability to steer telemetry signals to reduce data dropouts and minimize the effects of antenna to antenna interference.
- Continued Super High Frequency (SHF) Channel Modeling and Implementation efforts to incorporate effects of multipath interference in the SHF bands into the channel model. This channel model supports development of advanced robust modulation techniques required for telemetry in the SHF band.
- Continued Spectrally Efficient High Data Rate Telemetry System in 3-30Ghz range effort which will combine physically compact digital technology and complex software modulation schemes capable of mitigating effects of communications channel multipath error at high Doppler rates, while achieving implementations that are both power and spectrally efficient.
- Continued Phased Array Antenna effort to use low complexity centroid-based antenna algorithms to improve pointing accuracy and speed.
- Continued RF MEMS effort to develop a low cost, low profile, multifunctional phased array antenna using switchable micro elements which will enable rapid antenna geometry reconfiguration for specific test needs.
- Continued Beamformer Antenna effort to develop continuously steering, directional phased array antenna technology enabling high data rates for air vehicles during roll maneuvers which traditional omni-directional or fixed antennas can not support.

Initiated new research efforts including:

- Laser Telemetry to combine the latest components from a rapidly developing commercial market into a prototype test system to demonstrate that Free Space Optical (FSO) problems of the past have been overcome by technical advances
- Smart Modulating Retroreflectors will develop a lightweight, low power and low pointing complexity laser communications system for flight vehicles to augment limited RF spectrum.
- Broadband Telemetry Antennas will develop a single form, fit and function antenna covering three frequency bands, in a novel switched-beam array of 4 blade antennas, thereby providing a directional capability and increased gain with low complexity.
- Improved Linear Power Amplifiers to develop hybrid power amplifiers for telemetry applications using high power and high electron mobility resistors to achieve highest possible power supply and transmit amplifier efficiency.
- Medium Access Control to provide decentralized and distributed access to wireless media while supporting mobile and ad hoc behaviors.
- Aeronautical Network Telemetry to develop two way telemetry communications and dynamic data flow control as specified in the iNET architecture.

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- Enhanced Forward Error Correction to reduce Forward Error Correction (EFEC) code processing complexity while improving coding gain to improve aeronautical telemetry link availability and extend operating range at the MRTFB.
- Optical Communications and Advanced Telemetry Study will provide an in-depth analysis of existing FSO communications technologies and define requirements for FSO systems for the T&E community.

FY 2007 Plans:

Continue efforts initiated in prior fiscal years:

- Complete Super High Frequency Channel Modeling flight test data reduction and final report.
- Complete Spectrally Efficient High Data Rate Telemetry System for SHF flight-testing for real-time capability and deliver transition plan and final report.
- Complete RF MEMS system integration, package development, ground testing, flight testing, test data analysis and delivery of final report.
- Complete Beamformer Antenna software development, attitude control software interface and ground testing. Integrate payload with rocket for launch and deliver final report.
- Complete Laser Telemetry effort equipment integration and flight testing; deliver final report.
- Complete Smart Modulating Retroreflector modulator fabrication and systems analysis, characterize link stability and throughput, deliver phase 1 final report, perform dynamic testing and deliver data reduction report.
- Complete Broadband Telemetry Antenna fabrication, integration, test and delivery of antennas 1 and 2. Complete pointing algorithm development, ground and flight testing and deliver final report and hardware.
- Complete Improved Linear Power Amplifier phase 1 and deliver two amps. Complete phase 2 design and fabricate and test final amplifiers; deliver four amps and final report.
- Complete Aeronautical Network Telemetry coordinated layer-2 & layer-3 Quality of Service (QoS) approach, confirm transport layer interoperability and complete final architecture refinement; deliver final report.
- Complete Optical Communications and Advanced Telemetry Study – deliver results of analysis
- Continue Phased Array Antenna dynamic pointing test, flight test planning, and analysis.
- Continue Medium Access Control planning, scripting and analysis; optimize and upgrade model, rerun simulation and deliver initial report; develop high-fidelity (HF) model and prepare for HF simulation.
- Continue Enhanced Forward Error Correction (EFEC) by extending results from phase 1 to characterize the performance of the test suite of EFEC codes on the second and third of the three common telemetry modulation schemes; develop simplified coherent and noncoherent decoders for pulse code modulation/frequency modulation (PCM/FM) and advanced range telemetry continuous phase modulation (ARTM CPM) modulation schemes.

FY 2008 Plans:

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Continue efforts initiated in prior fiscal years. These efforts will provide risk mitigation and advanced technologies to support CTEIP's iNET project and include:

- Complete Phased Array Antenna flight tests and analysis of results; deliver final report.
- Complete Medium Access Control high fidelity simulations and deliver final report.
- Complete EFEC search of EFEC codes and finalize the coherent and noncoherent decoders; deliver detailed design of decoders with performance table identifying the best combinations of EFEC codes and decoders with any necessary design and implementation details along with final report.

Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Reactivate the SET focus area to provide risk mitigation and advanced technologies to support CTEIP's iNET project.

C. (U) **OTHER PROGRAM FUNDING SUMMARY** NA

D. (U) **ACQUISITION STRATEGY** NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			MULTI-SPECTRAL TEST					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Multi-Spectral Test	4.371	5.372	8.641	11.930	11.720	11.823	12.006	12.189

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

DoD S&T programs are developing new technologies for use in multi-spectral and hyperspectral sensors, seekers, and detectors for weapon systems and intelligence, surveillance, and reconnaissance systems. T&E of new multi-spectral and hyperspectral sensors to be used in these future weapon systems will require new T&E technologies. Current methods for testing multi-spectral and hyperspectral sensors rely heavily on expensive field test programs. While these field tests provide realistic data for sensor testing, they leave several critical gaps. For example, test conditions are not repeatable because environments observed one day will be different the next day. Imagery can be collected and stored to partially mitigate this deficiency, but this process is expensive and cannot cover the full spectrum of environments required for complete test article evaluation and performance analysis. The T&E community needs the ability to test these advanced seekers and sensors in a repeatable, objective fashion before and after integrating them into warfighting systems. This T&E/S&T focus area is addressing these needs through research efforts in scene generation, injection and projection to create test technologies that can be combined into integrated multi-spectral and hyperspectral test capabilities. Without these new T&E technologies, DoD will not be able to adequately test and evaluate the multi-spectral and hyperspectral weapon systems of the future.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Multi-Spectral Test	4.371	5.372	8.641	11.930

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FY 2006 Accomplishments:

Continued efforts initiated in prior fiscal years. Highlights for these projects included:

- Completed Ultra-Violet Light-Emitting Diode (UV LED) efforts to characterize the LEDs and conducted tests to determine the feasibility of using these LEDs to enable performance evaluation of missile warning systems (MWS) and signal processing algorithms by stimulating the UV sensors.
- Continued Dynamic Hyperspectral Thermal Signature Model (DHTSM) efforts to evaluate real-time performance of the DHTSM using High Performance Computing (HPC) assets to support real time hardware in the loop (HWIL) hyperspectral sensor testing. This signature model will allow generation of synthetic infrared imagery to provide a repeatable test environment for multi-spectral and hyperspectral imaging systems.
- Continued Multi-Spectral Stimulator Injection Test Method (MSSITM) efforts to demonstrate closed loop scene generation outputs with synchronized infrared (IR) and RF outputs to support hardware-in-the-loop testing of multi-spectral weapon systems in the mid-wave IR (MWIR), long-wave IR (LWIR) and millimeter wave frequency bands.
- Continued Hyperspectral Testbed efforts to develop a capability to generate multiple realistic hyperspectral targets across a broad span of environmental conditions and projection technology with realistic spatial and spectral radiance and high dynamic range at moderate frame rates in a large array format.

Initiated new research efforts including:

- A follow-on effort to UV LED to characterize thermal response under load.
- Super-lattice LEDs to use advanced semiconductor growth and processing techniques to develop high power superlattice LED's that provide output in multiple spectral bands from a single device, with apparent temperatures of 1000-3000 degrees Kelvin.
- A Multi-Spectral/Hyperspectral Sensor Survey (MS/HS SS) effort to better understand the interface, operational and performance requirements that must be satisfied by a MS/HS stimulator in order to adequately test the capabilities of existing and future MS/HS sensor systems.

FY 2007 Plans:

Continue efforts initiated in prior fiscal years. These efforts to include:

- Complete DHSTM efforts including scene builder, graphical user interface, and scenario editor; provide software, run-time analysis and final report along with user manuals and support documentation.
- Complete MSSITM efforts by providing results of HWIL demonstration, engineering drawings, deliver user manuals, final report, and prototype system.
- Complete Hyperspectral Testbed demonstration; complete and provide software, deliver user manuals and final report.
- Continue Super-lattice LED test and deliver MWIR array; begin design, fabrication and testing of LWIR array; begin

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development of multi-spectral processing protocols.

Initiate future investigations to address T&E technology challenges in this focus area for:

- UV/short wave infrared (SWIR) & Passive LWIR Polarization Signature Model (LPSM)
- UV-MWIR Micro-Plasma Projector (MPP)
- MS&HS Polarized Scene Projector (PSP) with Bandwidth Control
- Next Generation Read-in Integrated Circuits for IR Scene Projection (RIIC-IRSP)
- Dual-Band Scalable IR Projection System (DB-SIPS), and Dynamic Polarimetric Scene Generator (DPSG)

Initiate a BAA to select efforts for FY 2008 award.

FY 2008 Plans:

Continue efforts initiated in prior fiscal years. These efforts to include:

- Complete Super-luminescent LED by delivering 64x64 MWIR and LWIR arrays; optimize 512x512 MWIR and LWIR SLEDs and couple the two to form a monolithic two-color IR emitter for delivery; deliver scalability study for 1024x1024 or larger arrays, and final report
- UV/SWIR & Passive LWIR LPSM, UV-MWIR MPP, MS&HS PSP, Next Generation RIIC-IRSP, DB-SIPS and DPSG.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Modeling and simulation tools to generate high resolution visible and near IR background signatures including both polarized and non-polarized imagery.
- Projection and injection technologies for the presentation of Short-Wave IR images to multi-spectral and hyperspectral sensors
- Metrics and test methodologies to evaluate the spatial, temporal, and spectral performance of next-generation multi-spectral and hyperspectral sensors and seekers.

Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Continue efforts initiated in prior fiscal years. These efforts to include:

- UV/SWIR & Passive LWIR LPSM, UV-MWIR MPP, MS&HS PSP, Next Generation RIIC-IRSP, DB-SIPS and DPSG.
- Modeling and simulation tools to generate high resolution visible and near IR background signatures including both polarized and non-polarized imagery.
- Projection and injection technologies for the presentation of Near IR images to multi-spectral and hyperspectral sensors

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- Metrics and test methodologies to evaluate the spatial, temporal, and spectral performance of next-generation multi-spectral and hyperspectral sensors and seekers.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Additional methodologies to evaluate multi-spectral and hyperspectral data fusion algorithms, including data mining algorithms
- Additional projection and injection technologies for the presentation of visible and near IR images to multi-spectral and hyperspectral sensors
- Additional advanced modeling and simulation tools to create synthetic scenes for testing of multi-spectral and hyperspectral whole sky imagers

Initiate a BAA in FY 2009 to select efforts for FY 2010 award.

C. (U) **OTHER PROGRAM FUNDING SUMMARY** NA

D. (U) **ACQUISITION STRATEGY** NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			NON-INTRUSIVE INSTRUMENTATION					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Non-Intrusive Instrumentation	3.229	5.094	8.379	10.915	10.721	10.798	10.965	11.132

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

Instrumentation requirements for systems-under-test, hardware-in-the-loop testing, and training are increasing exponentially for new weapon systems. Onboard or personnel-borne instrumentation and equipment are required for sensing and collecting critical performance data; determining accurate time, space, position, and attitude information; interfacing with command and control data links; monitoring and reporting system-wide communications; reporting human operator performance; and storing and transmitting data. These requirements drive the need for enabling technologies for miniaturized, non-intrusive instrumentation (NII) suites with increased survivability in harsh environments.

There is minimal space available for adding instrumentation to new weapon systems subsequent to their development. Additional weight and power draw can adversely affect the weapon system's signature and performance. Instrumentation for humans-in-the-loop, such as a dismounted soldier, should not detrimentally affect the soldier's performance or operational burden. New technologies can be exploited to integrate small NII into new platforms during design and development, and, in some cases, into existing platforms. NII can provide the required data for T&E, training, and logistics throughout the system's lifecycle, and provide the ability to collect critical system performance data during combat missions.

The use of NII for T&E, training, and logistics has the potential for significantly reducing the total ownership costs of new weapon systems while enhancing force readiness. Accordingly, the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01D states that acquisition programs should include embedded instrumentation as part of system trade-off studies and design analyses. The NII focus area will also advance T&E technologies needed to facilitate compliance with CJCSI 3170.01D.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Non-Intrusive Instrumentation	3.229	5.094	8.379	10.915

FY 2006 Accomplishments:

Changed the name of this focus area from Embedded Instrumentation (EI) to Non-Intrusive Instrumentation (NII) to more accurately describe the technologies under development to meet the Major Range and Test Facility Base (MRTFB) missions and to expand the breadth of research areas within this focus area.

Continued efforts initiated in prior fiscal years. Highlights of these projects included:

- Completed Compact Holographic Data Storage efforts to fabricate and test a brassboard high density storage device. The storage device will be suitable for incorporation into Systems Under Test (SUTs) for storage of test data. The holographic storage device has no moving parts and is capable of storing a minimum of 750 gigabytes (0.75 terabytes) of data.
- Completed Gas Turbine Engine Probe efforts to design and fabricate a gas extraction probe capable of being embedded within a combustor and housing the Carbon Monoxide Emissions Sensor for Gas Turbine Engines. This will enable measurement of chemical species in the combustor region of gas turbine engines to provide improved evaluation of system performance.
- Completed Software Architecture for Embedded Instrumentation efforts to design and demonstrate extensible, platform-independent reusable software architecture. This architecture will support integration of non-intrusive instrumentation onto multiple weapon systems.
- Completed non-intrusive integrated telemetry efforts to test and evaluate microelectromechanical systems (MEMS) resonator technology for use in telemetry and datalink clocking applications for harsh environments to support smart munitions test.
- Completed Fiber Sensors Integrated Monitoring efforts to design, fabricate and test a breadboard smart sensor array. The smart sensor will be suitable for integration on a fiber sensor network for high temperature testing.
- Continued Advanced Munitions Flight Test Instrumentation efforts to fabricate second generation sensors through iterative runs within Jazz semiconductor process to implement on chip common electronics for multiple types of sensors and to test second generation packaged sensors.
- Continued High Speed and Temperature Diagnostics efforts to conduct bench hardware fabrication and test of optical, Mach flow angular, temperature and pressure probes.
- Continued MEMS Fiber Optic Sensors efforts to integrate pressure, temperature and shear stress sensors into a single

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- sensor head module. Efforts continued in the development color Moire system for 2-D shear stress measurement.
- Continued Digital Communications Test Data Bus efforts to develop smart sensor nodes, a subsystem controller and software for embedded architectural elements.
- Continued Open Modular Embedded Instrumentation Architecture efforts to design and develop an open, modular, and scalable embedded system architecture. Efforts continued to build the High-Temperature Superconducting generator embedded instrumentation module for large scale architecture demonstration.

Initiated new research efforts into Self Powered Chip, On-Board Wireless Data Communications, Wideband Location Positioning System, and Harsh Environment D-Fiber Sensors.

FY 2007 Plans:

Continue efforts initiated in prior fiscal years:

- Complete Advanced Munitions Flight Test Instrumentation efforts to develop, fabricate and flight test a MEMS-based instrumentation module on a munition. This embedded instrumentation package will provide time, space, and position information (TSPI) to improve munition evaluation without adversely impacting the munition design or function.
- Complete High Speed and Temperature Diagnostics efforts to develop and demonstrate a series of probes that can withstand continuous exposure to hypersonic test environments. The effort is developing an optical species probe, total pressure probe, total temperature probe and a Mach/flow angularity probe. These probes will support both ground and flight testing of hypersonic vehicles.
- Complete MEMS Fiber Optic Sensors efforts to design, fabricate, and demonstrate optical pressure, temperature, and shear stress sensors integrated into a single sensor head. These sensors will be embedded into a test article to demonstrate practical application in an operationally relevant environment. .
- Complete Digital Communications Test Data Bus efforts to develop and demonstrate a prototype miniaturized, self-calibrating embedded instrumentation system that consists of smart sensors, a subsystem controller and a processor. This instrumentation system will be capable of operating on missile system power in the operational environment and will be able to support continuous life cycle T&E.
- Complete On-Board Wireless Data Communications efforts to develop and demonstrate a prototype wireless data bus for use with smart sensors on a SUT. This will enable integration of non-intrusive instrumentation into test articles with minimal impact to the SUT.
- Continue Open Modular Embedded Instrumentation Architecture efforts to design and develop an open, modular, and scalable embedded system architecture. This architecture will be demonstrated in tests of the Multi-Megawatt Electric Power System being developed for directed energy weapons applications.

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- Continue Self Powered Chip efforts to design power mixer-supply system integrated circuit, sensor system integrated circuit and fuel cell-lithium ion brassboard. Efforts continue to test, evaluate and optimize wireless telemetry and sensor common off the shelf technologies.
- Continue Wide Band Location Positioning System efforts to develop acquisition waveform and algorithm to test acquisition and tracking software and to design and test receiver and transmitter reference frequency.
- Continue Harsh Environment D-Fiber Sensors efforts to enhance D-Fiber sensor such as improving the spectral response, reducing fiber brittleness and improving sensor packaging. Efforts continue to enhance the fiber sensor integrated monitoring to develop high speed monitoring and wavelength sweeping source.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Time Space Positioning Information (TSPI) instrumentation to provide accurate TSPI in extremely high dynamic environments..
- Advanced non-intrusive sensors that are survivable in extreme environments and that extend the state of the art in measurement accuracy while reducing weight and size.

Initiate a BAA in FY 2007 to select efforts for FY 2008 award.

FY 2008 Plans:

Continue efforts initiated in prior fiscal years.

- Complete Open Modular Embedded Architecture efforts to demonstrate an NII architecture that can be configured for incorporation into any SUT. This architecture will support incorporation of smart sensors and provide a standardized interface protocol for development of advanced non-intrusive sensors.
- Complete Harsh Environment D-Fiber Sensors efforts to integrate robust D-fiber sensors with an integrated monitoring system to create a fiber optic sensor suite. This NII package will be usable as either embedded instrumentation or as NII for integration into existing platforms.
- Continue Self Powered Chip efforts to fabricate and test mixer-supply system integrated circuit, sensor system integrated circuit and fuel cell-lithium ion brassboard. Efforts continue to design the system in package integration.
- Continue Wideband Location Positioning System to design and test miniature receiver prototype and to design and fabricate four portable transmitter prototypes.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Synthetic instrumentation that combines hardware and software to create instrumentation that can be reconfigured based on required measurements.
- Non-conventional power sources to provide continuous or peak power to non-intrusive instrumentation. These power sources include radioisotope power generators and MEMS-based fuel cells.

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- Advanced wireless data and communications techniques, including the use of vehicle power lines for data transfer and distribution
 - Human performance instrumentation to support T&E in Joint Urban Operations environments.
 - Non-intrusive network interfaces with critical operational components including the MIL-STD-1553 data bus to support gathering operational data without affecting operational performance.
 - Instrumentation command and control techniques to provide remote operation of instrumentation during T&E events.
- Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Continue efforts initiated in prior fiscal years.

- Complete Self Powered Chip efforts to design, integrate and demonstrate a self contained, MEMS sensor package that integrates a sensor and power supply into a package that is a few cubic centimeters in size. This integrated sensor design will support the incorporation of different sensors into non-intrusive sensor packages.
- Complete Wideband Location Positioning System efforts to develop and demonstrate a location positioning system using wide band radio frequency transmissions to provide position information in Global Positioning System (GPS) - denied environments. This will support T&E of systems in urban environments.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Telemetry on a Chip to provide miniaturized telemetry that is compatible with soldier-borne weapons.
- Tunable MEMS transceiver to provide small integrated local area communications between sensors packages to create ad-hoc instrumentation networks.
- Electro-adhesives to facilitate rapid installation and removal of appliqué instrumentation packages on SUTs.
- Advanced data fusion algorithms to support real-time assessment of test events with multiple instantiations of instrumentation networks.

Initiate a BAA in FY 2009 to select efforts for FY 2010 award.

C. (U) OTHER PROGRAM FUNDING SUMMARY NA

D. (U) ACQUISITION STRATEGY NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			DIRECTED ENERGY TEST					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Directed Energy Test	5.093	8.828	14.575	23.067	23.069	22.945	23.287	23.415

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

Directed Energy (DE) technologies are rapidly transitioning into acquisition programs and Advanced Concept Technology Demonstrations (ACTDs). These weapons technologies, which primarily consist of High Energy Laser (HEL) and High Power Microwaves (HPM), are outpacing their supporting test technologies. Advancements in HEL and HPM have created a new class of weapon systems in which energy is placed on a target instantaneously, making traditional test techniques for evaluating conventional munitions (with flight times ranging from seconds to minutes) not applicable to T&E of DE systems. As a result, new technology solutions are needed to ensure adequate developmental, live fire, and operational test capabilities are available when the DE acquisition programs are ready to test.

DE system and component testing requires two principal assessments: how well the weapon is performing and the specific interaction of energy and target. The current ability to assess DE systems performance and interactions is based on effects testing, i.e. determining if and when the target was destroyed. This does not provide the detailed test data required to understand DE system performance. Military utility of these weapons will be dependent on the knowledge acquired through T&E to know how much to trust the technologies under development and how best to use them. This T&E/S&T focus area is developing the needed technologies to quantitatively assess both HEL and HPM performance and target interaction to support thorough testing of DE systems.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Directed Energy Test	5.093	8.828	14.575	23.067

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FY 2006 Accomplishments:

Tailored this focus area to develop the advanced technologies required to mitigate risks identified through strategic planning for the Central Test & Evaluation Investment Program (CTEIP) Directed Energy Test & Evaluation Capability (DETEC) project.

Continued efforts initiated in prior fiscal years. Highlights for these projects included:

- Completed Directed Energy Data Acquisition Transformation (DEDAT) development and test of a simultaneous trigger capability. The simultaneous trigger will be used with the previously developed Compact Remote Data Acquisition (CRDAQ) system for conducting T&E of HPM systems.
- Completed Range Profiles of Turbulence efforts to integrate and demonstrate a brassboard Differential Image Motion (DIM) Light Detection and Ranging (LIDAR) system. The DIM LIDAR data was compared with truth data to verify system performance. This will support characterization of the test environment during HEL T&E events.
- Completed Microwave Test Diagnostics efforts to fabricate and test a prototype compact self-contained HPM field diagnostic system. This survivable diagnostic sensor is compatible with integration into test articles to capture test data to support T&E of HPM systems.
- Continued QWIP efforts to integrate a QWIP and Near Infrared (NIR) Indium-Gallium-Arsenide (InGaAs) focal plane array (FPA) with a Computed Tomographic Imaging Spectrometer (CTIS). The QWIP/NIR/CTIS camera will allow remote analysis of HEL interaction with targets to characterize laser performance.
- Completed Electro-Optical Sensor Technology efforts to fabricate and test a HPM field probe based on a novel electro-optical material that changes its optical characteristics when subjected to an HPM environment. This field probe will allow non-intrusive measurement of HPM environments with minimal impact on the fields measured.
- Continued T&E Adaptive Optics System efforts to design and fabricate hardware to build the prototype adaptive optics design. Efforts continued in software design to resolve target clipping and to improve imagery by using multi-frame blind deconvolution (MFBD) techniques.
- Continued Dielectric Electromagnetic Field Probes efforts to design E-field sensor arrays to evaluate detection methods for multiplexing and addressing individual sensor performance.

Initiated new research efforts into Holographic Target Board, Reflectance & Data Fusion Models, Multiple Waveband Temperature Sensor, Bistatic Optical Imaging Sensor, Dielectric Antenna Electro-Optical Sensor, Laser Irradiance T&E Tool, and Delivered Irradiance Assessment Tool.

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FY 2007 Plans:

Continue projects initiated in prior years. These efforts will provide risk mitigation and advanced technologies to support CTEIP's DETEC project and to include:

- Complete T&E Adaptive Optics System efforts to integrate and test an adaptive optics system to support remotely measure HEL temperature with high spatial and temporal accuracy. The adaptive optics system will be integrated into the Advanced Pointer Tracker at HELSTF.
- Complete QWIP efforts to test an integrated QWIP, NIR FPA, and CTIS. The prototype camera system will be demonstrated in both lab and field environments. The QWIP/NIR/CTIS camera system will allow off-board analysis of HEL beam interaction with a target to characterize the laser weapon performance.
- Complete Dielectric Electromagnetic Field Probes efforts to develop and demonstrate dielectric-based field probes based on planar waveguide technology that can measure electric and magnetic fields during HPM T&E events. These dielectric field probes will cause little or no perturbation of the electromagnetic environment during the event.
- Complete Reflectance and Data Fusion Model efforts to develop and demonstrate improved bidirectional reflection distribution function models to predict the laser irradiance based on reflected energy measurements from various target material compositions. This effort will also develop a dynamic data fusion model that will support projecting 2-dimensional HEL imagery onto 3-dimensional target representations. This will allow more detailed analysis of HEL-target interaction during T&E.
- Complete Delivered Irradiance Assessment Tool efforts to assess approaches for determining HEL irradiance delivered to the target. This will combine data from multi spectral imagery sensors and sensor/atmospheric propagation models to determine HEL irradiance to the target.
- Continue Holographic Target Board efforts to design, fabricate and test a small scale holographic HEL target board using photo-thermo-refractive (PTR) glass to measure HEL irradiance of the an incident laser beam.
- Continue Multiple Wave Temperature Sensor efforts to design a multi-band camera system for target surface temperature measurement.
- Continue Bi-static Optical Imaging Sensor efforts to design and fabricate a prototype ground based HEL diagnostics sensor and to install and characterize the prototype sensor.
- Continue Dielectric Antenna Electro-Optical Sensor efforts to design and fabricate a prototype device consisting of a Dielectric resonance antenna (DRA) and Electro-Optical (E-O) resonator.
- Continue Laser Irradiance T&E Tool efforts to develop algorithm for in-band and thermal imagery to determine incident irradiance from temperature distributions.

Initiate future investigations to address T&E technology challenges in this focus area for:

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- Wide-spectrum, single substrate imagers to enhance imaging and detection of HEL beams from a variety of systems and sources.
 - Inverse heat conduction sensor technology to determine laser energy deposition onto the target during lasing.
 - HEL and HPM hardened flight termination system/range destruct package to safely and reliably provide for termination of a target, even when high concentrations of DE are present on the target.
 - Physics-based HEL and HPM models that incorporate virtual geographical representations of T&E ranges to provide 3-dimensional, geodetically accurate models of beam propagation, beam spread, lethal range, and atmospheric effects.
- Initiate a BAA in FY2007 to select efforts for FY 2008 award.

FY 2008 Plans:

Continue efforts initiated in prior years. These efforts will provide risk mitigation and advanced technologies to support CTEIP's DETEC project and to include:

- Complete Bi-static Optical Imaging Sensor efforts to develop, fabricate and demonstrate a brassboard hyperspectral imager by utilizing a fiber-based field sensor. This effort will develop the technology to use a bi-static hyperspectral imager to remotely characterize multiple HEL beam wavelengths and power level signatures to support HEL test events.
- Complete Laser Irradiance T&E Tool efforts to develop a modeling and simulation tool that supports test safety and hazard prediction in a cost effective and timely manner. This tool will predict the range space that can be impacted during an HEL T&E event. This will improve range safety and allow multiple test events to occur simultaneously.
- Complete Dielectric Antenna Electro-Optical Sensor efforts to fabricate and test a dielectric antenna with an embedded electro-optic crystal to measure changes in the electric field during an HPM engagement. This sensor will allow non-intrusive measurement of HPM environments with minimal impact on the fields measured.
- Continue Holographic Target Board efforts to design, fabricate and test a large scale holographics HEL target board using PTR glass to measure HEL irradiance of the an incident laser beam.
- Continue Multiple Wave Temperature Sensor efforts to integrate multi-band focal plane array, electronics and operating software and to characterize the multiple wave temperature sensor performance.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Methods to measure optical transmissivity with a 100 fold increase in sampling rates over current measurement techniques at different wavelengths along laser beam paths to support HEL T&E.
- Physics based Modeling and Simulation (M&S) tools to simulate HEL target interaction in operationally relevant engagement environments to assess laser effects and target responses to supplement live-fire T&E.

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- HPM surrogate materials to replace energetic materials such as explosive, fuel and solid propellants with non hazardous materials that emulate the electric and magnetic field properties of the material with little or no effects on HPM live fire test results.
- HPM propagation environment measurement techniques for near real-time monitoring of soil and water conductivity, dielectric constant, atmospheric temperature and relative humidity conditions as well as the absorption of scattering effects of atmospheric obscurants within HPM beams to provide a baseline of test conditions during HPM T&E.

Initiate a BAA to select efforts for FY 2009 award

FY 2009 Plans:

Continue projects initiated in prior years. Highlights of these efforts to include:

- Complete Holographic Target Board efforts to fabricate and demonstrate large-scale holographic HEL target board that using PTR glass to measure HEL irradiance of an incident laser beam. The reusable system will deliver test data that is both spatially and temporally resolved.
- Complete Multiple Waveband Temperature Sensor efforts to fabricate and demonstrate a remote four-waveband infrared temperature sensor that allows measurement of target surface temperature during HEL field tests.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Advanced physics based M&S tools to predict HEL-Target interactions in real time.
- Advanced HEL measurement techniques that do not affect target dynamics or response to laser irradiation.
- Advanced HPM measurement techniques that do not perturb the RF environment and provide a reliable measurement of field strength in an HPM engagement.

Initiate a BAA to select efforts for FY 2010 award.

C. (U) **OTHER PROGRAM FUNDING SUMMARY** NA

D. (U) **ACQUISITION STRATEGY** NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			NETCENTRIC SYSTEMS TEST					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Netcentric Systems Test	1.852	5.373	11.547	17.977	18.339	18.950	19.310	19.671

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

Advancements in Netcentric Systems will provide commanders and staff with an adaptive, network-centric, configurable operational information visualization environment, which will improve the speed and quality of command decisions. Information assurance and survivability are central to achieving these advancements. These advances will enable a spectrum of operational capabilities ranging from enhanced management and exploitation of intelligence, surveillance, and reconnaissance assets to next-generation tactical radio systems. Successful implementation of these transformational capabilities will necessitate a corresponding transformation in DoD's ability to test and evaluate Netcentric Systems. The Netcentric Systems Test (NST) focus area will address the T&E scenarios, technologies, and analysis tools required to ensure that operational networked systems delivered to the warfighter provide an assured capability to acquire, verify, protect, and assimilate information necessary for battlefield dominance within a complex netcentric environment.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Netcentric Systems Test	1.852	5.373	11.547	17.977

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FY 2006 Accomplishments:

Tailored this focus area to provide risk mitigation and advanced technologies to support the Central Test & Evaluation Investment Program (CTEIP) Joint Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) Interoperability T&E Capability (InterTEC) project and CTEIP's Joint Information Assurance Test Suite – Web Enabled Test (JIATS-WET) project.

Continued projects initiated in prior fiscal years. Highlights for these projects included:

- Completed development and demonstration of the Tactical-Report Generation Test Bed (TGT) for C4ISR Systems. The TGT combines the Repeatable Performance Evaluation and Analysis Tool (REPEAT) with the Automated Scriptor Simulator Exercise Trainer (ASSET) to generate realistic sensor data and formatted message data streams from operational and exercise scenarios to support T&E of Service Oriented Architectures in a realistic netcentric test environment..

Initiated new efforts including:

- Executable Architecture Analysis Modeling
- Middleware for Netcentric Simulations
- Analyzer for T&E Confederations
- Status Monitoring and Adaptive Control
- Technology and Tools for Joint Testing
- Joint Virtual Netcentric Warfare

FY 2007 Plans:

Continue efforts initiated in prior years to include:

- Executable Architecture Analysis Modeling to develop architectures that can support T&E of C4ISR systems. These architectures will support both operational and developmental testing and allow for analysis of alternatives by allowing the user to replace system components in the architecture model.
- Middleware for Netcentric Simulations to improve on the efficiency of distributed netcentric operation for test infrastructures and Live-Virtual-Constructive (L-V-C) battlespace environments by extending state-of-the-art network coding approaches to provide robust operation of integrated network enhanced telemetry (iNET) and test and training enabling architecture (TENA) middleware.
- Analyzer for T&E Confederations to develop web-based test automation tools for complex pre-event test planning. This technology will support T&E of L-V-C based test assets in a federated system of systems environment.
- Status Monitoring and Adaptive Control, a battlespace awareness tool that integrates sensor imagery data with other Joint Mission Environment test data projected into the battlespace providing a more precise capability to determine in-

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system location errors.

- Technology and Tools for Joint Testing to develop and demonstrate web-based technologies for a netcentric system interface repository that can support the reuse and exchange of system interface information between entities in a netcentric test environment. This will support T&E of netcentric systems within a joint mission environment.
- Joint Virtual Netcentric Warfare to develop real time distributed simulations of communication networks using a common, scalable, standard simulation architecture running on High Performance Computer assets. This will enable T&E of netcentric systems in a L-V-C environment.
- Validation for Netcentric Systems to develop a software validation testbed within the netcentric-end-to-end simulation system by constructing robust statistical and analytical techniques to validate models and identify the range of scenarios in which they are valid. This effort will complete in FY07.

Initiate investigations to address T&E technology challenges in this focus area for:

- Feasibility study to determine the potential for candidate technologies to be developed into a multi-level security (MLS) capability for T&E. This effort will complete in FY07.
- A battlespace awareness tool that integrates sensor imagery data with other Joint Mission Environment test data
- Service-Oriented Architecture T&E Toolset effort to create an automated method to extract critical data from the weapon system under test, thus enabling network and interoperability testing of netted weapons using realistic trajectories of network participants.
- Configurable Situational Awareness Displays effort to develop a situational awareness 3D visualization tool for integrated test networks, tailorable to meet the needs of each netcentric test event.

Initiate a BAA in FY 2007 to select efforts for FY 2008 award.

FY 2008 Plans:

Continue projects initiated in prior years. These efforts will provide risk mitigation and advanced technologies to support CTEIP's InterTEC and JIATS-WET projects and to include:

- Complete Executable Architecture Analysis Modeling architecture, perform testing and deliver final technical report and software development plan.
- Complete Middleware for Netcentric Simulation efforts to apply phase 1 analysis and develop approach to a middleware architecture in terms of sub-layer mechanisms. Integrate into a T&E/S&T middleware platform to improve on the efficiency of distributed netcentric operations for test infrastructures and L-V-C environments.
- Complete Analyzer for T&E Confederations efforts; finish development of test event analyzer and supporting tools; integrate, validate and demonstrate the analyzer; deliver prototype analyzer software and data along with final report.
- Complete Service-Oriented Architecture T&E Toolset efforts that will provide a web-enabled display and

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- manipulation of test architectures.
- Complete Configurable Situational Awareness Displays effort; demonstrate and deliver final 3D visualization tool and final report.
- Continue Technology and Tools for Joint Testing effort; develop agile C2 data mining algorithm prototype; conduct data mining advanced visualization.
- Continue Joint Virtual Netcentric Warfare effort; demonstrate virtual communication link technology enabling visualization of transmit events, link connectivities, terrain cross sections, and line-of-sight visibilities.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Integrated architecture testing to evaluate the performance of Service Oriented Architectures in the Global Information Grid environment.
- Synthetic battlespace environment M&S tools to create realistic complex virtual environments for use in L-V-C testing of netcentric weapon systems.
- End-to-End mission thread testing tools to evaluate the effectiveness of data links by tracing mission events from sensor to shooter.

Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Continue projects initiated in prior years. These efforts will provide risk mitigation and advanced technologies to support CTEIP's InterTEC and JIATS-WET projects and to include:

- Complete Joint Virtual Netcentric Warfare effort; demonstrate virtual mobile ad-hoc network (MANET) technology and real-time virtual communication network; deliver final report.
- Continue Technology and Tools for Joint Testing; deliver system interface repository, transition plan, software documentation and final report.

Initiate future investigations to address T&E technology challenges in this focus area for:

- Capability to evaluate advances from a "human-out" perspective; i.e., determine what information actually enhances a warfighter's performance.
- Technologies to non-intrusively assess low probability of detection/low probability of intercept communications and data links.
- Methods to assess the contribution of netcentricity to decision superiority in operational scenarios.

Initiate a BAA in FY2009 to select efforts for FY 2010 award.

C. (U) OTHER PROGRAM FUNDING SUMMARY NA

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D. (U) ACQUISITION STRATEGY NA

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2)							February 2007	
DEFENSE WIDE RDT&E (0400) Budget Activity 3, PE 0603941D8Z			UNMANNED AND AUTONOMOUS SYSTEMS TEST					
\$ in Millions	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Unmanned and Autonomous System Test	0.138	2.033	4.251	5.635	5.636	5.719	5.824	5.929

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION

The next generation of unmanned warfighting support systems are in development and will rapidly transition from research efforts into acquisition programs. In addition, ongoing research into autonomous and semi-autonomous systems indicates such systems will soon emerge as a new test challenge. The Unmanned and Autonomous Systems Test (UAST) Focus Area is addressing the current and emerging challenges associated with T&E of these important warfighting assets. As the complexity of Unmanned and Autonomous Systems (UAS) increases, the capability to test these systems must also be developed. UAS T&E, technology advancements are required to enable testing the behavior of learning unmanned and autonomous systems. Ranges and installed system test facilities must be able to characterize UAS responses to mission priorities in densely-packed battlespaces, and predict from the data how these systems will respond in the future. The DoD must have the capability to test these systems' ability to interact safely and effectively with large groups of humans and determine how UAS respond to unscripted scenarios. This requires the development of technology to accurately collect and compare autonomous systems' situational awareness to the ground truth situation; test unmanned systems in a net-centric environment; maintain non-line-of-sight tracking; and execute controlled, repetitive and realistic stimulation of systems under test.

B. (U) ACCOMPLISHMENTS/PLANNED PROGRAM

	FY 2006	FY 2007	FY 2008	FY 2009
Unmanned And Autonomous Systems Test	0.138	2.033	4.251	5.635

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FY 2006 Accomplishments:

Initiated start up of UAST. This focus area was initially entitled Software Test (SWT). During a detailed review of the primary drivers for the T&E/S&T Program, the program office determined that the goals of the SWT focus area were better addressed in UAST. This aligns the focus area topics with operationally relevant challenges and avoids development of test technologies that are not focused on emerging weapons T&E challenges. In order to validate this change in emphasis, the T&E/S&T Program conducted a Test Technology Investment Workshop, which brought together leadership from both the T&E and S&T communities. The workshop participants wholly endorsed the change from SWT to UAST. Following this workshop, the program office completed initial planning for this new focus area:

- Generated draft roadmap identifying efforts in the 2006-2013 time frame
- Identified potential working group members with expertise in unmanned and autonomous systems
- Identified candidates for executing agent

FY 2007 Plans:

Initiate a BAA to select efforts for FY 2007 award. Initiate research efforts to address T&E technology challenges in this focus area for:

- Technologies to accurately collect and compare autonomous system's situational awareness to the ground truth.
- Modeling and simulation tools to provide controlled, repetitive, and realistic stimulation of systems under test
- Technologies to conduct T&E of unmanned systems in a net-centric environment where UAS-UAS and UAS-human interactions will occur.
- Off-board, remote instrumentation for miniature UAS T&E where SUT space and weight considerations preclude on-board instrumentation.

Initiate a BAA in FY 2007 to select efforts for FY 2008 award.

FY 2008 Plans:

Continue efforts initiated in prior fiscal years.

Initiate new research efforts to address T&E technology challenges in the focus area for:

- Development of a common architecture allowing integration of diverse systems from across the services and enabling distributed live, virtual, and constructive testing of unmanned and autonomous systems.
- Command and control techniques to safely control multiple lethal unmanned systems in densely packed battlespaces (air, land, & sea and combinations of all three).
- Techniques to test and control UAS in an unscripted scenario.
- Technologies to conduct Non-line-of-sight (NLOS) tracking of UAS during T&E events.

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- Creation, manipulation, and reproduction of the full battlespace environment for test of unmanned and autonomous systems' learning algorithms.

Initiate a BAA in FY 2008 to select efforts for FY 2009 award.

FY 2009 Plans:

Continue efforts initiated in prior fiscal years.

Initiate new research efforts to address T&E technology challenges in the focus area for:

- Modeling of semi-autonomous/autonomous systems to facilitate prediction of UAS performance in scenarios to supplement development and operational T&E events.
- Techniques to conduct T&E in deep sea operations (data rates, telemetry, way points, off-board sensors) for unmanned undersea vehicles.
- Methods for testing autonomous space systems (accessibility, latency, safety/health hazards, etc.) in an operationally relevant environment.
- Tools to evaluate the cognitive behavior and predict future performance of learning algorithms in semi-autonomous and autonomous systems.

Initiate a BAA in FY 2009 to select efforts for the FY 2010 award.

C. (U) **OTHER PROGRAM FUNDING SUMMARY** NA

D. (U) **ACQUISITION STRATEGY** NA