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FY 2001 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET

DATE: February 2000

BUDGET ACTIVITY: 2

PROGRAM ELEMENT: 0602232N

PROGRAM ELEMENT TITLE: Command, Control, Communications, Computers, Intelligence, Surveillance & Reconnaissance (C4ISR)

(U) COST: (Dollars in Thousands)

PROJECT NUMBER & TITLE	FY 1999 ACTUAL	FY 2000 ESTIMATE	FY 2001 ESTIMATE	FY 2002 ESTIMATE	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	TO COMPLETE	TOTAL PROGRAM
C4ISR	71,139	91,166	79,905	81,094	82,000	81,293	79,921	CONT	CONT

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This Program Element (PE) supports future command, control, communications, computers and intelligence, surveillance & reconnaissance (C4ISR) systems for surface, subsurface, air and space platforms and ashore for Naval Warfare. C4ISR technology focuses on the delivery of critical, time sensitive, tactical information to decision makers for fusion and management of information between the warrior, command centers, and National Command Authorities. Technology developments include network Centric architecture and information infrastructure, intelligent information exploitation and retrieval, consistent tactical picture development, collaboration environments, and interactive decision support including continuous plan-execute cycles, and navigation. Funding for Computer Technology previously contained within PE 0602234N has been realigned and is now presented in the Command Support thrust of this program element. While this transfer takes place in FY 01, the funding accomplishments and plans for the Computer Technology Program in PE 0602234N for FY 99 and FY 00 are shown here for the sake of program clarity and continuity. The major goal is to provide the Navy with the capacity to interconnect government and commercial telecommunication assets, worldwide, that are efficient and responsive to regional theater challenges and the National interest. Surface/Aerospace/Intelligence, Surveillance and Reconnaissance (ISR) technology emphasizes advanced sensor and processing systems for theater wide air and surface surveillance, battle group surveillance, real-time reconnaissance and ship self-defense. Major technology goals include increased long-range target detection and discrimination, precision track, and positive target identification in complex countermeasure and adverse environmental conditions. Navigation and timing are key to the Department of Defense (DoD) capability to conduct precision engagement, dominant maneuver and information dominance. Navigation is a critical aspect of most naval missions, including precision targeting, amphibious

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assault and mineclearing. Current dependence on the Global Positioning System (GPS) leaves the United States (U.S.) vulnerable to enemy efforts to make GPS unavailable through electronic warfare means (i.e., jamming). Navigation technology emphasizes development of counter-countermeasures for GPS and of GPS alternative navigation such as inertial technology with greater precision. C4ISR technologies directly support the Joint Warfighter Mission Areas and Areas of Precision Force (Strike Warfare) including Littoral Warfare, Combat Identification (ID), Joint Theater Missile Defense, and Information Superiority. Specifically: Precision Force efforts address technology issues in real-time targeting, long range target detection, track and engage and Battle Damage Assessment (BDA). Programs include mission planning, en-route Command, Control, Communications and Computers (C4), precision targeting, precision navigation, multisensor fusion, and temporal and spectral discrimination algorithms. Precision Force in the Littorals addresses issues in air and surface battle-space and develops technology for ship self-defense, cooperative engagement and power projection systems including ship-based and off-ship radar and electro-optic/infrared (EO/IR) sensors, connectivity and robust, enduring communications and navigation. ISR technology efforts address issues of precise target location and real-time targeting, counter-jamming and deception. Program includes multi-platform radar and IR sensors for detection, identification, tracking, BDA, and timely distribution of surveillance information to all levels of command. Command and Control (C2) efforts address Networked Operations supported by distributed collaborative battle management. Navigation technology efforts address Digital-Signal-Processor (DSP) based GPS antennas with adaptive beamforming/null steering and integration of navigation and communications systems (e.g., GPS and Joint Tactical Information Distribution Systems (JTIDS)). GPS alternative technologies to improve inertial navigation capabilities include Fiber Optic Gyroscopes (FOGs), Micro-Electro-Mechanical (MEMs) accelerometers, and miniaturized clocks for precision time information. Operational focus areas are littoral warfare, strike and operations other than war (OOTW) e.g. humanitarian assistance. This PE emphasizes C4ISR technology to provide Naval Warfighters with seamless, timely situational awareness of the total battle-space and indications and warning of threat operations and intentions.

(U) These efforts support the Joint Warfare Strategy "Forward... From the Sea". Programs are jointly planned in the Defense Technology Area Planning Process within the Department of Defense.

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(U) Due to the sheer volume of work included in this PE, the programs described in the Accomplishments and Plans sections are only representative selections of the work included in this PE and are not an exhaustive presentation.

(U) The Navy Science and Technology (S&T) program includes projects that focus on or have attributes that enhance the affordability of warfighting systems.

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

(U) PROGRAM ACCOMPLISHMENTS AND PLANS:

1. (U) FY 1999 ACCOMPLISHMENTS:

- (U) RADAR TECHNOLOGY: The Radar Technology program investment addresses Navy surveillance needs and exploits radar sensor technology opportunities. Emphasis is on major platforms such as ships and aircraft and cross cutting technologies that apply across platforms. Major drivers include affordability and sensor performance in complex target, electronic countermeasures (ECM) and adverse environmental conditions including operations in the littorals.
 - (U) Completed multi-band, flexible waveform, shipboard radar sensor test at Wallops Island for performance and operational utility assessments against representative targets in varying environmental clutter and sea state conditions. Report to be delivered.
 - (U) Completed evaluation of adaptive waveforms for multi-band shipboard radar to maximize detection and track performance in complex target and multi-path conditions and to minimize system dynamic range and analog-to-digital converter requirements. Addressed Program Executive Officer, Theater Air Defense Surface Combatants (PEO-TAD/SC) and N-86 needs for continuous track in severe multi-path and clutter conditions.

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- (U) Integrated scale model voltage controlled diode array with test bed radar system to develop performance versus cost trade-off metrics. Responds to Navy needs for affordable high performance radio frequency (RF) apertures. Joint program with Defense Advanced Research Project Agency (DARPA).
- (U) Continued development of Millimeter Wave High Resolution Radar Demonstration Model for close in anti-ship cruise missile (ASCM) tracking. Incorporated High Power source developed by the Electronics program under PE 0602234N.
- (U) Characterized performance of full scale model of the ultra high frequency (UHF) electronically scanned array in static chamber testing and at the experimental radar facility at Pacific Missile Range Facility (PMRF), Kauai, Hawaii. Performance equaled or exceeded existing E-2C TRAC-A, and ADS-18 antenna systems. Conducted E-2C integration studies including electromagnetic compatibility determinations. This development addresses technology needs identified by Chief of Naval Operations (CNO-N88), Program Executive Officer, Anti-Submarine Warfare (PEO-A) and PMA-231 for multi-target tracking of theater ballistic and cruise missiles and for 360 degree continuous Identification Friend or Foe (IFF) capability.
- (U) Completed technology development of UHF digital receiver and characterized performance in preparation for field testing at the Mountaintop Radar Facility in Kauai, Hawaii.
- (U) Flight tested concealed/buried target detection ultra-wideband radar to quantify target detection and image qualities in high false alarm conditions. DARPA and Army participated in flight test effort.
- (U) Integrated test bed model of airborne multi-mode radar system into test aircraft for performance evaluation against small seaborne craft and moving and stationary ground targets. DARPA, Air Force (AF) (Wright Laboratories) and Joint Surveillance Target Attack Radar System (JSTARS) program participated in evaluation.
- (U) Continued joint program with AF and DARPA to develop automatic target recognition algorithms in support of Tri-Service needs for long range identification of stationary and slow moving ground targets.
- (U) Integrated UHF Electronically Steered Array into Kauai, Hawaii Mountain Top Test Facility. Effort includes improvements to the facilities experimental radar and established connectivity to the Maui High Performance Computing Center (MHPCC).
- (U) EO/IR TECHNOLOGY: The EO/IR technology investment addresses Navy surveillance needs and exploits technology opportunities leading to advanced EO sensor and autonomous processing capabilities. The program emphasizes needs of major Navy air platforms for detection, acquisition, precision targeting and fire control handoff. Technologies such as multi-wavelength passive/active sensors and multi-dimensional signal processing algorithms to enhance detection and track

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performance in adverse environments are stressed. Optical apertures to enable multiple EO sensors to operate simultaneously from a single aperture are being developed.

- (U) Integrated dual band airborne Surveillance Infrared Search and Tracks (SIRSTs) sensor into a fleet configured E-2C aircraft for aircraft compatibility and performance evaluation. Ballistic Missile Defense Organization (BMDO) funded laser ranger added to sensor to provide three dimensional (3D) targetting capability was included. This technology addresses needs for long range detection and tracking of Theater Ballistic Missiles identified by PEO- TSC and Program Executive Officer, Tactical Air (PEO-T).

- (U) Continued development of target discrimination and recognition algorithms to distinguish unique characteristics of man made objects relative to naturally occurring background clutter.

- (U) Continued joint program with United States Air Force (USAF) to develop Hyper-spectral infrared sensors for Naval airborne Intelligence, Surveillance and Reconnaissance missions. Addresses needs identified by PMA-290 and PMA-265.

- (U) Continued modeling and simulation to optimize sensor operating characteristics and fusion of multi-wavelength EO passive and active sensor attributes. Developed cueing and control processing strategies to enable rapid hand-off of precision fire control data to on and off-board engagement systems.

- (U) Integrated multi-function electro-optic sensor technology completed in FY 98 into a distributed aperture infrared sensor system (DAIRS) specifically for the Joint Strike Fighter (JSF). This development addresses the JSF program office needs for passive infrared sensors to provide continuous situational awareness and missile warning. This development was coordinated with the Air Force within the JSF program office as part of Multifunction Infrared Distributed Aperture System (MIDAS) Fleet Air Defense (FAD) program and within the Defense Reliance Sensors, Electronics and Battlespace Environments Panel.

- (U) Initiated joint program with DARPA and PMA-290 to develop and demonstrate Hyper-spectral Electro-Optical Imaging technology on the EP-3 aircraft. Technology development emphasizes high resolution, multi-band imaging sensor and algorithms for target detection and confirmation. Initial plans for insertion of this technology is for EP-3 with follow-on application to F-18F Shared Reconnaissance POD (SHARP). This effort addresses needs identified by CNO-N88 and PEO-T for real time situational awareness, precision targeting and battle damage assessment.

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- (U) MULTI-SENSOR TECHNOLOGY: The Multi-Sensor technology program investment addresses Navy Intelligence, Surveillance and Reconnaissance needs and exploits technology opportunities leading to the integration, fusion and automated management of sensors operating within a platforms Combat System Architecture. The program emphasizes needs of major ship and air platforms and is developing crosscutting technologies that apply across platforms. Technologies such as processing architectures and algorithms to fuse, filter and correlate data and automated resource management processing are pursued.
 - (U) Completed development of targeting avionics sensor technology to provide precision targeting capabilities for U.S Navy and High Speed Anti-Radiation Missile (HARM) capable International aircraft.
 - (U) Demonstrated laser encoded IFF on AV-8B and F/A-18 aircraft at CNO-N66 sponsored All Service Combat ID Evaluation Team (ASCIET) trials. Follow-on evaluation will be conducted by cooperative research groups from North Atlantic Treaty Organization (NATO) member Nations.
 - (U) Integrated Data Fusion/Resource management processing algorithms into the SPY-1 radar at the Aegis Combat Systems Center and conducted ground system characterization and effectiveness assessments during theater ballistic missile tracking exercises. Addresses PEO-T SC needs for sensor resource management technology.
 - (U) Initiated system studies for the E-2C aircraft to define an integrated multi-sensor architecture to include tactical data links and the cooperative engagement capability (CEC) system. This effort responds to needs identified by CNO-N88 and PMA-231 for detection, discrimination, fire control quality tracking and engagements of missile threats.

- (U) COMMUNICATIONS NETWORKS: Continued development of technologies critical to performance and robustness of Naval Communications networks.
 - (U) Completed design of version 2 of the Multicast Dissemination Protocol (MDFPv2) and transitioned technology into the Army's Force XXI Battle Command Brigade and Below (FBCB2) system via successful testing of 50 radios.
 - (U) Tested and analyzed the prototype software for the high performance reliable multicast transport protocol and the Quality of Service (QOS) enhancements to the Internet Protocol (IP). This work extends Commercial off the Shelf (COTS) based reliable multicast protocols to various military applications. Presented the results to the Internet Engineering Task Force (IETF) for consideration in the next generation standards-track protocols. Coordinated via the Information Systems Technology (IST) Panel of the Defense S&T Reliance.

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- (U) Incorporated the enhanced transport and IP prototype software in the Asynchronous Transfer Mode (ATM) network testbed and tested their performance relative to existing protocols. Borrowed ATM switches from France for performance testing. Conducted tests employing different ATM switches to determine quality of performance and interoperability. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) Investigated technical issues related to ATM use, such as signaling, interoperability robustness, and ability to support QOS at the application layer. Military use of ATM switches requires adaptation to RF media and is not limited to fiber-optic wires. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) Developed robust protocols and Quality of Service mechanisms for expeditionary warfare mobile networks. Coordinated via the IST Panel of the Defense S&T Reliance and co-chairing the IETF working group on Mobile Ad-Hoc Networking.
- (U) RADIO COMMUNICATIONS: Continued development of key communications technologies for air, ship and submarines.
 - (U) Concluded the residual noise tests of the on-hull extremely low frequency (ELF) submarine antenna. This development provided first time capability for submarines to receive ELF transmissions without having to deploy a long trailing wire.
 - (U) Analyzed data from the sea tests of the low profile buoyant cable submarine antenna. Performed comparative at-sea testing with DARPA buoyant-cable multi-element phased array design. This development enables up to an order of magnitude increase in data rate with UHF operation at speed and depth.
 - (U) Completed development of the structurally-embedded, reconfigurable aircraft antenna array reconfiguration using optically activated switches. Structural embedment of antenna arrays reduces life cycle costs and radar cross-section. Coordinated via the IST Panel of the Defense S&T Reliance.
 - (U) Conducted laboratory and field tests of the improved modem for UHF line-of-sight ship communications. Compared results with expectations, and defined further improvements as needed in the modem design and the power management algorithms. Coordinated via the IST Panel of the Defense S&T Reliance.
 - (U) Demonstrated the use of CDMA and LPI technologies in Navy tactical networks in a series of line-of-sight field tests up to 50 miles using only 25 microwatts of power. CDMA requires adaptation from commercial networks to mobile military networks that require low probability of intercept/detection. Coordinated via the IST Panel of the Defense S&T Reliance.
 - (U) Demonstrated a capability to provide a 45 Mbps link via a Ka-band satellite from a disadvantaged user with a 1 meter antenna system to a ship at sea.

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- (U) Developed Mechanically Assisted Phased Array (MAPA) antenna for the Ultra-Small Aperture Terminal (USAT) capable of Global Broadcast Service (GBS) reception on board Navy ships and aircraft. Demonstrated use of back-channel connectivity to the GBS. Coordinated via the IST Panel of the Defense S&T Reliance.

• (U) C2 AND COMBAT SYSTEMS: This merges previous projects in High Performance Computing, Artificial Intelligence/Human Computer Interface, and Engineering of Complex Systems from PE 0602234N, and Command Support from this program element (0602232N) into a more integrated and comprehensive Command, Control and Combat Systems Technology thrust that supports Navy needs in Network Centric Warfare. Integration of these important technology areas will be pursued in FY 99 and beyond in this PE. Scientific domains of interest include (1) dependable and high assurance computing; (2) image processing and information exploitation; (3) visualization of the Common Operational Picture (COP)/Common Tactical Picture (CTP) including virtual reality environments; (4) decision support and collaboration; and (5) network engagement and operation. Focus is on high assurance requirements specification and requirements testing, image compression and feature recognition, 3D virtual displays, architectures to merge Command and Control and Combat Systems, and distributed software development to support Defense Information Infrastructure Common Operating Environment (DII-COE) systems such as the Global Command and Control System (GCCS).

- (U) In support of the Common Operational Picture/Common Tactical Picture, implemented a video abstract agent and web-based agents; developed a cooperative query capability; and tested inter-agent architecture operation.

- (U) In support of Common Operational Picture/Common Tactical Picture, defined the real-time prototype environment to support distributed nodes; and integrated real-time mechanisms to support distributed collaboration.

- (U) In support of Common Operational Picture/Common Tactical Picture, evaluated the Covariance Intersection approach as a method to fuse data in a distributed environment.

- (U) Advanced decision support technologies through the development of case-based plan authoring and advanced use interfaces; implemented intelligent agents into existing real-time execution decision support; developed common representation and interaction between planning and monitoring support capabilities.

- (U) In support of Network Operations, defined the requirements and design specifications for Adaptive Rules of Engagement. Conducted user experiments with collaboration and decision support capabilities in coordination with Space and Naval Warfare Systems (SPAWAR) and the Sea-Based Battle Lab (USS Coronado). Incorporated collaborative environment and

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execution monitoring capabilities into Extending the Littoral Battlespace (ELB) Advanced Concept Technology Demonstration (ACTD) 1999 Demonstration.

- (U) Incorporated intelligent agents into 3D virtual reality architecture to control interactions and data flow between entities.
- (U) Developed collaborative software for combat system applications with allied and coalition countries leading towards interoperable systems.
- (U) Demonstrated the ability to fuse multi-spectral images as well as imagery and digital terrain elevation data to produce improved maps supporting targeting and mission planning. Applied techniques to produce image mosaics with variable spatial resolution.
- (U) Demonstrated feasibility of using ocean wave slope measurement by remote wave sensing in the littoral region toward improving the Rapid Airborne Mine Clearance System (RAMICS) anti-mine system. Devised, implemented, and tested a methodology for removal of capillary wave distortion in airborne lidar images of underwater mines.
- (U) Demonstrated real-time video image compression capability to be implemented onto the next generation Tomahawk. Demonstrated version 2 of the System of Systems software and evaluated the joint effects of compression and noise upon data link performance. Modularized the compression algorithms, template design algorithms and communications channel models and performed Monte Carlo simulations to analyze the effects of compression on the quality of the templates generated.
- (U) Software infrastructure for agent-based systems was developed in compliance with specifications developed by an international organization of R&D organizations, and is being used in ongoing project work and experimentally in at least three other system development efforts sponsored by the Department of Defense (DoD).
- (U) Designed and tested a prototype software tool that uses three formal techniques (term rewriting, Binary Decision Diagrams, and a constraint solver) to detect errors in software requirements specifications containing variables of different types (real, integer, Boolean, and enumerated): analysis of such specifications is not feasible with current technology.
- (U) Demonstrated flexible techniques to significantly reduce vulnerability of Navy Internet traffic to traffic flow analysis, making it difficult for commercial Internet routers to determine which Navy facilities are communicating with other Navy facilities via the commercial Internet infrastructure.

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- (U) Developed a technical architecture that will provide needed interfaces for achieving distributed force coordination between command and control information grid (non-real-time) and combat system (real-time) grid in support of network centric speed of command and force synchronization.
- (U) Developed a scaleable architecture for a consistent COP/CTP that portrays a coherent visualization of the battlespace among distributed decision makers from the Commander-in-Chief to the unit level.

- (U) NAVIGATION: This program develops key navigation technologies for Naval aircraft, ships and submarines.
 - (U) Compared quantum-well mirror ring laser gyro measurement results with conventionally designed ring laser gyros. This development promises to eliminate mechanical dithering and make ring laser gyros more producible and affordable.
 - (U) Investigated use of pseudolites for acquiring ranging in addition to timing data using Global Positioning System (GPS) signals. This development would lower the vulnerability of GPS users to enemy jamming.
 - (U) Applied modern digital signal processing technologies to the design and development of next generation GPS receivers for improved anti-jam protection.
 - (U) Tested the Advanced Development Model II of the high performance fiber-optic gyro for FY01 transition to the Navy Special Project Office (SP-24). This development enables replacing the Electrostatic Suspended Gyro Navigator (ESGN) presently deployed on submarines with more affordable fiber-optic gyro navigators.

- (U) STRATEGIC SYSTEMS TECHNOLOGY: The objective of the Strategic System Sustainment project is to develop and demonstrate technologies in the areas of Missile Flight Science, Submarine Navigation, and Underwater Missile Launch to sustain these strategic capabilities that will (1) reduce the reliance on unique materials and processes, (2) reduce the reliance on human-expertise intensive processes, and (3) reduce the cost of maintaining these systems.
 - (U) Assessed the existing missile flight science design and analysis codes for integration into a platform-independent architecture.
 - (U) Developed Underwater Launch systems architecture.

2. (U) FY 2000 PLAN:

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- (U) RADAR TECHNOLOGY: The Radar Technology program investment addresses Navy surveillance needs and exploits radar sensor technology opportunities. Emphasis is on major platforms such as Ships and aircraft and cross cutting technologies that apply across all platforms. Major drivers include affordability and sensor performance in complex target, ECM and adverse environmental conditions including operations in the littorals. The radar technologies being developed in this program element are critical elements of Future Naval Capabilities Programs addressing Naval needs and requirements in Theater Air and Missile Defense (TAMD) and Time Critical Strike (TCS).
 - (U) Conduct initial laboratory and field evaluations of High Power Millimeter Wave Radar Demonstration Model. Tracking quality and consistency will be evaluated against a variety of representative targets and countermeasure environments. Jointly conducted with the Electronics program under PE 0602234N.
 - (U) Transition baseline UHF Electronically Steered Antenna (UESA) array technology to a technology demonstration phase of development under PE 0603238N. The technology demonstration of UESA is endorsed by OPNAV N-88 and the Commander Naval Air Systems Command (COMNAVAIRSYSCOM) and PEO-T PMA-231.
 - (U) Integrate UHF Digital Receiver into the improved Mountaintop experimental Radar at PMRF, Kauai, Hawaii. Complete technology valuation during the UESA demonstration and transition to an advanced Airborne Early Warning (AEW) aircraft sensor system.
 - (U) Complete flight test characterization of the Concealed Target Detection/Ground Penetrating Ultra Wideband Radar. This project is coordinated with the Defense S&T Reliance Sensors, Electronics and Battlespace Environments (SEBE) Panel.
 - (U) Conduct flight measurements of the airborne Multi-Mode Radar system to characterize performance against ground targets in all operating regimes (moving, stationary). Jointly conducted with DARPA, USAF Wright Laboratories and the JSTARS program.
 - (U) Complete joint program with AF and DARPA to develop automatic target recognition algorithms and signal processing in support of joint Warfighter and Tri-Service needs for long range identification of stationary and slow moving ground targets. Coordinated with Defense Reliance SEBE Panel.
 - (U) Conduct system studies and technology assessments necessary to define and develop an advanced digital L/S-band volume surveillance radar (VSR) for surface combatants. Responds to technology needs of PEO-TSC.

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- (U) Develop algorithms and signal processing technology to enable naval forces to determine Combat Identification (CID) of Air Targets at long range. Supports needs identified by The Joint Theater Air and Missile Defense Office (JTAMDO).
- (U) EO/IR TECHNOLOGY: The EO/IR technology program investment addresses Navy surveillance needs and exploits technology opportunities leading to advanced EO sensor and processing capabilities. The program emphasizes needs of major Navy air platforms and is developing crosscutting technologies that apply across platforms. Technologies such as multi-wavelength passive/active sensors and multi-dimensional signal processing algorithms to enhance detection and track performance in adverse environments are stressed. Optical apertures to enable multiple EO sensors to operate simultaneously from a single aperture are being developed. Electro-Optical sensor technologies developed within this program element are critical elements of Future Naval Capabilities Programs addressing Naval needs and requirements in TAMD and TCS.
 - (U) Complete in flight evaluation of the dual band Infrared Search and Tracks (IRST) on a fleet E-2C aircraft participating in Theater Ballistic Missile (TBM) detection and tracking exercises. This effort responds to stated needs of PEO TAD/SC and PEO-T for long range detection and precision tracking of TBMs. Jointly coordinated with the Air Force via Defense Reliance SEBE Panel.
 - (U) Integrate BMDO funded eye safe laser sensor into dual band airborne E-2C IRST for sensor compatibility and performance evaluations. Responds to Joint Theater Air and Missile Defense Office needs for long range, detection and precision tracking of TBMs.
 - (U) Continue development of target discrimination and recognition algorithms to distinguish unique characteristics of man made objects relative to naturally occurring background clutter.
 - (U) Continue modeling and simulation to optimize sensor operating characteristics and fusion of multi-wavelength passive and active EO sensor attributes. Develop and optimize sensor cueing and control processing strategies to enable rapid hand-off of precision fire control information to on- and off-board engagement systems.
 - (U) Transition baseline Distributed Aperture Infrared Sensor (DAIRS) to a technology demonstration phase as part of the Multifunction Infrared Distributed Aperture System (MIDAS) under PE 0603238N. This technology is identified as a critical element of the Joint Strike Fighter roadmap for situational awareness and missile warning.

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- (U) Continue joint program with DARPA and PMA-290 to develop Hyper-spectral Imaging sensor and processing for demonstration on the EP-3 aircraft. This effort addresses needs identified by CNO-N-88 and PEO-A for real time situational awareness, precision targeting and battle-space assessment.
- (U) Develop concepts for development of laser and laser identification image profiling, leveraging DARPA developments in high frame rate Focal Plane Arrays to provide Navy and Marine Corps platforms with real-time, long-range target discrimination and identification capability.

- (U) MULTI-SENSOR TECHNOLOGY: The Multi-Sensor technology program investment addresses Navy Intelligence, Surveillance and Reconnaissance needs and exploits technology opportunities leading to the integration, fusion and automated management of sensors operating within a platform Combat System Architecture. The program emphasizes needs of major ship and air platforms and is developing crosscutting technologies that apply across platforms. Technologies such as Multi-Sensor processing architectures and algorithms to fuse, filter and correlate data and automated resource management procession are pursued. Multi-Sensor technologies are fundamental to addressing needs in platform and network centric warfare. The multi-sensor integration (MSI) technologies addressed within this program element focus on Naval needs and requirements being addressed in the Future Naval Capabilities programs in TAMD and TCS.
 - (U) Continue evaluation of Radar Resource Management processing algorithms in SPY-1 Radar at Aegis Combat Systems Center, Wallops Island, VA. This effort responds to needs identified by PEO TSC for long range detection, discrimination and continuous tracking of theater ballistic missiles.
 - (U) Evaluate multi-source integration and data fusion algorithms in the E-2C aircraft Sensor Integration Laboratory and assess operational effectiveness improvements in Theater Air and missile defense operating environments. Responds to needs identified by the Fleet, Program Executive Officer, Tactical Aircraft Programs (PEO-T) for timely integration and dissemination of on and off board sensor information in all operating scenarios.
 - (U) Develop algorithms and system interfaces incorporating the cooperative engagement capability network into the E-2C MSI and data fusion system architecture.

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PROGRAM ELEMENT: 0602232N

PROGRAM ELEMENT TITLE: Command, Control, Communications, Computers, Intelligence, Surveillance & Reconnaissance (C4ISR)

- (U) COMMUNICATIONS NETWORKS: Continue development of technologies critical to performance and robustness of Naval Communications networks. Technologies within this program support Future Naval Capabilities (FNC) programs Information Distribution.
 - (U) Continue development of key communications network technologies for air, ship and submarines necessary for network-centric warfare.
 - (U) Evaluate the performance of the new reliable multicast and IP QOS protocols. Make analytic results available to the IETF in order that the commercial standard is compatible with military applications. Coordinated with Information Systems Technology (IST) Panel of the Defense S&T Reliance.
 - (U) Conduct performance and interoperability testing of different ATM switches over the high speed ATM testbed employing the new reliable multicast and IP QOS protocols. Coordinated with the IST Panel of the Defense S&T Reliance.
 - (U) Develop end-to-end multicast congestion control technology and simulate performance. Develop involvement with related standards and research community via the Internet Engineering Task Force (IETF).
 - (U) Evaluate simulation results of wireless, mobile network performance in relation to projected needs of military applications. Transition results to the Interoperable Networks for Secure Communications (INSC) 6.3 program to enable test/demonstration for coalition warfare. Coordinated with the IST Panel of the Defense S&T Reliance and co-chairing the IETF working group on Mobile Ad-Hoc Networking.
 - (U) Develop adaptive, dynamic wireless networking protocol for the Tactical Data Link. Coordinate with the Link-16 Program Office.
 - (U) Develop networking requirements and provide a functional description of a wideband networked waveform for the Joint Tactical Radio System (JTRS) Joint Program Office (JPO). Coordinated with the RF Networking IPT within the JTRS JPO and via the IST Panel of the Defense S&T Reliance.
- (U) RADIO COMMUNICATIONS: Continue development of key communications technologies for air, ship and submarines.
 - (U) Investigate Code Division Multiple Access (CDMA) links as back channel for GBS, employing very small aperture terminals appropriate for small craft use.

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- (U) Demonstrated the use of Code Division Multiple Access (CDMA) technologies in Navy tactical networks. CDMA requires adaptation from commercial networks to mobile military networks that require low probability of intercept/detection. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) Continue field testing of low probability of intercept/detection technologies using microwatt power levels.
- (U) Transition the low-profile buoyant cable antenna enhancement to 6.3 Advanced Technology Demonstration.
- (U) Transition the on-hull extremely low frequency (ELF) antenna to the Submarine Integrated Antenna System (SIAS) 6.4 project within PMW-173.
- (U) Develop technologies to enable large aperture multiple frequency band, multiple function antennas for current and future Navy attack submarines. Provide enhanced submarine connectivity and maximum stealth. Coordinated via the IST panel of the Defense S&T Reliance.
- (U) Transition the improved modem technology for Ultra-High Frequency (UHF) line-of-sight communications to the Joint Tactical Radio System (JTRS). Coordinated with the JTRS RF Networking IPT and via the IST Panel of the Defense S&T Reliance.
- (U) Incorporate the Mechanically Assisted Phased Array (MAPA) antenna as part of Ultra-Small Aperture Terminal (USAT). Test and evaluate performance of MAPA antenna on different naval platforms. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) Investigate new advanced waveform and turbo coding technology to achieve higher data throughput within existing military channel bandwidths. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) COMMAND, CONTROL (C2) AND COMBAT SYSTEMS: This program develops and demonstrates software components and technologies that enable the Navy's concepts of Network-Centric Warfare and the Joint Chiefs Joint Vision 2010. The focus is on militarily-unique information processing technologies that enable information dominance through vastly improved speed of command. Particular emphasis is directed to issues involving the ability of geographically distributed Naval decision-makers to collectively generate and perceive a Common Tactical/Operational picture, and to jointly plan and monitor military missions. All of the research efforts recognize the important role of COTS software components, and consequently they focus on maximizing the integration of such software into software functionality for Naval applications. Technologies within this program support FNC programs addressing Decision Support and Information Distribution.

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- (U) In support of Common Operational Picture/Common Tactical Picture, continue development of intelligent agent technology to provide agent-based user profiling. Transition agent architecture to DISA GCCS.
- (U) Integrate visualization basic research efforts into Common Operational Picture/Common Tactical Picture. Apply spatial database techniques for correlating covariance intersection estimates for corresponding entities to enhance consistency across different tactical pictures. Initiate effort on developing techniques to enhance real-time picture with non-real-time information.
- (U) Develop initial prototype for a tactical collaborative environment to use during Littoral Warfare.
- (U) In support of continuous planning-execution cycle, continue advances in a case-based reasoning plan authoring tool; develop a prototype Dynamic Resource Allocation capability to support real-time retargeting situations.
- (U) In support of Network Operations, investigate the process and issues associated with Rules of Engagement (ROE) at all echelons of control starting with the National Command Authority (NCA) through the Commander in Chief (CINC) to the Battle Group to the individual Support Element Weapon System.
- (U) Identify requirements and functional building blocks of a Commander in Chief Pacific Fleet (CINCPACFLT) HQ21 Architecture with the goal of developing a facility to test and evaluate COTS software in a military operational context.
- (U) Demonstrate distributed software that will enable users at remote locations to collaborate for effective planning using 3D, interactive virtual reality displays with objects having physical realism.
- (U) Precisely quantify image spatial domain error propagation and further study the problem of feature detection in wavelet space.
- (U) The agent-based information exploitation and retrieval system will be applied to the task of monitoring dynamic data sources in order to supply information to a decision-support system for planning-execution-re-planning of military operations. Demonstrate this application and the general-purpose information exploitation and retrieval system
- (U) Under the System of Systems program, demonstrate chip out technology and develop/understand transmitting the targeting template through additional compression stages in the presence of channel noise. Introduce techniques to optimize joint channel source encoding to maximize performance and adapt the system.
- (U) Demonstrate a distributed software infrastructure prototype development for use in integrated COTS tools by incorporating Software Process, Configuration Management, and wide-area traceability capabilities.

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- (U) Continue development of interface specification and architecture merging command and control functions and platform battle management in a secure distributed network combining non-real-time and real-time databases and operations.
- (U) Continue study and develop methodology for accurate geo-rectification of sensor images with digital terrain elevation data. Integrate algorithms into Powerscene.

- (U) NAVIGATION: This program develops key navigation technologies for Naval aircraft, ships and submarines.
 - (U) Transition the high performance fiber-optic gyro, Advanced Development Model-II to the Director, Navy Strategic Systems Project (SP-24).
 - (U) Perform laboratory proof-of-concept demonstration of the next generation digital GPS receiver for anti-jam performance.
 - (U) Develop advanced aircraft antenna technologies that reduce the vulnerability of GPS to jamming through beamforming/null steering.
 - (U) Develop higher stability fiber-optic gyros by reducing fiber thermal dependence.
 - (U) Enhance navigation accuracy and robustness through integration of LINK 16, GPS and other applicable navigational sensors and communication systems.
 - (U) Transition the quantum-well mirror ring laser gyro technology to Navy tactical missiles and ring laser gyro manufacturers.
 - (U) Develop the atom interferometer gravity gradiometry technology to achieve sensitivity adequate for passive terrain avoidance.

- (U) STRATEGIC SYSTEMS TECHNOLOGY: The objective of the Strategic System Sustainment project is to develop and demonstrate technologies in the areas of Missile Flight Science, Submarine Navigation, and Underwater Missile Launch to sustain these strategic capabilities that will (1) reduce the reliance on unique materials and processes, (2) reduce the reliance on human-expertise intensive processes, and (3) reduce the cost of maintaining these systems.
 - (U) Continue development of methodologies for drag reduction, nuclear survivability, and solid motor ignition codes for the missile flight science design and analysis tool.

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- (U) Continue development of electronic databases for Underwater Missile Launch tool.

3. (U) FY 2001 PLAN:

• (U) RADAR TECHNOLOGY: The Radar Technology program investment addresses Navy surveillance needs and exploits radar sensor technology opportunities. Emphasis is on major platforms such as ships and aircraft and cross cutting technologies that apply across platforms. Major drivers include affordability and sensor performance in complex target, ECM and Adverse environmental conditions including operations in the littorals. The radar technologies being developed in this program element are critical elements of Future Naval Capabilities Programs addressing Naval needs and requirements in TAMD and TCS.

- (U) Continue performance evaluation of High Power Millimeter Wave Radar Demonstration Model in varying target and clutter conditions typical of Naval Surface Combatant operations in littoral environments. Program jointly conducted with the Electronics program under PE 0602234N.

- (U) Continue risk reduction development of UHF Electronically Steered Array emphasizing spacetime adaptive processing and solid State transmitter module development to improve E-2C radar performance in Littoral Environments.

- (U) Continue Multimode Airborne Radar development and integrate into a fleet EP-3 aircraft for flight evaluation.

- (U) Conduct system study and identify critical technologies necessary to develop a Precision Surveillance and Targeting Radar technology in support of Time Critical Strike Targeting needs.

- (U) Continue Volume Surveillance Radar development for surface combatants.

- (U) Continue CID algorithm and signal processing development in support of the Joint Theater Air and Missile Defense office (JTAMDO) needs.

• (U) EO/IR TECHNOLOGY: The EO/IR technology program investment addresses Navy surveillance needs and exploits technology opportunities leading to advanced EO sensor and processing capabilities. The program emphasizes needs of major Navy air platforms and is developing crosscutting technologies that apply across platforms. Technologies such as multi-wavelength

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passive/active sensors and multi-dimensional signal processing algorithms to enhance detection and track performance in adverse environments are stressed. Optical apertures to enable multiple EO sensors to operate simultaneously from a single aperture are being developed. Electro-Optical sensor technologies developed within this program element are critical elements of FNC. Programs addressing Naval needs and requirements in TAMD and TCS.

- (U) Initiate development of split aperture optics to enable E-2C surveillance IRST to simultaneously detect and track both theater ballistic and cruise missiles. This development responds to needs for long range detection and precision tracking of theater ballistic and cruise missiles in response to the Joint Theater Air and Missile Defense Office, CNO-N-88, PEO-TSC and PMA-231 needs.
- (U) Conduct performance and operational utility evaluation of E-2C surveillance IRST with integrated eye safe laser (BMDO developed) during theater ballistic missile detection and tracking exercises at PMRF, Kauai, Hawaii. This development responds to needs identified by the Joint Theater Air and Missile Defense Office, CNO-N88, PEO TAD/SC and PMA-231.
- (U) Complete development of target discrimination algorithms once deficiencies identified during FY2000 land and flight evaluations are corrected. These algorithms will be the baseline signal processing for both E-2C IRST and the ship based staring infrared panoramic sensor system. This development responds to needs for long range target detection and discrimination in varying and extreme environmental clutter conditions. Needs identified by PEO (CLA) and PMA-231.
- (U) Continue development modeling and simulation tools to enable cost effective evaluation of new device and signal processing technologies for integration into existing and planned Naval Infrared Sensor systems.
- (U) Integrate Hyper-spectral Imaging Sensor into EP-3 aircraft for in flight sensor performance and operational utility evaluation. Flight evaluation is planned to begin in FY-2002 and will be conducted by PMA-290 in operational scenarios. Joint program with DARPA.

- (U) MULTI-SENSOR TECHNOLOGY: The Multi-Sensor technology program investment addresses Navy Intelligence, Surveillance and Reconnaissance needs and exploits technology opportunities leading to the integration, fusion and automated management of sensors operating within a platforms Combat System Architecture. The program emphasize needs of major ship and air platforms and is developing crosscutting technologies that apply across platforms. Technologies such as processing architectures and algorithms to fuse, filter and correlate data and automated resource management processing are pursued. Multi-Sensor

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technologies are fundamental to addressing needs in platform and network centric warfare. The MSI technologies addressed within this program element focus on Naval needs and requirements being addressed in the FNC programs in TAMD and TCS.

- (U) Transition radar resource management processing technology improvement to Aegis SPY-ID radar to improve track consistency and quality against theater ballistic missile targets. This technology responds to CNO-N-86 and PEO-TSC needs for long-range detection and fire control quality tracking of TBMs.

- (U) Continue development of MSI technology specifically for the E-2C airborne early warning aircraft sensors and network centric warfare systems. This technology program responds to needs for onboard platform fusion of multi-sensor information and networking of sensor measurement information via tactical data links and the cooperative engagement capability system to facilitate real time situational awareness and timely engagement of threats. Needs for this technology identified by Joint Theater Air and Missile Defense Office, CNO-N88, N-86, PEO TAD/SC, PEO-A and PMA-231.

- (U) Continue development of algorithm and interface technology to enable effective integration of CEC into the E-2C MSI system.

- (U) COMMUNICATIONS NETWORKS: Continue development of technologies critical to performance and robustness of Naval Communications networks. Technologies within this program support FNC programs addressing Information Distribution.

- (U) Support planning for mobile networking demonstrations as part of the Interoperable Networks for Secure Communications (INSC) program. Coordinated via the IST Panel of the Defense S&T Reliance and co-chairing the Internet Engineering Task Force (IETF) working group on Mobile Ad-Hoc Networking.

- (U) Complete reliable multicast and congestion control design and simulation. Maintain involvement with related standards and research community via the Internet Engineering Task Force (IETF). Begin transition of technology into Navy Communications (INSC). Continue involvement with related standards and research community via the Internet Engineering Task Force (IETF). Coordinated via the IST Panel of the Defense S&T Reliance.

- (U) Continue development of the adaptive, dynamic wireless networking protocol for the Tactical Data Link and add IP networking with Quality-of-Service capability. Coordinate with the Link-16 Program Office.

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- (U) Complete expeditionary warfare mobile networking design with Quality of Service features and incorporate into INCS 6.3 program for demonstration in a coalition environment. Coordinated via the IST Panel of the Defense S&T Reliance.
- (U) Participate in the Joint Tactical Radio System (JTRS) RF Networking IPT and evaluate candidate wideband networked waveforms for inclusion in the future JRR. Coordinated with the JTRS Joint Program Office.
- (U) RADIO COMMUNICATIONS: Continue development of key communications technologies for air, ship and submarines.
 - (U) Demonstrate CDMA satellite link as a GBS back channel employing commercial or military satellites. Coordinated via the IST Panel of the Defense S&T Reliance.
 - (U) Integrate submarine electromagnetic structures with large aperture multi-band, multifunction submarine antenna for satellite communications. Technology to eventually transition into new attack submarines.
 - (U) Complete design of new advanced waveform and turbo coding technology to achieve 3 to 5 times higher data throughput within existing military channel bandwidths. Complete prototype hardware and testing for satellite application. Coordinated via the IST Panel of the Defense S&T Reliance.
 - (U) Complete development of the Ultra Small Aperture terminal (USAT) for K/Ka band satellite connectivity to mobile users. This technology is expected to provide 1.5 Mbps data rates to mobile users (aircraft, ships and ground mobile vehicles).
- (U) C2 AND COMBAT SYSTEMS: This program develops and demonstrates software components and technologies that enable the Navy's concepts of Network-Centric Warfare and the Joint Chiefs Joint Vision 2010. The focus is on militarily-unique information processing technologies that enable information dominance through vastly improved speed of command. Particular emphasis is directed to issues involving the ability of geographically distributed Naval decision-makers to collectively generate and perceive a Common Tactical/Operational picture, and to jointly plan and monitor military missions. All of the research efforts recognize the important role of Commercial-off-the-Shelf software components, and consequently they focus on maximizing the integration of such software into software functionality for Naval applications. Technologies within this program support FNC programs addressing Decision Support and Information Distribution.
 - (U) In support of Common Operational Picture/Common Tactical Picture, continue development of intelligent information retrieval techniques that automate a user's profile with intelligent agent software for retrieval of data (i.e. right

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information, right time, right person); continue enhancing the Common Operational Picture/Common Tactical Picture using 3D virtual reality display techniques.

- (U) Test and evaluate data fusion techniques (e.g., covariance intersection) on various platforms and with diverse sensor data sources. Continue effort to develop software for use in interoperable real-time and near-real time systems.
- (U) Continue to test, evaluate, and enhance collaborative software for application to Littoral Warfare.
- (U) Integrate a case-based reasoning plan-authoring tool for mission planning with intelligent decision support visualization techniques for user experimentation.
- (U) In support of Theater Missile Defense, continue development of a prototype for an Adaptive Rules of Engagement. Incorporate collaborative environments and interactive decision support tools into the Extending the Littoral Battlespace ACTD.
- (U) Demonstrate a full multi-modal Human Factor Interface for the Virtual Reality Responsive Workbench and GROTTTO systems including voice, sound, gesture, and other interactive methods that can be used by decision makers.
- (U) Develop a framework of data compression techniques to be used in a two-way communications link.
- (U) Develop, test and evaluate algorithms exploiting geometrically invariant techniques for image-on-image (multi-spectral) and image-on-map registration in a coarse-to-fine multi-resolution approach.
- (U) NAVIGATION: This program develops key navigation technologies for Naval aircraft, ships and submarines.
 - (U) Transition the high performance fiber-optic gyro, Advanced Development Model-II to the Director, Navy Strategic Systems Project (SP-24).
 - (U) Complete accuracy and stability assessment of the atom interferometer gravity gradiometer to enable passive avoidance of undersea terrain for submarine.
 - (U) Design a high dielectric 7-element GPS Antenna array with digital beamforming and null steering electronics.
 - (U) Develop demonstration hardware/software for the integrated LINK-16/GPS/inertial navigation system.
 - (U) Design and test in the laboratory a low observable M-CRPA (Miniature-Controlled Reception Pattern Antenna) GPS anti-jam aircraft antenna.

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- (U) Plan to transition techniques that reduce GPS vulnerability to jamming and spoofing to the Navy GPS modernization program in PMW/PMA-187.

- (U) SPACE/STRATEGIC SYSTEMS TECHNOLOGY: This program is developing new component technologies, design codes and simulations to preclude obsolescence in ballistic missile system circuitry, design approaches and launch systems.
- (U) Continue the development a design code to minimize the expertise required to design Ballistic Missiles.
- (U) Continue the development of an underwater missile launch computer simulation model.

B. (U) PROGRAM CHANGE SUMMARY:

	FY 1999	FY 2000	FY 2001
(U) FY 2000 President's Budget	67,008	68,823	70,272
(U) Appropriated Value		82,823	
(U) Program Execution Adjustments	-2,685		
(U) Comparability Adjustment	7,929	8,857	
(U) Program Adjustments			10,985
(U) FY 99 SBIR/STRR Transfer	-823		
(U) Inflation Adjustment	-290		
(U) Various Rate Adjustments			-1,352
(U) Congressional Recission		-514	
(U) Congressional Plus Ups		14,000	
(U) FY 2001 PRESBUDG Submission	71,139	91,166	79,905

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PROGRAM ELEMENT TITLE: Command, Control, Communications, Computers, Intelligence, Surveillance & Reconnaissance (C4ISR)

(U) CHANGE SUMMARY EXPLANATION:

(U) Schedule: Not applicable.

(U) Technical: Not applicable

C. (U) OTHER PROGRAM FUNDING SUMMARY: Not applicable

(U) RELATED RDT&E: This program adheres to Defense Science and Technology Reliance Agreements with oversight provided by the Joint Directors of Laboratories-(JDL) Reliance. Work in this PE is related to and fully coordinated with efforts in the following PEs:

- (U) PE 0602702F (Command, Control and Communications)
- (U) PE 0602204F (Aerospace Avionics)
- (U) PE 0602782A (Command, Control and Communications (C³) Technology)
- (U) PE 0602204F (Aerospace Avionics)
- (U) PE 0602709A (Night Vision Technology)
- (U) PE 0601153N (Defense Research Science)
- (U) PE 0603792N (Advanced Technology Transition)
- (U) PE 0603217N (Air Systems and Weapons Advanced Technology)
- (U) PE 0603238N (Precision Strike and Air Defense Advanced Technology)
- (U) PE 0603794N (C3 Advanced Technology)
- (U) PE 0602234N (Materials, Electronics and Computer Technology)

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D. (U) SCHEDULE PROFILE: Not applicable.

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