FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

BUDGET ACTIVITY: 2

PROGRAM ELEMENT: 0602271N
PROGRAM ELEMENT TITLE: RF Systems Applied Research

(U) COST: (Dollars in Thousands)

PROJECT NUMBER & TITLE	FY 2001 ACTUAL	FY 2002 ESTIMATE	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	FY 2006 ESTIMATE	FY 2007 ESTIMATE	TO COMPLETE	TOTAL PROGRAM
RF Systems Applied Research	**	68,300	56,263	57,974	57,702	60,333	60,233	CONT.	CONT.

**The Science and Technology (S&T) Program Elements (PEs) were restructured in FY 2002. FY 2001 efforts were funded in PEs 0602232N, 0602233N, 0602234N, and 0602270N.

A (U)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, communications, navigation, RF solid state power amplifiers, 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. Projects within this PE have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts of the Naval Fleet/Force Technology Innovation Office (NFFTIO) to maintain proactive connectivity and collaboration between Department of the Navy (DoN) S&T and Joint, Navy, and Marine Corps commands worldwide.

(U) Due to the number of efforts in the PE, the programs described are representative of the work included in the PE.

(U) JUSTIFICATION FOR BUDGET ACTIVITY: This program is budgeted within the APPLIED RESEARCH Budget Activity because it investigates technological advances with possible applications toward solution of specific Naval problems short of a major development effort.

B. (U) PROGRAM ACCOMPLISHMENTS AND PLANS:

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1. (U) FY 2001 ACCOMPLISHMENTS:

- (U)($17,610) RF Surveillance Technology. 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, discrimination, target identification (ID) and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments. Shipboard S-Band Digital Array Radar (DAR) technology investigations were conducted and included wideband (1.0 GHz–1.8 GHz) digital Transmit/Receive modules, array architectures and beam forming techniques. DAR is identified as a needed new long range sensor for theater air and missile defense operations by Program Exective Office (PEO) Theater Surface Combatants (TSC), PMS-426. Design efforts were conducted for the Electronically Steered Array (ESA) antenna for the AN/APY-6 Multi-Mode Air-Ground prototype radar. The ESA antenna is needed to extend the test bed radar system field of view and provide beam-on-demand and real time track-while-scan capabilities for time critical strike operations. The baseline AN/APY-6 Wideband Multi-Mode Air-to-Ground prototype radar installed in the Naval Air (Hairy Buffalo) P-3C test bed aircraft successfully demonstrated new capabilities for radar imaging of slow moving ground targets in both Fleet Battle Exercises and in North Atlantic Treaty Organization (NATO) Project Caesar. The AN/APY-6 is the first radar system configured for carrier based tactical aircraft to simultaneously perform multi-mode synthetic aperture and ground moving target operations from a single radar system. Laboratory performance assessment and operational utility evaluations of an 89 GHZ Passive Millimeter-Wave Imaging (PMMWI) Sensor for passive, all weather short range reconnaissance and surveillance operations were performed. The PMMWI sensor demonstrated significant capability gains over similar infrared sensing when operating in fog and clouds. PMMWI technology is being considered for transition to the Assistant Chief of Naval Operations for Naval Expeditionary Warfare. A fifty-four channel Silicon Carbide (SiC) transmitter and corresponding fifty-four channel digital receiver that operate over the E-2C radar Ultra High Frequency (UHF) operating band were developed. This effort provides the RF front-end efficient power generation needs of the UHF Electronically Scanned Array (UESA) to be used for an advanced Airborne Early Warning (AEW) radar applications on the E-2C AEW radar. The multi-channel SiC transmitter and digital receiver technologies are considered key enablers for the E-2C Radar Modernization Program (RMP). AEW Space Time Adaptive Processing (STAP) technologies to enable high performance radar operations in clutter and countermeasures typical of littoral operations were developed. This work permits correlation of measured circular array data and theoretical predictions to be made. STAP has the potential to significantly mitigate dynamic range limitations experienced by most fleet radar systems when operating in littoral/near land and electronic countermeasure environments. Development and performance assessment of littoral Small Craft Automatic Target

Recognition algorithms were conducted which are now being considered for transition to Naval Air Systems Command (NAVAIR), PMA-290 AN/APS-137 radar system improvement program. A system concept development and trade studies were conducted for an Affordable Ground Based Radar (AGBR) for US Marine Corps applications. (Future AGBR system development will be pursued under PE 0603271N in FY 2002 and beyond.) (FY 2001 accomplishments in this thrust were funded in PE 0602232N.)

- (U)($5,258) RF Electronic Warfare Technology. Emphasizes non-optical passive sensors and active and passive RF countermeasure systems including High Power Microwave (HPM) which exploit and counter a broad range of electromagnetic threats. Program focus is on maintaining near perfect real-time knowledge of the enemy; countering the threat of cruise missiles to deployed Naval forces; precision ID and location of threat emitters, and networking of electronic warfare sensors and systems. In FY 2001 new routines were developed in the Next Generation Specific Emitter Identification (SEI) and Signal Processing project with the evaluation and selection of a statistical clustering algorithm for pulse matching. SEI provides the capability to detect, locate, identify and track tactical emitters of interest to on-scene and theater commanders. Several different breadboard models were fabricated for the most promising designs under the Surgical Global Positioning System (GPS) Denial project that attempts to provide the U.S. military use of RF navigation information but denies hostile forces the use of the same information. The ANGUILA project develops technology to provide warfighters with near real time targeting of threat radars. All hardware and software was developed prior to FY 2002 live-fire testing. Work in the Digital Deception Technologies area that will provide the capability to generate realistic false target signatures against synthetic aperture, inverse synthetic aperture (ISAR) and high range resolution (HRR) radars was developed with the evaluation of various tradeoffs in tap circuit design. Assembly and testing of the Command and Control Warfare (C2W) net emulator was developed under the Electronic Attack (EA) for Coherent Complex Modern Emitters project that provides electromagnetic battlefield dominance through target denial, obscuration and signature alteration. The single card digitizer was laboratory and field tested as part of the RF electronic warfare (EW) Sensor Miniaturization project to provide small surface and land-based units with RF EW surveillance systems. The fuzzy resource manager was developed under the Network Centric Battleforce EW project that will develop an EW architecture that produces a self-adaptive force behavior. New algorithms for interference suppression were developed and demonstrated. Hardware for maximizing existing wavelets processing capability under the Wavelets technology area that is attempting to demonstrate emitter classification without jammer blanking was also demonstrated. The miniature SEI module was developed and tested for the SEI Miniaturization project which provides the capability to identify and track specific emitters based upon unique signal characteristics. (FY 2001 accomplishments in this thrust were funded in PE 0602270N.)

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- (U)($8,959) RF Communications Technology. Addresses critical Navy communications technology deficiencies and needs that are not addressed by the commercial technology sector. The program emphasis is on reliable interoperable communications between U.S and coalition forces, at all levels of command, and rapid and reliable utilization of government and commercial telecommunications assets worldwide that are efficient and responsive to warfighting needs. To extend the dynamic range of receiving systems operating aboard ship and permit multiple ultra high frequency (UHF) users to coexist onboard the same surface platform, an effort on co-site interference mitigation was emphasized. Design trade and optimization studies to maximize performance of a high performance K/Ka band phased array was continued. This effort to permit naval surface and ground platforms to effectively communicate with beyond-line-of-sight forces by using the relay capabilities of the Wideband Gapfiller Satellite, MILSTAR and Commercial Satellite constellations was continued. The Ultra Small Aperture Terminal (USAT) K/Ka Band Phased Array is a limited capability being developed jointly with Defense Advanced Research Projects Agency (DARPA) and can be used aboard surface ships and moving ground vehicles. The Code Division Multiple Access High Data Rate satellite communications (SATCOM) network, which included the development and testing of a Very Small Aperture Terminal (VSAT) for use on Navy ships and other mobile ground-based platforms, was studied and validated. This effort focused on bi-directional networked connectivity among disadvantaged users. Codes Division Multiple Access technology to provide Low Probability of detection (LPD) access to a internet protocol network was designed. LPD access technology in the Extending the Littoral Battlespace advanced concept technology demonstrations (ACTD) was demonstrated, and the Joint Wireless Working Group, with membership from the Joint Services, DARPA and National Security Agency (NSA), was formed. Studies of multi-functional antenna designs for X/Ku-band and the development of Bandwidth Efficient Advanced Modulation (BEAM) technology were conducted. A turbo coding design for additive white Gaussian noise SATCOM channels was developed which provides a three to five-fold data throughput increase and is being targeted as an improvement for the ARC-210 radio. The design of a large aperture submarine antenna for K/Ka band was conducted and a compact, submarine-survivable 20 GHz receive array was successfully designed, fabricated, and tested. To enable interoperable UHF SATCOM communications with submarines below periscope depth, a concept for UHF demand-assigned multiple access (DAMA) was designed. To develop antennas that can significantly improve gain, bandwidth, beam pattern and polarization performance over current state-of-the art UHF and above antenna designs, the design study of buoyant cable advanced antenna technologies was conducted. The study of a Vertical Takeoff Unmanned Aerial Vehicle (UAV) communications payload capability to provide extended range for surveillance information gathering was conducted. This effort focused on directional antennas between two UAVs in order to relay high data rates. The study for an On-Hull Extremely Low Frequency (ELF) communications system antenna that will support the reception of ELF signals on

submarines while submerged, without the operational restrictions associated with the current Buoyant Cable Antenna, was conducted. Algorithms and the design of a Littoral Mobile Wireless Networking effort focused on providing over-the-horizon reach in littoral and expeditionary warfare environments were developed. The adaptive, reconfigurable networking algorithms developed will allow for the seamless transfer of communications between Navy ships and Marine Corps forces ashore. (FY 2001 accomplishments in this thrust were funded in PE 0602232N.)

- (U)($2,385) RF Navigation Technology: Develops key navigation technologies for Naval Battle Groups, Aircraft, UAVs, Unmanned Underwater Vehicles (UUVs), Ships, Submarines and other Navy vehicles and platforms. This technical area applies leading-edge S&T to enhance GPS capabilities in order to make GPS more resistant to noise and jamming. This effort is also concerned with the coupling of GPS with inertial systems. This effort generally does not cover guided munitions, nor does it duplicate DARPA developments in Micro Electromechanical Systems (MEMS) devices. The development of anti-jam antennas to preserve GPS functions in a hostile jamming environment continued through three antenna efforts. The first, the Miniature-Controlled Radiation Pattern Antenna (M-CRPA) has sensitivity patterns that allow jamming signals originating from earth to be suppressed and allow clustered jammers that may dominate the GPS signal even at great distances off shore to be suppressed. This allows Navy aircraft to travel from carriers towards shore-based jammers and to not be markedly affected by them. This antenna has been fabricated and its angular response pattern measured and found to be acceptable. The second effort, Non-linear Array Antenna, achieves nulling of jammers and beaming towards desired signals through non-linear coupling algorithms. This work has application to scenarios in which there is a large number of jammers or the jammers have wide angular separation. This antenna would be particularly effective if a jamming-field approach was employed by enemy forces. Algorithms have been developed and circuit cells have been fabricated allowing cell/element coupling to be demonstrated. The third effort, High Dielectric Mini-Array, actively suppresses jammers by a null-steering approach and can result in low cost and small size antennas. The size feature will allow this antenna to be a quick-change-out for the existing omni antenna on a wide range of platforms, with a resulting very significant savings when the installation is performed on aircraft. A single frequency antenna has been fabricated and has demonstrated nulling depths of 35dB. The effort to reduce GPS vulnerability to jamming by integrating GPS with inertial navigation capabilities is part of this effort. This integration is being pursued at Raytheon (using a MEMS Inertial Measurement Unit (IMU) approach) and Litton Industries (using a Fiber Optics Gyro IMU approach). In such hybrid systems, reliance is placed upon the inertial subsystem during intense jamming and GPS during periods of non-jamming. The development addressed system architecture and security issues concerning the encryption aspects of system operation. The Geophysical Low Observable Bathymetric Enhancement (GLOBE) effort treats non-GPS approaches to navigation that utilize topographical features of land or

undersea areas. Analyses performed in this effort quantified the level of positional accuracy that can be obtained in bathymetric sounding, as would be achieved from a submarine platform. These levels are considered to provide acceptable positional accuracy to SSN platforms. (FY 2001 accomplishments in this thrust were funded in PE 0602232N.)

- (U)($10,139) RF Solid State Power Amplifiers. Provides for the generation of Very High Frequency (VHF), UHF, Microwave (MW), and Millimeter Wave (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. Silicon carbide (SiC) bipolar transistors, suitable for high RF pulsed power generation at UHF-L band frequencies, for application to naval airborne surveillance sytems were developed based upon Ft and Fmax predictions. The development of millimeter wave (MMW) AlGaN/GaN wide bandgap, high electron mobility transistors (HEMTs) for naval electronic warfare and surveillance system applications continued with the demonstration of 5W/mm at 26 GHz. This work is laying the foundation for expanded circuit work by DARPA and the Army where the focus is MMIC demonstrations. The development of multi-octave wide bandgap power amplifiers, that will enable highly versatile, multifunction systems with multiple simultaneous RF beams, demonstrated a doubling of the output power. No other agencies are sponsoring similar work. (FY 2001 accomplishments in this thrust were funded in PE 0602234N.)

- (U)($7,500) RF Vacuum Electronics Power Amplifiers. Provides for the development of MW, MMW, submillimeter wave power amplifiers for use in naval all-weather radar, surveillance, reconnaissance, EA, and communications weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interest from the Navy satellite community, the Vacuum Power Booster (VPB) effort was focused on the development of a highly efficient ultra-linear amplifier capable of handling the complex digital waveforms required to support network centric warfare. The objective is to demonstrate improved digital signal error performance using a vacuum power booster (VPB) amplifier designed using newly-developed digital optimization criteria. This will result in a several fold increase in power margin and provide the capability to handle the ten-fold increase in data-rates for data rates exceeding 1 Gbps. Ongoing efforts in industry to develop K_a-band Coupled Cavity Traveling Wave Tubes (CC-TWTs) for radar (PAC-3) and communications applications are adversely affected by limitations in available circuit design capabilities. In response, the extension of GATOR, a multi-dimensional, large-signal code, for coupled-cavity circuits, was emphasized. The experimental development of multiple beam klystrons (MBKs) requires a complete suite of three

dimensional (3D) design codes. The development of a 3D electron gun collector code, MICHELLE, is ongoing and MAGY, a two dimensional (2D) large-signal code, was emphasized for application to klystrons. An updated version of CHRISTINE-1D was released to industry and the development of 2D/3D helix TWT design codes continued with the introduction of models to handle reflection at severs and internal matching elements. For computational simplicity, all current nonlinear circuit design codes operate in the frequency domain. Proper understanding of device physics relevant to amplification of the complex digital waveforms to be used in high data rate (HDR) communications will require the availability of codes operating in that time domain. To provide initial guidance to HDR TWT development, a methodology to incorporate the results of frequency-domain, nonlinear TWT simulation, using the improved version of CHRISTINE, into simplified time-domain models was demonstrated. The development of a true time-domain code for helix circuits will use 1D models. A W-band gyro-twystron (P_{pk} = 65 kW, bandwidth = 1.5 GHz) and a K_a-band gyro-TWT are under development. Reliable (> 10^5 hrs), high current density (>10 A/cm^2) cathodes will be required for the development of the multiple beam klystrons needed for reduced noise improvement of shipboard multi-function radars. Experimentation with noble metal-based scandate emitters has established the effectiveness of using rhenium to promote cathode life. (FY 2001 accomplishments in this thrust were funded in PE 0602234N.)

- (U)($13,064) Supporting Technologies. Provides for the radiation, reception, signal control and processing of VHF, UHF, MW, and MMW power for Navy all-weather radar, surveillance, reconnaissance, EA, communications, and smart weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the requirements placed on power, frequency, linearity, bandwidth, weight, and size. Indium phosphide (InP) devices and circuit architecture were developed for a 20 GHz Direct Digital Synthesizer(DDS) frequency source, with programmable integral modulation capabilities, for application to a new class of multifunction electronically scanned arrays. The approach and goals of the DDS are unique to the Navy. Alumimum Gallium Nitride (AlGaN) HEMTs with a 1.08 dB noise figure at 10 GHz were demonstrated to support the development of high dynamic range low noise amplifiers (LNAs) covering the 4-20 GHz range. The use of AlGaN will provide for a more compact LNA by eliminating the need for input protection diodes. The effort to develop a digitally programmable true-time delay (TTD) integrated circuit using ultra high-speed InP, to achieve sub-pico second levels needed for performing electronic scanning of arrays operating at microwave frequencies, continued with a demonstration of key circuit devices and elements. The objective of a monolithic integrated circuit that can be packaged into a DDS is unique to the Navy. Development of a high performance analog-to-digital converter (ADC) continued with the record demonstration of 20 GHz using a unique superconducting low-pass ADC that has application to a "software radio" style, digital receiver designed to reduce co-site interference. Development of compact tunable filters for multifunction system applications continued with

the demonstration of a wideband filter that could be tuned over a 4X frequency range by use of a micro-electromechanical MEMS switched device. The 100 GHz low noise digital clock effort being developed to enhance system dynamic range continued with fabrication of the full custom packaging necessary for concept demonstration. The development of a MW frequency DDS capable of generation of very stable RF/microwave frequency sources for use in wide bandwidth communications, high-resolution radar and electronically scanned arrays continued with demonstration of a world record frequency of 4.56 GHz direct digital signal conversion. The development of ultra low noise, broad band, high linearity receiver amplifiers for multifunction systems applications continued with the demonstration of low noise receiver amplifiers that cover the 4-20 GHz range, with a noise figure below 1.5 dB over the full frequency range. Development of silicon-compatible 4 Gb/in^2 giant magneto-resistance (GMR) non-volatile memory technology to implement a hard-drive on a chip continued with the demonstrated control of vertical GMR devices. A 3.3V silicon-based power converter demonstrated 100 W/in^3 power density and 93% efficiency for application to avionics and communications systems. Supporting Technologies also provides a small effort in macro-electrical power conditioning and distribution. The development of SiC-based bipolar transistors and properties of interfacial nanostructures (PIN) diodes for application to motor-drive power conversion systems resulted in devices with a record current gain of 50 and blocking voltages over 1000 V. (FY 2001 accomplishments in this thrust were funded in PE 0602234N.)

- (U)($1,798) NFFTIO. The purpose of NFFTIO is to ensure the Fleet/Force (F/F) helps shape the DoN investment in S&T, develop teaming relationships to rapidly demonstrate and transition technology, support development of technology-based combat capability options for naval forces, and enable warfighting innovations based on technical and conceptual possibilities. This is accomplished through proactive connectivity and collaboration between DoN S&T and Joint, Navy, and Marine Corps commands worldwide. Projects executed by NFFTIO are used to accelerate the process of exploring good ideas and initiatives that originate in the Fleet/Force. Special emphasis is given to force protection and development of transformation capabilities that address situational awareness. The operational commands in Command, Control, Communications, Computers, Intelligence, Surveillance, & Reconnaissance (C4ISR) were supported. Specifically, support to develop the following systems was provided: Radiant Argon Hyperspectal Imaging; Collaborative Digital Target Folders (DTF); Environmental Analysis and Receiver Systems (EARS); and the Virtual Information Processing Agent Research (VIPAR). Provided support to the Fleet/Force in quality of service and quality of life initiatives to reduce maintenance frequency and manpower requirements. Projects included a Shipboard Quality of Life (QOL) electronic deck log system utilizing a wireless network and a Shipboard Non-tactical Automated Data Processing (SNAP) system for off-ship connectivity. Addressed F/F operational readiness and combat capability issues that were amenable to the demonstration and application of technology solutions. Accomplishments included a Remote

Water Craft (RWC) project for force protection and counter-drug applications, an Amphibian Suit for Navy Special Operations Forces, Submarine Platform Avoidance of Close Encounters (SPACE), and Air Warfare Training Technology Development (AWTTD). (FY 2001 accomplishments in this thrust were funded in PE 0602233N.)

(U) FY 2001 Congressional Plus-Ups:

(U)($1,448) Advanced Materials Innovative Communications Materials (Funded in PE 0602234N) The goal of this effort is to develop a special class of magnetic materials called barium ferrites which would have properties necessary for implementing advanced microwave circuits. These circuits are essential for making improvements in radar and communication systems, with components which are smaller in size, lower in volume, and more cheaply fabricated and assembled. To achieve the goal, methods for growing thin films of these barium ferrites on an appropriate substrate without altering their properties must be developed. It has been demonstrated that by careful design of the layering of the materials, the intrinsic magnetic properties could be achieved.

(U)($1,932) Innovative Communications Material (Funded in PE 0602234N). The goal of this effort is to develop materials processing procedures which are necessary for the large scale manufacturing of high density, non-volatile memory circuits, based on magnetic storage called Magnetic Random Access Memory. This technology is expected to provide an alternative source of memory components for computing, data storage, and portable communications. These memory components have no mechanical parts, unlike hard disk drives and CD drives, it is faster than any other type of computer memory, there will be much higher density memory, it is non-volatile, and it allows for orders of magnitude faster data transfer. Accomplishments include installation and operation of equipment for making nanoscale magnetic elements, the fabrication of test structures of nanometer dimension and the development of procedures and processes to optimize the properties of the magnetic memory devices.

(U)($1,938) Laser Welding and Cutting (Funded in PE 0603508N). The goal of this program is to provide for the qualification of the process, and products of the process, for laser fabricated structural shapes for Naval applications. All members of the project team are under contract and an overall project plan and schedule have been developed integrating the statements of work for all participants. Steel required for testing has been ordered. The structural testing matrix has been developed. Welding and testing fixtures have been built. The manufacturing system control architecture has been selected. The economic analysis has been initiated.

FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

BUDGET ACTIVITY: 2

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(U)($2,414) Nanoscale S&T Program (Sensor Research) (Funded in PE 0602234N). The goal of this effort is to develop new material structures which have novel properties when reduced in size to nanometer dimensions. Nanoscale electronic and magnetic devices have enormous potential for electronic functions, such as high speed computing, high data storage for computers and sensors, which are focus areas for the DoD. This effort has demonstrated that nanoscale magnetic devices exhibit enhanced magnetic properties for exploitation in magnetic logic and memory. Several new materials have been discovered which allow for novel new technology developments.

(U)($1,448) Program Increase (Materials, Electronics, and Computer Technology) (Funded in PE 0602234N). The goal of this program is to develop the materials processing technology for large scale fabrication of magnetic memory circuits, based on Giant Magnetoresistance effects in multi-layer materials. The large magnetoresistance effects in these materials are being incorporated in the design of high density memory components which can replace all forms of computer memory currently in use. A new device design and improvements in the processing technology which will be required for high density memory development were demonstrated.

(U)($3,865) Silicon Carbide Semiconductor Material (Funded in PE 0602234N). The goal of this effort is to identify and, to the extent possible, eliminate structural and electrical defects from SiC, and help discover and develop technologies for exploiting the properties of SiC in DoD related electronics. Accomplishments include the reduction in crystal defect densities in epitaxial SiC films by a factor 8, (1-> 0.12) by using porous SiC substrates, demonstration of n- and p-Si MOSFETs (8µm - 0.35µm) on SiC, AlSiC and AlN substrates that exhibited 35% increased performance with applied strain <0.05%/, development of methods to determine the transport and impurity concentrations in wide gap semiconductors without adjustable parameters, and experimental demonstration that the density of micropipes in SiC bulk crystals can be reduced to < 100/cm2 at a high growth rate by increasing the growth temperature.

(U)($9,659) UHF Electronically Scanned Array (UESA) Signal Processing Support (Funded in PE 0602232N). A performance specification was developed, a competitive procurement conducted and a contract to design, fabricate, integrate and evaluate an advanced UESA signal processor in the Mountaintop advanced radar technology testbed was conducted. Development of a UESA signal processor is planned for completion and delivery to the Navy in FY 2002.

2. (U) FY 2002 PLAN:

FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

BUDGET ACTIVITY: 2

PROGRAM ELEMENT: 0602271N
PROGRAM ELEMENT TITLE: RF Systems Applied Research

- (U) ($16,180) RF SURVEILLANCE SYSTEMS. Emphasizes technology developments in 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, discrimination, target ID and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments. Digital Array Radar technologies that include wideband digital beamforming techniques to enable rapid steering and precision control of multiple beams over multiple degrees of freedom in azimuth and elevation will be developed. Processing technologies to detect and track large doppler variations, generate and control environmentally-adaptive waveforms, and perform non-cooperative target identification (NCTR) will also be developed. Investigations into automated beam steering and aperture management technologies for the AN/APY-6 Electronically Steered Array to enable strike aircraft to simultaneously discriminate, detect, geo-locate/track and identify both stationary and slow moving ground targets without compromising full volume surveillance operations needed for continuous situational awarenesss will also be pursued. Horizon extension radar system technology investigations will be performed with emphasis on light weight, high power RF transmit/receive front-ends that are integral to multi-element electronically steered arrays and are deployable from surface combatants via tethered or powered elevated platform methods. Non-Cooperative Target Recognition techniques will be developed that include one dimensional high resolution signatures, coupled with multi-dimensional characteristics, such as two- and three-dimensional imaging combined with radar signal modulation and micro-doppler techniques. These technology areas have been identified as needed to address identified enabling capabilities for missile defense, time critical strike and platform protection. E-2C UESA with embedded L-Band Identification Friend or Foe (IFF) antennas will be developed. UESA with embedded/co-boresighted IFF will enable fleet units to perform real time Identification Friend or Foe at the same look angle of the radar system. The Current E-2C TRAC-A antenna IFF elements are one hundred eighty degrees off the radar boresight resulting in non-real time interrogation of radar targets. STAP techniques and algorithms will be developed to enable high performance E-2C radar operation in complex clutter and electronic countermeasure environments typical of those encountered in littoral operations. Shipboard digital array radar wideband RF transmit/receive technologies with emphasis on performance in the S-band (3.0 GHZ – 4.0 GHZ) frequency spectrum will be developed. This technology is identified in the Surface Navy Radar Roadmap as a critical system enabler for planned Theater Air and Missile Defense radar developments, and is also identified as a critical element in PEO-TSC, PMS-426’s high power S-band radar system development for application to future surface combatant platforms. Advanced algorithms will be developed to enable new AN/APY-6 wideband, multi-mode radar capabilities for the simultaneous detection, geo-location/track and identification of stationary and moving ground targets moving at velocities of less than three knots over the ground, and provide for ISAR detection, discrimination and

identification of sea-going platforms ranging in size from small craft (<150ft) to large commercial and combatant platforms (>500ft).

- (U)($12,537) Electronic Warfare Technology. Supports those technologies that enable the development of affordable, effective and robust 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 RF countermeasure systems that exploit and counter a broad range of electromagnetic threats. Program focus is on maintaining near perfect real-time knowledge of the enemy; countering the threat of missiles to deployed Naval forces; and precision identification and location of threat emitters. Development in the Expeditionary EW Grid for Surface Unit project will provide for modification of the Advanced Reactive EW Simulation (ARES) code for application to surface unit defense against RF systems. This effort will enable offboard devices to be coupled with existing EA systems to deny surveillance, targeting and missile seeker radars the capability to acquire and track surface platforms. The Wideband EW Channelizer project will develop a 500 MHz Very Large Scale Integration (VLSI) single chip filter bank. This effort will enable the development of low cost, small size and low power channelizers for use in tactical applications such as unmanned aerial vehicles. The Advanced Countermeasures Technique Development project will develop coherent and non-coherent deception techniques that will support future EA testing against advanced threat seekers. The Hard Kill (HK)/EW Techniques Development project will develop and demonstrate EA techniques against frequency modulated continuous wave surveillance radars that will ultimately increase survivability of U.S. Naval units. The Electronic Support (ES) Detection of Low-Probability of Intercept (LPI) Periscope Detection Radar project will develop requirements, definitions and system design to enable U.S. naval units to approach, enter and operate in denied areas by detecting the presence of LPI threat systems. Optimization of the C2W/EA network and second field test will occur under the EA for the Coherent Complex Modern Emitters project that supports future testing of a heterogeneous EA network. The Network Centric Battle Force EW project will conduct testing of new multi-platform EA techniques and experiments that will assist in the formulation of coordinated EA defense strategies. Evaluation of Phase-Locked Loop (PLL) and synthesized local oscillator (LO) design for the miniature receiver will be conducted under the continuing RF EW Sensor Miniaturization project, that will ultimately expand the deployability of EW surveillance systems to small platforms. Investigation of output digital-to-analog converter processing requirements will continue under the Digital Deception Technologies project that increases platform survivability in the presence of advanced surveillance systems. The ANGUILA project will conduct light testing of the fully integrated system. The Next Generation SEI and Signal Processing program which aids in platform discrimination and identification will integrate the statistical clustering algorithm to SEI and the AN/UYX-4. EA Techniques to Counter Advanced Threats will develop

and demonstrate advanced EA techniques to counter advanced RF-guided missiles that can be used in an anti-ship role. In FY02 work will be focused on coherent false target techniques versus anti-ship missiles (ASM) and time/amplitude/frequency modulated techniques evaluations.

- (U)($7,629) RF Communications Technology. Addresses critical Navy communications technology deficiencies and needs that are not addressed by the commercial technology sector. The program emphasis is on reliable interoperable communications between U.S and coalition forces at all levels of command, and rapid and reliable utilization of government and commercial telecommunications assets worldwide that are efficient and responsive to warfighting needs. A VHF/UHF L-Band Antenna design effort will be conducted to consolidate antennas from several bands into a single configuration, thereby reducing topside space requirements while maintaining electromagnetic compatibility for legacy and future communications equipment. This system includes a new class of low-observable maritime antennas. An X/Ku band antenna will be designed to provide improved Intelligence, Surveillance, and Reconnaissance (ISR) connectivity through the use of transmitting and receiving phased array antennas compatible with the shipboard environment. This antenna will also facilitate wideband communications to airborne relay assets via the Tactical Common Data Link to support beyond line-of-sight connectivity needed in network centric warfare. A multi-function digital receiver incorporating a superconductive front-end with a digital cross correlator for use in a Joint Tactical Radio compliant system will be developed. The hardware simplicity should result in cost savings and an increased number of simultaneous users. To achieve higher data rates and interference mitigation for the user, Bandwidth efficient advanced modulation Line-of-sight Technologies (BLT) that focus on advanced modulation, turbo coding designs and equalization for multipath mitigation over LOS channels will be developed. An optically-tunable microwave filter for multifunction antennas for out-of-band signal interference rejection and co-site interference mitigation will be developed. A Next Generation Buoyant Cable Antenna will be designed to provide submarines a multi-band buoyant cable antenna capable of supporting sufficient network connectivity for participation in network centric operations. Technologies to support a Naval Battleforce Network (NBN) will be investigated. Networking architectures to integrate line-of-sight wireless networks into the existing over-the-horizon (satellite-based) network will be developed. Reduction of current dependence on satellite connectivity and reduced latency for communications within the battle group, for both the joint planning and joint data networks, is important. An ELF submarine On-Hull Antenna design will be developed with improved noise mitigation performance. This will allow ELF operation when the submarine is operating at speed and depth. The Ultra Small Aperture Terminal (USAT) K/Ka Band Phased Array is a limited capability being developed, jointly with DARPA, and can be used aboard surface ships and moving ground vehicles. More capable K/Ka band phased arrays will be developed with the ultimate goal of addressing K/Ka/Q Band Phased array antenna

technology needed for use on Naval surface/ground platforms. This effort will provide a means of connecting to the Wideband Gapfiller Satellite, MILSTAR and Commercial satellite constellations to support the beyond-line-of-sight connectivity needed in network centric warfare. Demonstrate co-site interference mitigation to enable dynamic range extension of receiving systems operating aboard ship. The effort will permit multiple UHF users to operate on the same surface platform.

- (U)($2,211) RF Navigation Technology. Develops key navigation technologies for Naval Battle Groups, Aircraft, UAVs, UUVs, Ships, Submarines and other Navy vehicles and platforms. This technical area applies leading-edge S&T to enhance GPS capabilities in order to make GPS more resistant to noise and jamming. This effort is also concerned with the coupling of GPS with inertial systems. This effort generally does not cover guided munitions nor does it duplicate DARPA developments in MEMS devices. Development of the Miniature-Controlled Radiation Pattern Antenna will continue with extensive testing and design refinement. Practical consideration for airframe installation will be treated to insure the designed-in features are realized in a stable manner and the antenna is immune to weather-related effects. The non-linear antenna concept will be carried to the RF stage and tested in a laboratory setting. The high dielectric antenna will be weatherized and field tested. Further design will be performed to extend the capability to both L1 and L2 GPS frequencies. The development of techniques to suppress jamming will continue with an effort emphasizing digital signal processing. Processing methods will be identified and their effectiveness will be assessed.

- (U)($3,500) RF Solid State Power Amplifiers. 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 COTS as a result of the simultaneous requirements placed on power, frequency, linearity, bandwidth, weight, and size. Development of silicon carbide bipolar transistors suitable for high RF pulsed power generation at UHF-L band frequencies will be continued with demonstration of transistors that will output 300 W (pulsed) at 425 MHz. AlGaN/GaN wide bandgap HEMTs will provide the basis for demonstration of a 10 W amplifier with 45% power added efficiency at 35 GHz. The design of ultra broadband (multi-octave) power amplifiers will be optimized for efficiency and packaged parts tested for application to highly versatile, multifunction systems with multiple simultaneous RF beams. No other agencies are sponsoring similar work.

- (U)($6,500) RF Vacuum Electronics Power Amplifiers. Provides for the development of MW, MMW, submillimeter wave power amplifiers for use in naval all-weather radar, surveillance, reconnaissance, EA, and communications weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. An experimental high dynamic range (HDR) vacuum power booster will be designed and fabricated using current analog standards of linearity for use as a test vehicle to validate physics-based, time dependent codes and simplified communication-link models. This effort addresses the need for improved amplifier models and VPB designs that support the increased dynamic range, phase linearity, and bandwidth requirements associated with the multi-level, broadband digital signals needed in such systems as the Wideband Gapfiller and the improved AN/WSC-6 shipboard terminal. The development of 2D/3D CC-TWT design codes continues with the insertion of an improved alternating current (AC) space charge model in GATOR. The 1 dimensional (1D) large signal circuit design code will be used interactively with HDR VPB experiments to guide the development and validate the code. Following the development of 2D/3D CTLSS/CHRISTINE, this helix TWT design code will be released to industry for beta testing and validation. The 2D klystron design code for single-beam configurations will be tested and then extended to multiple beams beginning with the development of appropriate AC and direct current (DC) space charge models. These models will be inserted into the multiple beam version of MAGY. A K_a-band gyro-TWT will be developed using a ceramic loaded circuit to obtain a 3% bandwidth. Targeted performance is peak power of 140 kW, 50 dB gain, and an efficiency of 20%. Once the 60 kW W-Band gyro-twystron is fabricated and assembled 1.5% bandwidth will be demonstrated. Based on the success of the rhenium coating studies, the effort was extended to investigate the use of pulsed laser deposition to fabricate uniform, high current density scandate emitters.

- (U)($11,015) Supporting Technologies. Provides for the radiation, reception, signal control and processing of VHF, UHF, MW, and MMW power for Navy all-weather radar, surveillance, reconnaissance, EA, communications, and smart weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the requirements placed on power, frequency, linearity, bandwidth, weight, and size. A new class of >2:1 bandwidth active filters and linearizer circuits needed for use in high power microwave amplifier circuits to enable Navy systems to simultaneously operate over greater bandwidths, higher power and improved sensitivity will be developed. The materials and processing issues that contribute to the instability failure mechanisms of wide bandgap devices (SiC and GaN) at microwave frequencies will be initially determined. Results of this work will accelerate the insertion of wide bandgap technologies into DoD systems and will have collateral return in the area of power switching for applications such as the all-electric ship. High power (20W/channel) channelizers, small enough to be used behind a

transmitter array face as power combiners in a multifunction system, will be developed. This effort is essential to multiple simultaneous signal transmission and is currently unavailable except in units ~4x the required size. A high power, wideband isolator technology will be developed by application of improved modeling and control of low frequency losses (<2 dB insertion) to a low power isolator with >15dB of isolation operating over the 4-20 GHz frequency range. Development of a DDS frequency source to 20 GHz with programmable integral modulation capabilities will be continued with demonstration of the scaling of Indium-Phosphide transistors and development of the supporting devices and circuits required in the DDS. The high performance analog-to-digital converters effort will continue with the development of bandpass designs to reduce the complexity, hardware parts count, and cost of receivers used in multifunction system arrays. The development of compact tunable filters will be continued with the demonstration of a 100 MHz filter that can be tuned anywhere in a 4 GHz band, in a package smaller than achieved to-date, to enable testbed demonstrations of software-selected digital reception. The 100 GHz low noise digital clock effort will continue by development of a phase locking subcircuit and demonstration of the expected ultra-low phase noise performance over both the short time scales, critical for accurately clocking digital circuits, and long time scales, required to accurately beam steer a 10 m^2 phased array. Development of robust, wide bandgap low noise amplifiers will continue with the integration of HEMTs to form high gain, low noise LNA circuits. Development of ultra low-noise, broadband, high linearity receiver amplifiers will continue with the demonstration of 4-20 GHz receiver amplifiers using an optimized Metamorphic HEMT structure, with increased linearity and dynamic range to further reduce intermodulation products. A SiC power converter using large BJT's with optimized design to realize Ion = 15A and VB=1200 for application to a 16-40 kW motor drive will be developed. A packaged MW Frequency DDS with integral modulator in integrated circuit form, for use in an electronically scanned array operating to 4.5 GHz, will be demonstrated. The effort to develop a digitally programmable true-time delay (TTD) integrated circuit will demonstrate a monolithic integrated circuit (IC) with low phase noise. Operation of a 4Gb/in^2 basic GMR non-volatile memory cell will be demonstrated and the technology will be transitioned to private industry.

(U)($1,988) NFFTIO. The purpose of NFFTIO is to ensure the F/F helps shape the DoN investment in S&T, develop teaming relationships to rapidly demonstrate and transition technology, support development of technology-based combat capability options for naval forces, and enable warfighting innovations based on technical and conceptual possibilities. This is accomplished through proactive connectivity and collaboration between DoN S&T and Joint, Navy, and Marine Corps commands worldwide. Projects executed by NFFTIO are used to accelerate the process of exploring good ideas and initiatives that originate in the F/F. Special emphasis will be given to force protection and development of transformation capabilities that address situational awareness and service/quality of life

initiatives to reduce maintenance frequency and manpower requirements. Projects will include the development of a capability for the Tactical Exploitation of Side Scan Sonar and the continued development of the RWC for force protection and counter-drug applications.

- (U) FY 2002 Congressional Plus-Ups:

(U) ($4,262) Maritime Synthetic Range. This program will develop a synthetic virtual range at the Pacific Missile Range Facility (PMRF) to extend the PMRR's capability. Realistic world models will be used in conjunction with real time systems.

(U) ($991) Nanoscale Devices (Wide Bandgap Materials). This program will develop nanometer dimension electronic devices based on wide bandgap semiconductor materials which could be used as sources of high power, high frequency electromagnetic radiation for applications in radar and communication systems.

(U) ($1,487) Nanoscale Science and Technology Program. This program will perform applied research to advance the understanding and applications of magnetic, electronic and optical nanostructures leading to programmable logic, mass storage, non-volatile storage, and electromagnetic devices.

(U) Magnetic Random Access Memory (Appropriated in PE 0602234N ($991)). This program will perform applied research to develop technology for the magnetic random access memory with emphasis placed on growth optimization to enhance the signal-to-noise ratio in high density non-volatile memories.

(U) High Brightness Electron Source Program (Appropriated in PE 0602234N ($1,487)). This program will perform applied research to develop advanced cathodes for use in high power vacuum electronic devices and ultra-bright display devices.

(U) Microarray Technology (Appropriated in PE 0602234N ($3,470)). This program will perform applied research to develop microarray technology for Navy and Marine Corps needs.

(U) Silicon Carbide Semiconductor Material (Appropriated in PE 0602234N ($1,388)). This program will perform applied research to develop insulating SiC boules of high quality and larger than three inches in diameter.

(U) Thick Film Ferrite Magnetic Materials for Microwave Applications (Appropriated in PE 0602234N ($991)). This program will perform research in thick film ferrite magnetic materials for microwave applications for Navy and Marine Corps needs.

3. (U) FY 2003 PLAN:

- (U)($13,085) RF Surveillance Technology. Emphasizes technology developments in 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, discrimination, target ID and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments. Advanced adaptive radar exciter/waveform generator technologies will be developed for application to current and future radar systems to significantly improve operational performance in dense background clutter and complex electronic countermeasure environments. Development of the UESA with embedded L-Band IFF antennas will continue with emphasis placed on system compatibility to enable low risk cost effective integration into the E-2C Radar Modernization Program (RMP) system. Development and refinement of STAP techniques and algorithms for application to the E-2C RMP system will be continued with emphasis placed on improving the performance of electronically scanned circular arrays in the presence of directional jamming and complex clutter sources typical of those encountered in littoral operations. Initial laboratory and field evaluations of STAP processing and algorithms integrated with the E-2C RMP/UESA system will be conducted and performance metrics quantified. Shipboard Digital Array Radar (DAR) wideband digital beamforming technologies will be developed and preliminary performance evaluations in a high fidelity (multiple degrees of freedom) modeling and simulation environment will be conducted. S-band RF transmit/receive modules will be developed and electrical operating characterization and performance evaluations in a laboratory environment conducted. Performance metrics and operational characteristics will be incorporated into the PMS-426 Advanced S-band radar system specification. Horizon extension radar system investigations will be performed to include RF front-end design and definition of lift vehicle requirements and options. Elevated radar sensing is expected to provide extended range surveillance, target discrimination and detection capabilities against low flying targets out to three times current shipboard horizon limited range capabilities. Advanced algorithms for the AN/APY-6 wideband multi-mode radar will be developed with emphasis placed on processing technologies to improve image fidelity and provide real time high confidence recognition of both sea going targets and slow moving (<3Kts) ground targets in adverse clutter and countermeasure environments. A flyable

brassboard of the AN/APY-6 electronically steered array test and evaluation system will be developed. This array will be the technological basis for follow on development of a Pod Configured ESA for time critical strike, surveillance, and targeting operations aboard Navy F/A-18 aircraft.

- (U)($12,469) Electronic Warfare Technology. Supports those technologies that enable the development of affordable, effective and robust 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 RF countermeasure systems that exploit and counter a broad range of electromagnetic threats. Program focus is on maintaining near perfect real-time knowledge of the enemy; countering the threat of missiles to deployed Naval forces; and precision identification and location of threat emitters. Technology development efforts will be conducted in the areas of Surface MMW Countermeasures and Autonomous EW CM/Sensors Network that will demonstrate the ability of a autonomous jammer to adapt itself to the dynamic environment and provide maximum protection against precision guided munitions. These will include antenna integration technology for decoy platforms, MMW target characterization for anti-ship missile defense and developing optimum network EA concepts for C2W. Analyses of EA grid constellations will be conducted for the Expeditionary EW Grid for Surface Unit project to assist scenario development. Evaluation of Monolithic Microwave Integrated Circuit (MMIC) receiver modules will continue under the RF EW Sensor Miniaturization project to provide optimum subsystem integration and performance. Fabrication of Application Specific Integrated Circuits (ASICs) will be performed under the Digital Deception Technologies project that provides real time alteration of operating parameters permitting rapid and adaptive shifting among different type of large targets. Analysis and optimization of hardware for the third field test and identification of concept performance and enabling technologies are planned for the EA for Coherent Complex Modern Emitters project that will protect surface vessels against modern and future anti-ship missile threats. The Wideband EW Channelizer project will continue by combining the on-chip filter bank and channel discrimination on a single chip with the goal of providing a 6U Virtual Memory Extension (VME) brassboard channelizer with a instantaneous operating bandwidth of 2GHz. The Advanced Countermeasures Technique Development project will continue with shore-based field testing of coherent countermeasures techniques that provide enabling technologies to counter advanced MMW, surface-to-air and air-to- air threats. The HK/EW Techniques Development project will continue with the development of a datalink to network EW systems in order to facilitate cooperative synchronized blinking jamming between platforms and to provide frequency set-on and spot width information to off-board active decoys to radiate noise techniques. This project provides layered EA concepts to increase capability against the launch platform and a stream of maneuvering anti-ship missiles having fixed or frequency agile capability. A proof of concept demonstration will be conducted under the Network Centric Battle Force EW project

that will enable fleet assets to use coordinated EA techniques to achieve battle force defense. The Electronic Support (ES) Detection of LPI Periscope Detection Radar project will enable U.S. naval units to approach, enter and operate in denied areas by detecting the presence of LPI threat systems and will emphasize system fabrication and algorithm development. EA Techniques to Counter Advanced Threats will develop and demonstrate advanced EA techniques to counter advanced RF-guided missiles that can be used in an anti-ship role. In FY03 work will focus on synthetic sea clutter waveform effectiveness vs ASM seekers and coordinated coherent/non-coherent techniques.

- (U)($7,587) RF Frequency Communications Technology. Addresses critical Navy communications technology deficiencies and needs that are not addressed by the commercial technology sector. The program emphasis is on reliable interoperable communications between U.S and coalition forces at all levels of command, and rapid and reliable utilization of government and commercial telecommunications assets worldwide that are efficient and responsive to warfighting needs. The design and development of a prototype multi-band X/Ku band phased array antenna, that has multiple simultaneous transmit/receive beams, operates across both frequency bands and is compatible with shipboard environments (Electro-magnetic Compatibility (EMC) and Radio Frequency Interference (RFI)) and operations will be continued. This effort will provide significant improvements in connectivity for non-line-of-sight Intelligence, Surveillance and Reconnaissance (ISR) operations. Continuous and reliable network connectivity using satelite communications channels not previously accessible for such use by Naval surface combatants will also be provided. The Ultra Small Aperture Terminal (USAT) K/Ka Band Phased Array that can be used aboard surface ships and moving ground vehicles, and being developed jointly with DARPA, will be demonstrated on ground platforms. Development of a multi-function digital receiver, which uses a superconducting front-end with a digital cross-correlator with application to a Joint Tactical Radio compliant system, will be continued with emphasis placed on completing the receiver design. Development of bandwidth efficient advanced modulation line-of-sight technologies (BLT) will be continued with emphasis focused on the waveform design and preparing for a demonstration in FY 2004. The design of an optical tunable microwave filter for multifunction antennas will be developed and preparations made for a demonstration in FY 2004. Prototype of the Next Generation Buoyant Cable Antenna will be designed for demonstration of submarine connectivity at operational depth. The design of a Naval Battleforce Network (NBN) architecture to enable dispersed units to operate with connectivity comparable to line-of-sight units will be optimized.

- (U)($2,199) RF Navigation Technology. Develops key navigation technologies for Naval Battle Groups, Aircraft, UAVs, UUVs, Ships, Submarines and other Navy vehicles and platforms. This technical area applies leading-edge S&T to enhance GPS capabilities in order to make GPS more resistant to noise and jamming. This effort is also concerned with

the coupling of GPS with inertial systems. This effort generally does not cover guided munitions, nor does it duplicate DARPA developments in MEMS devices. Development of the Miniature-Controlled Radiation Pattern Antenna (M-CRPA) will be continued with installation of the antenna on Navy airframes and the performance assessed under the actual conditions for which the antenna was designed. Development of the Non-linear array effort will continue with progression to an operational prototype capable of operating at RF frequencies and functioning successfully against a field of jammers in a simulated environment. The Geophysical Low Observable Bathymetric Enhancement (GLOBE) efforts are to be demonstrated to submarine forces. Development of digital signal processing routes shown to be effective will be implemented in one of several candidate GPS receivers. Field tests will determine the efficacy of these approaches and viability for network-wide incorporation.

- (U)($3,500) RF Solid State Power Amplifiers. 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 COTS as a result of the simultaneous requirements placed on power, frequency, linearity, bandwidth, weight, and size. GaN wide bandgap, high dynamic range, linear RF power amplifier for MW applications will be developed to increase the third-order intercept by 10 dB for multifunction systems applications. Wide bandgap psuedomorphic HEMTs with Indium incorporated in the channel region will be developed to improve the high frequency gain and amplifier efficiency for application to multifunction systems. If successful, this device type could be included in future phases of the DARPA Wide Bandgap Program. SiC bipolar transistors suitable for high RF pulsed power generation at UHF-L band frequencies will demonstrate a very high pulsed output power at 1.5 GHz.

- (U)($4,500) RF Vacuum Electronics Power Amplifiers. Provides for the development of MW, MMW, submillimeter wave power amplifiers for use in naval all-weather radar, surveillance, reconnaissance, EA, and communications weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. High dynamic range vacuum power booster experiments will demonstrate improved digital signal error performance resulting in a two-fold increase in power margin and data rates in excess of 1 Gbps. 2D/3D CC-TWT design code development continues with the addition of a model to handle reflections at internal matching elements. The time dependent helix TWT design codes will be extended to 2D. The gyro-amplifier effort continues by extending the bandwidth of the K_a-band gyro-TWT to 2.5 GHz (~7%). The high brightness scandate emitter effort continues with emphasis on the optimization of top-layer scandate composition.

FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

BUDGET ACTIVITY: 2

PROGRAM ELEMENT: 0602271N
PROGRAM ELEMENT TITLE: RF Systems Applied Research

- (U)($10,946) Supporting Technologies. Provides for the radiation, reception, signal control and processing of VHF, UHF, MW, and MMW power for Navy all-weather radar, surveillance, reconnaissance, EA, communications, and smart weapons systems. The technology developed cannot, for the most part, be obtained through COTS as a result of the requirements placed on power, frequency, linearity, bandwidth, weight, and size. The development of a new class of >2:1 bandwidth active filters and linearizer circuits needed for use in high power microwave amplifier circuits will be continued with the development of digital and active filter hardware for demonstration of high linearity and dynamic range at microwave frequencies. The wide bandgap transistor reliability effort will be continued with insertion of the knowledge gained in FY 2002 into the device technology and subsequent testing to document the improvements in the stability and lifetime of next-generation SiC and GaN devices. The effort to develop high power channelizers will be continued by demonstrating the feasibility of meeting channelizer size and power requirements in a single filter, and development of a preliminary design for the channelizer. The development of high power, wide band, isolators will be continued by demonstrating increased power handling (up to 20 Watts), reduced losses (<1 dB), and size reduction to fit the 20 GHz array spacing. Development of a DDS frequency source to 20 GHz with programmable integral modulation capabilities will be continued with the demonstration of a design to achieve a world record for digitally generated frequency of at least 10 GHz. Development of a high performance ADC will continue with demonstration in simulation of the desired band pass characteristic along with the hardware design, fabrication, and test of critical components. Development of tunable compact filters will continue with a demonstration of 10x narrower band filters with acceptable size and insertion loss and design for a 7 bit assembly that is no larger than current 4 bit units. Development of 100 GHz low noise digital clock will continue by demonstrating fine control of the frequency and full phase noise testing of the complete unit will be performed at NIST. Monolithic wide bandgap low noise receiver amplifiers with increased survivability under RF drive, enhanced linearity, and high temperature operation will be developed. Within the SiC power converter effort BJT's and PiN diodes with Ion=25A and Vb=1200 will be fabricated and demonstrated for application to a 40-100 kW motor drive.

- (U)($1,977) NFFTIO. The purpose of NFFTIO is to ensure the F/F helps shape the DoN investment in S&T, develop teaming relationships to rapidly demonstrate and transition technology, support development of technology-based combat capability options for naval forces, and enable warfighting innovations based on technical and conceptual possibilities. This is accomplished through proactive connectivity and collaboration between DoN S&T and Joint, Navy, and Marine Corps commands worldwide. Projects executed by NFFTIO are used to accelerate the process of exploring good ideas and initiatives that originate in the F/F. Special emphasis will be given to force protection

and development of transformation capabilities that address situational awareness. Technology developments to the F/F in high life cycle cost maintenance areas through the application of transitional technologies to reduce maintenance frequency and manpower requirements will be supported.

C. (U) PROGRAM CHANGE SUMMARY :

	FY 2001	FY 2002	FY 2003
(U) FY 2002 President's Budget	**	62,141	
(U) Adjustments from FY 02 PRESBUDG:			
Congressional Plus-ups		6,800	
Section 8123 Management Reform Initiative Reductions		-609	
FFRDC Reduction		-32	
(U) FY 2003 President's Budget Request:	**	68,300	56,263

**The Science and Technology PEs were restructured in FY 2002. FY 2001 efforts were funded in PEs 0602232N, 0602233N 0602234N, and 0602270N.

(U) PROGRAM CHANGE SUMMARY EXPLANATION:

(U) Schedule: Not applicable
(U) Technical: Not applicable

D. (U) OTHER PROGRAM FUNDING SUMMARY: The Navy's 6.1 program contributes to this effort.

(U) RELATED RDT&E:

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

FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

BUDGET ACTIVITY: 2

PROGRAM ELEMENT: 0602271N
PROGRAM ELEMENT TITLE: RF Systems Applied Research

(U) PE 0603114N (Power Projection Advanced Technology)
(U) PE 0603123N (Force Protection Advanced Technology)

(U) NON NAVY RELATED RDT&E:
(U) PE 0601102A (Defense Research Sciences)
(U) PE 0601102F (Defense Research Sciences)
(U) PE 0602204F (Aerospace Sensors)
(U) PE 0602702F (Command, Control, and Communications)
(U) PE 0602782A (Command, Control and Communications Technology)
(U) PE 0602705A (Electronics and Electronic Devices)
(U) PE 0602303A (Missile Technology)
(U) PE 0602270A (Electronic Warfare Technology)
(U) PE 0603270A (EW Technology)
(U) PE 0603270F (Electronic Combat Technology)

E. (U) SCHEDULE PROFILE: Not applicable.