FY 2007 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2006
Exhibit R-2

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602271N
PROGRAM ELEMENT TITLE: RF SYSTEMS APPLIED RESEARCH

COST: (Dollars in Thousands)

Project Number & Title	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
RF SYSTEMS APPLIED RESEARCH	60,316	64,642	42,619	33,378	44,907	45,199	45,583

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: The Radio Frequency (RF) Systems Applied Research Program addresses technology deficiencies associated with Naval platform needs for new capabilities in RF Surveillance, RF Electronic Warfare, Navigation, RF Solid State Power Amplifiers, RF Vacuum Electronics Power Amplifiers, and Supporting RF Electronics Technologies. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection (including Electric Warship), Time Critical Strike, and Information Distribution. RF Systems Applied Research Developments directly support the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities within this Program Element (PE) have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide. This PE supports the Future Naval Capabilities (FNC) Programs in Communications Technology, Supporting Technologies, and RF Electronic Warfare (EW) Technology.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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B. PROGRAM CHANGE SUMMARY:

	FY 2005	FY 2006	FY 2007
FY 2006 President's Budget Submission	64,640	47,302	53,521
Congressional Action	0	18,050	0
Congressional Undistributed Reductions/Rescissions	-50	-710	0
Execution Adjustments	-3,494	0	0
FY 2005 SBIR	-905	0	0
GWOT Counter IED Efforts	125	0	0
Program Realignment	0	0	-10,803
Rate Adjustments	0	0	-99
FY 2007 President's Budget Submission	60,316	64,642	42,619

PROGRAM CHANGE SUMMARY EXPLANATION:
Technical: Not applicable.

Schedule: Not applicable.

C. OTHER PROGRAM FUNDING SUMMARY:
Not applicable.

D. ACQUISITION STRATEGY:
Not applicable.

E. PERFORMANCE METRICS:
Performance Metrics are discussed within the R-2a.

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COST: (Dollars in Thousands)

Project Number & Title	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
RF SYSTEMS APPLIED RESEARCH	44,697	46,592	42,619	33,378	44,907	45,199	45,583

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This project addresses technology deficiencies associated with Naval platform needs for new capabilities in Radar Frequency (RF) Surveillance, RF Electronic Warfare, Communications, Navigation, RF Solid State Power Amplifiers, Vacuum Electronics Power Amplifiers, and Supporting RF Electronics Technologies. The project supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection (including Electric Warship), Time Critical Strike, and Information Distribution. RF Systems Applied Research Developments directly support the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Projects within this Program Element (PE) have attributes that focus on enhancing the affordability of warfighting systems. The project also provides for technology efforts to maintain proactive connectivity and collaboration between Department of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide.

B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 2005	FY 2006	FY 2007
ELECTRONICS AND COMMUNICATIONS TECHNOLOGIES	17,335	15,968	10,015

Sea Shield (formerly Electronics and Communications Technologies) provides technologies developed under the Future Naval Capabilities (FNC) Program; specifically the Multi-Source ISR to the Warfighter and the Advanced Electronic Sensor Systems. Emphasis is placed on the development of Electronic Warfare, Multi-Function and advanced multifunction RF and microwave electronic components. Included are; the development of capabilities to increase the effectiveness in countering a broad range of threats from anti-ship missiles, and increasing the overall real time situational awareness of operational forces through the detection and processing of RF signals designed with low probability of detection characteristics. The electronics components are developed, optimized and demonstrated in component chains that must meet size, weight and power requirements and will

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form the basis of new multifunction modules to help support these functions.

The funding profile from FY06 to FY07 reflects the reorganization of Future Naval Capabilities (FNC) Program investments into Enabling Capabilities (ECs). As a result of this reorganization, the funding for each EC has been aligned to a Budget Activity 2 and Budget Activity 3 PE as appropriate. This Activity reflects the alignment of investments for the following ECs: Multi-Source ISR to the Warfighter and Advanced Electronic Sensor Systems for Missile Defense.

Funding decreases FY 2005 to FY 2007 due to completion of initiatives and technology maturing and moving into Budget Activity 3.

FY 2005 Accomplishments:

• Continued the Electronic Support(ES) Detection of Low Probability of Intercept (LPI) Periscope Detection Radar effort and performed at-sea testing of the ultra-wideband chirp subsystem with an instantaneous bandwidth of 2.0 GHz.
• Continued the Electronic Attack (EA) Techniques to Counter Advanced Threats effort by completing 90% of the EA technique modules for the advanced techniques generator.
• Continued the effort to improve Direct Digital Synthesizers (DDS) and power digital to analog converter (Power-DAC) device performance and yield with a target of up to 20 GHz.
• Completed Next Generation Buoyant Cable (NGBCA) and transitioned to development of Next Generation Communications at Speed and Depth (NGCSD) funded under PE 0603271N.
• Completed Advanced Multi-function Radio Frequency Concept (AMRFC) Test Bed successfully.
• Completed fabrication and testing of linearizers optimized with Gallium Nitride (GaN) high power amplifiers having a minimum of 4 GHz of bandwidth.
• Completed initial Silicon Carbide (SiC) RF life tests, demonstrated >106 hour lifetimes, and transferred results into the manufacturing technology. Industry has internally funded further testing.
• Completed development of True Time Delay (TTD) digital signal processing techniques that support affordable multi-GHz bandwidth RF microwave transmitter (TX) beamsteering. Simulations demonstrate feasibility for integration into DDS and Power-DAC components, and are planned for insertion into TX arrays to be initiated in FY07 Multi-Function Electronics Warfare (MFEW) and other multi-function systems.
• Initiated AMRFC Version 2 (V2) renamed MFEW program and aligned with DD(X), compliant to new DODI 5000.2 acquisition rules as the Technology Development Phase, to build an Electronic Warfare (EW) Advanced Development Model (ADM) for the DD(X) program using the technology from the AMRFC testbed as the basis.

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• Selected the system design and architecture for the ADM and awarded contracts to produce the major hardware pieces. This system will maintain the scalability and multi-functionality from the AMRFC V1 program's architecture. This will enable adding the communications and radar functions when the next generation of transmit array is developed (starts in FY07 through FY11). Program will move from RF Communications Technology to Electronics and Communications Technology in FY06.
• Initiated highly integrated and affordable receiver (RX) component optimization supporting AMRFC/multifunction electronic warfare (MFEW) with a transition target of FY08. This includes the optimization of entire component chains of Low Noise Amplifier (LNA), Analog-to-Digital Converters (ADC's), tunable filters, channelizers, and radiating elements specific to the MFEW receiver, 2-D electronically scanned arrays. Objectives are to reduce cost to 1/3 of current multi-function RF systems for a minimum of 6-18 GHz bandwidth.

FY 2006 Plans:

• Continue all efforts of FY 2005 less those noted as completed above.
• Complete the ES Detection of LPI Periscope Detection Radar effort by performing laboratory testing of the frequency modulated continuous wave (FMCW) and Advanced Phase Coded LPI radar detection subsystems with the BLQ-10(V) system.
• Initiate development of RF technologies that support advances in receiver architecture, antenna performance, subsystem miniaturization, decoys and advanced signal processing.
• Initiate establishment of an industrial standard appropriate for the demonstration of >106 hour lifetime for RF life testing of GaN based Millimeter-Wave Integrated Circuits (MMICs) and devices and being to apply this standard to state-of-the-art (SOA) MMICs and devices.
• Initiate component chain optimization for AMRFC MFEW transmitter technology with a target of meeting FY11 transition target date.

FY 2007 Plans:

• Continue all efforts of FY 2006 less those noted as completed above.
• Complete the EA Techniques to Counter Advanced Threats effort by development of 100% of the EA technique modules for counter terminal and counter targeting.
• Complete initial phase of GaN HEMT life testing with demonstration of greater than 104 hour lifetimes for 175 degree channel temperatures.
• Initiate demonstration packaging techniques to provide cost reduction and affordability for modules,

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including component architecture, packaging, and scale of integration optimization.
• Complete the Shipboard Electro-optic/Infrared (EO/IR) Closed Loop Self Protection effort by developing additional jam codes and tracking algorithms to support final at-sea testing of the Shipboard Integrated Electro-Optic Defense Systems (SHIELDS) hardware. This effort previously funded in PE 0602123N.

	FY 2005	FY 2006	FY 2007
RF ELECTRONIC WARFARE TECHNOLOGY	6,324	9,342	9,859

Supports technologies that enable the development of affordable, effective and robust Electronic Warfare (EW) systems that will increase the operational effectiveness and survivability of U.S. Naval units. Emphasis is placed on non-optical passive sensors and active and passive Radio Frequency Countermeasure (RFCM) systems that exploit and counter a broad range of electromagnetic threats. The focus is on maintaining near perfect real-time knowledge of the enemy; countering the threat of missiles to deployed Naval forces; precision identification and location of threat emitters; and, development of technologies that have broad application across multiple disciplines within the EW mission area.

FY06 increase is due to a focus on counter threat technologies.

FY 2005 Accomplishments:

Technology development in the areas of Tactical Aircraft, Surface Ships, Submarines, Unmanned Air Vehicles (UAVs), and EW Enabling Technology continues. Some specific accomplishments include:
• Continued to develop a new RF detection process at Millimeter Wave (MMW) frequencies for wideband, low cost signal detection systems for high probability of intercept wideband receivers utilizing ultra high dynamic range photonics. (NRL)
• Continued the fabricating a hardware breadboard incorporating range/phase correction algorithms for offset Synthetic Aperture Radar (SAR) countermeasures and examined a planar geometry arrangement of receive antennas to obtain phase and delta-frequency data and resolve ambiguities. (NRL)
• Continued countermeasures technology and algorithm development efforts against wireless communications and transitioned most highly effective techniques into operational Navy and Air Force electronic attack (EA) systems currently being used in the Global War On Terrorism. (NRL)
• Continued the Countermeasures (CM) for Wideband Antiship Threats effort with a 6-month vulnerability analysis of seeker discrimination and home-on-jam (HOJ) subsystems to the ECM system.
• Developed jamming technology to counter Radio-Controlled Improvised Explosive Devices (RCIED). System was

transitioned to the Joint IED Defeat Task Force. (NRL)
• Completed the development and demonstration of key technologies that will enable an air-launched unmanned platform carrying an advanced EW payload for the Suppression of Enemy Air Defense (SEAD) mission. (NRL)
• Completed the development of key capabilities of an Autonomous MMW receiver and coherent techniques to counter 18-40 GHz airborne threats. (NRL)
• Completed the Hybrid Interferometer Technology Development effort with the analysis and modeling to develop and refine the detailed Direction Finding (DF) antenna design and the fabrication and lab demonstration of the DF antenna to achieve a DF accuracy of 0.1 degree.
• Initiated the development of an integrated Digital EW, EA and ES suite using a tightly coupled common architecture so that there is a synergistic coupling between the sub-functions of ES and EA. (NRL)

FY 2006 Plans:

Technology development in the areas of Tactical Aircraft, Surface Ships, Submarines, UAVs, and EW Enabling Technology continues.
• Continue all efforts of FY 2005 less those noted as completed above.
• Complete advanced wireless communication countermeasures systems technology and algorithm developments. (NRL)
• Complete the CM for Wideband Antiship Threats effort with closed loop software testing of six electronic CM techniques.
• Complete development of RCIED countermeasures for urban environment applications. (NRL)
• Complete the development of SAR countermeasures false image focusing algorithms with a laboratory demonstration. (NRL)
• Initiate the Specific Emitter Identification (SEI) Capabilities Extension effort with development of two hardware independent algorithms to address known shortfalls in existing SEI systems.
• Initiate development of RF technologies that support advances in receiver architecture, antenna performance, subsystem miniaturization, decoys and advanced signal processing.
• Initiate the EW Tactical Decision Algorithms (TDA) for Satellite Communications effort by evaluating two atmospheric propagation models to assist in visualizing the impact of satellite communications on future planning and tactics.
• Initiate the Autonomous Classification of Low Probability of Intercept (LPI) Radar Emitters effort to develop an advanced signal processing architecture using algorithms evaluated using a computer equipped with two 1000 MHz Intel Xenon processors.
• Initiate the Unmanned Vehicle Integrated Electronic Warfare Payload (UVIEWP) effort for employment of

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modeling and simulation tools to optimize technique selection to maximum electronic attack effectiveness in counter targeting and counter surveillance operations.
• Initiate the Advanced Pulse De-interleaving effort to investigate methods of improving pulse de-interleaving that will support detection and identification of complex emitters and allow sorting of multiple tracks and support raid analysis.
• Initiate the investigation of MMW technologies to support the development of off board and onboard countermeasures.
• Initiate the development and demonstration of a compact EA technology for tactical unmanned vehicle systems to counter wideband, spread spectrum active electronically steered array radars. (NRL)

FY 2007 Plans:

Technology development in the areas of Tactical Aircraft, Surface Ships, submarines, UAVs, and EW Enabling Technology continues.
• Continue all efforts of FY 2006 less those noted as completed above.
• Complete the Autonomous Classification of LPI Radar Emitters effort by testing and evaluating feature extraction algorithms on actual digitized LPI radar signals.
• Complete the Advanced Pulse De-interleaving effort by lab and field testing of the de-interleaving algorithms with an Electronic Support Enhancement (ESE) processor used for the Surface Electronic Warfare Improvement Program (SEWIP).
• Complete the UVIEWP effort by conducting a multiplatform demonstration of an autonomous UVIEWP escort constellation that provides countertargeting and countersurveillance for expeditionary force ships.
• Complete the development of a RF detection process at MMW using photonics. (NRL)
• Complete the SEI Capabilities Extension effort with implementation of advanced SEI algorithms into Windows based SEI software and SEI hardware using a flexible architecture employing IFD-120 Field Programmable Gate Arrays (FPGA) with 3 million gates.
• Initiate the Ka/W Band Miniature Sensor Development effort with Ka/W Band architecture device selection and downconverter subsystem conceptual design.
• Initiate the Countermeasures to Anti-Helicopter Mines effort by reviewing current and previous Army efforts and developing initial countermeasure concepts.
• Initiate the Compact Electro-Magnetic (EM) Source for Improvised Explosive Device (IED) and Engine Defeat effort by measuring the RF impedances of the materials and comparing the results with conventional theory.

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	FY 2005	FY 2006	FY 2007
RF SURVEILLANCE TECHNOLOGY	5,996	9,372	10,272

Emphasizes non-optical advanced sensor and sensor processing systems for continuous high volume theater-wide air and surface surveillance, battle group surveillance, real time reconnaissance and ship defense. Major technology goals include long-range target detection and discrimination, Target Identification (ID) and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments.

Increase from FY 05 to FY 06 is due to new surveillance technology efforts.

FY 2005 Accomplishments:

• Continued the Horizon Extension Sensor System (HESS) project with form factored integration of High Power Amplifier (HPA) and development of a Silicon Germanium (SiGe) downconverter in support of HESS and Digital Array Radar (DAR) efforts.
• Continued development efforts to demonstrate signal processing, waveform generation and one dimensional active phased array apertures for Harbor Surveillance and situational awareness.
• Continued broadband-array effort by designing the radiating element and the feed for the single-element approach and fabrication of a 3-element array. (NRL)
• Continued the design and fabrication of Electromagnetic Bandgap (EBG) structures, validate computational-code designs through measurements, and test for isolation of RF waves. (NRL)
• Completed development of prototype level hardware for the Digital Array Radar (DAR) and characterize its performance at the element, sub-array and system levels. Effort will transition to the Knowledge, Superiority and Assurance (KSA) FNC.
• Completed Radar Electronic Counter Countermeasures (ECCM) algorithms and performed and evaluated associated wideband experiments. (NRL)
• Initiated demonstrations of advanced Non-Cooperative Target Recognition (NCTR) algorithms in congested harbor environments.
• Initiated the design and development of a field probe and radome assembly for a real-time calibration technique that will utilize an optical-to-RF distribution network to inject a low-level RF Continuous Wave (CW) signal into each element of a phased array. Demonstrated the polarization properties of a wideband probe using a zero-bias optical detector. (NRL)

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FY 2006 Plans:

• Continue all efforts of FY 2005 less those noted as completed above.
• Initiate an element level DAR effort on down conversion and digital beam formers.
• Initiate a program to develop and demonstrate methodologies that provide small threat radar detection in the presence of large masking radar returns using an Adaptive Pulse Compression technique. (NRL)

FY 2007 Plans:

• Continue all efforts of FY 2006 less those noted as completed above.
• Complete demonstrations of advanced NCTR algorithms in congested harbor environments by real time implementation of automated parameter extraction algorithms for small surface crafts.
• Complete the development and testing of reconfigurable/tunable EBG structures. (NRL)
• Complete the broadband-array effort by demonstrating a dual polarized array with coincident phase center and true time delay beam steering. (NRL)
• Initiate a harbor surveillance tracking demonstration with integrated automated parameter extraction for small surface craft identification.

	FY 2005	FY 2006	FY 2007
SUPPORTING TECHNOLOGIES	4,687	1,919	1,517

Provides for the radiation, reception, signal control and processing of Very High Frequency (VHF), Ultra High Frequency (UHF), Micro Wave (MW), and MilliMeter Wave (MMW) power for Navy all-weather radar, surveillance, reconnaissance, Electronic Attack (EA), communications, smart weapons, networked sensors, and precision time and navigation systems. The technology developed which includes nanotechnology cannot, for the most part, be obtained through commercial off the shelf (COTS) as a result of the requirements placed on power, frequency, linearity, bandwidth, weight, and size. This activity includes SwampWorks efforts in FY 2005 which developed and demonstrated technologies that addressed emergent and enduring operational problems in an accelerated timeframe. Swampworks initiatives transferred to PE 0603758N in FY06 and out.

FY 2005 Accomplishments:

• Continued effort on superconducting ADC/Programmable digital channelizer combination that derives a Local Oscillator (LO) from an externally supplied signal and, when signals in 2-175 MHz range are supplied to the

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ADC, outputs software defined bandwidth signal centered on the LO frequency.
• Continued to demonstrate flip-chip bonding of semiconducting and superconducting devices to form a functional hybrid circuit.
• Continued research to enable growth, fabrication, and testing of 6.2-6.3 Angstrom High Electron Mobility Transistors (HEMTS) with alloy channels and barriers. (NRL)
• Continued developing prototype identification algorithms for the lock-logic and Electronic Counter Countermeasures (ECCM) components of the automated RF ASCM threat model. (NRL)
• Continued measuring Monopulse tracking accuracy at low elevation angles using towed targets and low flying aircraft and tracking error mitigation techniques suitable for millimeter wave frequencies. (NRL)
• Continued development to extend the tuning range of band reject filters. (NRL)
• Conducted efforts within Project Shield (Classified program).
• Developed and completed demonstration technologies that addressed emergent and enduring operational problems in an accelerated timeframe.
• Initiated effort on current recycling in superconducting digital circuits.

FY 2006 Plans:

• Continue all efforts of FY 2005 less those noted as completed above.
• Complete effort on a superconducting ADC/Programmable digital channelizer combination that derives 20MHz-20GHz Local Oscillator (LO) for digital down mixing from master clock and outputs software defined bandwidth signal centered on any center frequency in range supplied to ADC.
• Complete the development of prototype identification algorithms for the lock-logic and ECCM components of the automated radio frequency (RF) ASCM threat model and document results. (NRL)
• Complete the 94GHz measurement effort and determine the effect of frequency agility on the diffuse multi-path component and implement a two-antenna configuration to measure atmospheric turbulence. (NRL)
• Complete development of 6.2-6.3 Angstrom Heterojunction Bipolar Transistor (HBT) operating at microwave frequencies. (NRL)
• Initiate the development of analysis/modeling infrastructure and prototype improvement concepts for electronic countermeasures and counter-targeting against RF surveillance threats. (NRL)

FY 2007 Plans:

• Continue all efforts of FY 2006 less those noted as completed above.
• Complete the demonstration of a current recycling technology for superconducting digital circuits that is

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mature enough to yield a four fold reduction of bias current.
• Complete the proof of feasibility of hybrid Nb Josephson Junction/InP HBTs ADC modulator circuits operating properly at 4K and with 10 GHz clock when the hot InP transistors are <3mm away from the active Josephson junctions.
• Complete the effort to extend the tuning range of band reject filters. (NRL)
• Initiate a demonstration of > 6dB improvement in state of the art, S or X band, band pass, ADC dynamic range.
• Initiate the development of a semiconductor-based frequency selective limiter. (NRL)

	FY 2005	FY 2006	FY 2007
RF SOLID STATE POWER AMPLIFIERS	4,491	4,169	4,501

Provides for the generation of VHF, UHF, MW, and MMW power amplifiers for Navy all-weather radar, surveillance, reconnaissance, electronic attack, communications, and smart weapons systems. The technology developed cannot, for the most part, be obtained through Commercial-Off-the-Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, linearity, bandwidth, weight, and size.

FY06-FY07 increase is due to the focus on new efforts dealing with the component level power capabilities and duration.

FY 2005 Accomplishments:

• Continued development of MMW Aluminum Gallium Nitride/Gallium Nitride (AlGaN/GaN) wide bandgap High Electron Mobility Transistor (HEMT).
• Continued development of AlGaN HEMT broadband amplifiers for electronic warfare decoys with output powers up to 10 times that achieved with conventional solid state amplifiers.
• Completed development of an Indium Gallium Nitride (InGaN) HEMT with a unity gain cutoff frequency * gate length (ft*lg) product of 20 GHz-microns. (NRL)
• Initiated effort on radiation effects and hardness studies of wide bandgap semiconductors. (NRL)

FY 2006 Plans:

• Continue all efforts of FY 2005 less those noted as completed above.

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FY 2007 Plans:

- Continue all efforts of FY 2006.
- Complete MMW AlGaN/GaN HEMTs effort and transition to communications and missile seeker platforms.
- Complete broadband AlGaN/GaN amplifier effort and transition to communications and missile seeker platforms.
- Initiate work on GaN MMW components at >44 GHz to allow for Extremely High Frequency (EHF) SATCOM insertion.
- Initiate the expansion of scope of the GaN MMW device program.
- Initiate component development in support of multifunctional electronic warfare.

	FY 2005	FY 2006	FY 2007
RF VACUUM ELECTRONICS POWER AMPLIFIERS	3,251	3,385	3,444

Provides for the development of MW, MMW, submillimeter wave power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through commercial off the shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications and high-power high-frequency radar applications. Technologies include techniques for power and efficiency enhancement of millimeter-wave amplifiers, multiple-beam amplifiers, notably the Multi-Beam Klystron (MBK), and physics-based modeling and simulation.

FY 2005 Accomplishments:

- Continued effort to identify and test algorithms to implement in the Telegrapher's Equation Solution for Linear Amplifiers (TESLA) design code for broadband single-beam klystron development.
- Continued effort to develop a four-cavity narrow-band (~2%) S-band MBK at 600 kW peak power and 40% efficiency.
- Continued effort on Michelle v3.0 with addition of Graphical User Interface (GUI) and postprocessor to implement Michelle v4.0 and initiated effort to release the code.
- Initiated effort to develop Ku-band, C-band and Ka-band low distortion Traveling Wave Tubes (TWT’s) for High Data Rate (HDR) communications that will utilize 16 and 32 symbol Quadrature Amplitude Modulation (QAM) waveforms.

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• Initiated research on bandwidth enhancement (~ 6%) techniques for 500 kW S-band MBK. (NRL)

FY 2006 Plans:

• Continue all efforts of FY 2005 less those noted as completed above.
• Complete effort on low distortion TWT for HDR communications. (NRL)
• Initiate research on 3D modeling of beam transport with quadrapole magnetic focusing for high power Ka band TWT. (NRL)
• Initiate effort on the large signal code CHRISTINE to model beam wave interaction with quadrapole focusing effects for beam transport.
• Initiate effort on the gun/collector code MICHELLE with improved interface with the large signal codes CHRISTINE and TESLA.

FY 2007 Plans:

• Continue all efforts of FY 2006.
• Complete the effort on the broadband (~ 6%) S-band MBK performance. (NRL)
• Complete the effort on the release of the gun/collector code MICHELLE v4.0 with improved GUI and postprocessor.
• Initiate effort on experimental demonstration of beam propagation with quadrapole magnetic focusing that will result in a factor of 2 reduction in peak magnetic field compared to Permanent Periodic Magnet (PPM) focusing. (NRL)
• Initiate effort on generation and transport of sheet beam with 5:1 aspect ratio. (NRL)

	FY 2005	FY 2006	FY 2007
RF NAVIGATION TECHNOLOGY	2,613	2,437	3,011

Develops key navigation technologies for Naval Battle Groups, Aircraft, Unmanned Air Vehicles (UAVs), Unmanned Underwater Vehicles (UUVs), Ships, Submarines and other Navy vehicles and platforms. This activity applies leading-edge Science and Technology (S&T) to enhance Global Positioning System (GPS) capabilities in order to make GPS more resistant to noise and jamming. Much of the near-term effort concerns the development of antennas with special features.

FY 2005 Accomplishments:

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• Continued Digital Antenna Electronics (DAE)-based anti-jam systems with small patch antenna elements using low-loss ceramic materials for an array of 7 elements (less than quarter (1/4)-wavelength elements with spirals).
• Continued to integrate Space-Time Adaptive Processing (STAP) for GPS Antennas. Specific jammer types were addressed in this effort (the signal strength 12 dB below thermal noise could be detected).
• Continued to design the STAP for GPS Antennas in one of the receiver-antenna systems developed in this activity and to strike weapon systems such as Paveway and Tactical Tomahawk (additional 43 dB improvement in AJ capability).
• Continued field testing of the Submarine mast-mounted Controlled Radiation Pattern Antenna (CRPA) to determine if the laboratory performance can be achieved in a more realistic environment; conducted nulling optimization in submarine mast environment for the best broadband nulling performance (achieved 8 elements in 4.25-inch submarine mast).
• Initiated development of GPS Anti-Jam (AJ) processor (Space-Frequency Adaptive Processing (SFAP)) with Poly-Channelized, Code Gated Maximum Likelihood (PC-CGML) technique to cancel the effect of a large number of jammers (up to 8 jammers with 4 array elements).
• Initiated development of GPS AJ Antenna Electronics (AE) with low-cost analog processor technique for Direction of Arrival (DOA) estimation and nulling (up to 60dB nulling capability).
• Initiated development of GPS AJ processor to reliably lock to the GPS carrier signal and in this way make it possible to extract very high precision positional information from the GPS receiver. Carrier slips are a measure of degraded GPS positional performance (vertical and lateral navigation system errors of 40 and 30 cm respectively).

FY 2006 Plans:

• Continue all efforts of FY 2005.
• Complete DAE based anti-jam systems with small patch antenna using low-loss ceramic materials for an array of 7 elements.
• Complete the development of GPS AJ processor to reliably lock to the GPS carrier signal and in this way make it possible to extract very high precision positional information from the GPS receiver. Carrier slips are a measure of degraded GPS positional performance.
• Complete the integration of STAP for GPS Antennas. Specific jammer types will be also addressed in this effort (the signal strength 12 dB below thermal noise could be detected).
• Complete field testing of the Submarine mast-mounted Controlled Radiation Pattern Antenna to determine if

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the laboratory performance can be achieved in a more realistic environment; complete nulling optimization in submarine mast environment for the best broadband nulling performance (achieved 8 elements in 4.25-inch submarine mast).

FY 2007 Plans:

- Continue all efforts of FY 2006 less those noted as completed above.
- Complete the design and development of Space-Frequency Adaptive Processing (SFAP) for GPS AJ antenna to improve receiver AJ performance by adding channelization to the existing Code Gated Maximum Likelihood (CGML) receiver; Completed the evaluation of the effectiveness of the Poly-Channel (PC) CGML technique by simulation and build it in software radios (up to 8 jammers with 4 array elements).
- Initiate the Improved GPS/INS Integration using a Particle Filter Accelerator project.
- Initiate the Deeply Integrated Navigation Grade GPS Inertial System project.
- Initiate the Advanced Spoofer Mitigation and Geolocation through Spoofer Tracking project.

CONGRESSIONAL PLUS-UPS:

	FY 2005	FY 2006
ADVANCED MICROWAVE FERRITE RESEARCH FOR RF SYSTEMS	1,156	1,500

FY 2005 - In FY05 very thick (1 mm) hexagonal ferrite films of outstanding quality were grown by Liquid phase epitaxy. Microwave loss and insertion characterization were performed. Microwave radar circuit tuning continued, and a novel planar MMW antenna was designed and demonstrated.

FY 2006 - This effort supports advanced microwave ferrite research for RF systems.

	FY 2005	FY 2006
BROADBAND ELECTRONICS FOR RF SYSTEMS	0	1,250

This effort supports broadband electronics for RF systems research.

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602271N PROGRAM ELEMENT TITLE: RF SYSTEMS APPLIED RESEARCH
PROJECT TITLE: RF SYSTEMS APPLIED RESEARCH

	FY 2005	FY 2006
CENTER FOR MICROWAVE FERRITES AND MULTIFUNCTIONAL INTEGRATED CIRCUITS	0	1,000

This effort supports center for microwave ferrites and multifunctional integrated circuits research.

	FY 2005	FY 2006
CORE REPARATIVE MEDICINE FOR TRAUMATIC INJURIES	0	1,000

This effort supports core reparative medicine for traumatic injuries research.

	FY 2005	FY 2006
GALLIUM NITRATE RF POWER TECHNOLOGY	1,928	1,000

FY 2005 - In FY05 plans were developed to improve the performance and reliability of GaN High Electron Mobility Transistors (GaN HEMTs) for RF power applications by exploiting innovative new methods for the production of GaN HEMT epitaxial material on SiC and by developing novel GaN HEMT device designs and fabrication techniques. Plans to conduct accelerated lifetime test measurements to document improvements were also developed.

FY 2006 - This effort supports gallium nitrate RF power technology research.

	FY 2005	FY 2006
HIGH BRIGHTNESS ELECTRONICS	1,446	0

In FY05 device fabrication and material synthesis of carbon nanostructure for application to 50W, 10 GHz vacuum electronic power amplifier were optimized with respect to; dielectric thickness of the buried line devices, back-gate geometry to maximize field at the emission sites, nanosheet crystallinity and hydrogen content, field uniformity at the cathode surface, and efficiency of electron emission to vacuum.

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602271N PROGRAM ELEMENT TITLE: RF SYSTEMS APPLIED RESEARCH
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	FY 2005	FY 2006
LITHIUM-BASED BATTERY DEVELOPMENT FOR ASSET TRACKING	0	1,000

This effort supports lithium-based battery development for asset tracking research.

	FY 2005	FY 2006
MARITIME SYNTHETIC RANGE	4,148	6,700

FY 2005 - In FY05 this effort developed and enhanced the Maritime Synthetic Range with; increased real-time participation in operational training, creation of synthetic forces, scenario generation, and creation of Common Synthetic Battlespace (CSB) and advanced threat environments.

FY 2006 - This effort supports maritime synthetic range research.

	FY 2005	FY 2006
NOVEL SILICON CARBIDE TECHNOLOGY DEVELOPMENT	963	1,000

FY 2005 - In FY05 an existing SiC epitaxial growth system was modified to accept hydrogen chloride (HCl) gas. Growth with added HCl has markedly increased the growth rates (3 -> 20 microns per hour), improved morphology, and purity (|Ne-Np| less than 1e14cm-3.)

FY 2006 - This effort supports novel silicon carbide technology development research.

	FY 2005	FY 2006
PACIFIC THEATER DATA FUSION TESTBED	2,412	0

In FY05 the project developed a Pacific-theater data fusion testbed initiative and tracking capabilities. The program developed a framework theater-wide sensor fusion center, developed multiple discrimination and tracking algorithms, and provided performance verification from development through testing. An open systems architecture was utilized to support design integration and testing of next generation active and passive sensors, sensor data fusion, and discrimination tracking technology.

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602271N PROGRAM ELEMENT TITLE: RF SYSTEMS APPLIED RESEARCH
PROJECT TITLE: RF SYSTEMS APPLIED RESEARCH

	FY 2005	FY 2006
RADAR/VIDEO FUSION VESSEL AND PORT SECURITY DEMONSTRATION	963	0

In FY05 completed installation of automated identification system, specific emitter identification, and radar at first site and began data collection.

	FY 2005	FY 2006
REPARATIVE HEALTH INITIATIVE	0	1,000

This effort supports reparative health initiative research.

	FY 2005	FY 2006
RF VACUUM ELECTRONICS POWER AMPLIFIERS	963	0

In FY05 the development of design tools for the gun, collector and large signal analysis of vacuum electronics amplifiers with sheet electron beams were initiated and the design of a sheet beam gun using 3D gun code MICHELLE was demonstrated.

	FY 2005	FY 2006
WIDE BANDGAP MATERIALS FOR POWER ELECTRONICS	1,640	2,600

FY 2005 - In FY05 plans to; reduce thermal strain-induced structural defects (which adversely affect device performance), reduce unintentional impurities, and allow more reproducible and affordable product were developed. This would have the effect of further improving the performance and capability of DOD's high power electronics by reducing the defect densities in power semiconductor substrates and thin device films. The contractor met with scientists from the Naval Research Laboratory and an approach to testing which will validate progress was defined.

FY 2006 - This effort supports wide bandgap materials for power electronics research.

BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602271N PROGRAM ELEMENT TITLE: RF SYSTEMS APPLIED RESEARCH
PROJECT TITLE: RF SYSTEMS APPLIED RESEARCH

C. OTHER PROGRAM FUNDING SUMMARY:

NAVY RELATED RDT&E:
PE 0601153N (Defense Research Sciences)
PE 0602114N (Power Projection Applied Research)
PE 0602123N (Force Protection Applied Research)
PE 0603114N (Power Projection Advanced Technology)
PE 0603123N (Force Protection Advanced Technology)
PE 0603271N (RF Systems Advanced Technology)

NON NAVY RELATED RDT&E:
PE 0601102A (Defense Research Sciences)
PE 0601102F (Defense Research Sciences)
PE 0602204F (Aerospace Sensors)
PE 0602702F (Command, Control, and Communications)

D. ACQUISITION STRATEGY:
Not applicable.