Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Office of Secretary Of Defense	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603662D8Z / *Networked Communications Capability*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	21.476	5.000	-	-	-	-	-	-	-	Continuing	Continuing
P663: *Network Communications Analysis*	-	21.476	5.000	-	-	-	-	-	-	-	Continuing	Continuing

The FY 2015 OCO Request will be submitted at a later date.

Note

Change from FY 2013 to FY 2014 reflects Departmental decision to conduct this program with a five-year “sunset” clause, which has elapsed.

A. Mission Description and Budget Item Justification

The Networked Communications Capability Program (NCCP) seeks to accelerate the wireless mobile networking capability of Department of Defense’s (DoD) current and planned investments in response to national military strategy and ever growing needs. Today's Warfighter rely more and more on communications networks to support and enable actions from targeting and shooting weapons to video-conferencing. Though military basic infrastructure capabilities follow the mainstream commercial internet, for many reasons (security, mobility, and robustness), commercial telecommunications especially commercial wireless (tactical edge) communications are not well-matched with the requirements of today’s warfighter. These trends will continue as the military data load becomes more diverse and heavy. These tactical edge technology challenges cut across all warfare domains (space, air, ground, and sea). In response to recognized technical problems today, as well as anticipated problems in the future, this research will focus on two key problems in networked technologies: the need for "Joint interoperability" and "expanded reach" (resilient and robust) where no communication infrastructure exists. The main research objectives of this program are to:

– Perform Network Communications Analysis to establish the scientific foundations for tactical mobile networking with a specific emphasis on integrating heterogeneous Networks and Integrated Network Operations (NetOps) for tactical networks.
– Complete the enhancements of joint integrated capability to predict performance of heterogeneous communication networks and expand the reach/connectivity and capacity.
– Jointly manage and operate existing and planned diverse communications networks, services and applications.
– Create mature products for transition to programs of record (POR) or directly to field.
1) Wireless mobile network design, development and operations, spectrum management, information assurance and information dissemination management software tools.
2) Joint Aerial Layer Networking (JALN), services and applications packages including hardware and software systems and integrated/joint network operations software tools and new information architectures.

This research provides the technical basis to standardize the implementation of military network communications capabilities in the areas of joint airborne network gateways and network communications analysis across the military services, Joint Staff, Office of the Secretary of Defense, and defense agencies.

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Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603662D8Z / *Networked Communications Capability*		
B. Program Change Summary ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO**	**FY 2015 Total**
Previous President's Budget	25.393	20.000	-	-	-
Current President's Budget	21.476	5.000	-	-	-
Total Adjustments	-3.917	-15.000	-	-	-
• Congressional General Reductions	-	-15.000			
• Congressional Directed Reductions	-2.325	-			
• Congressional Rescissions	-0.033	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.951	-			
• SBIR/STTR Transfer	-0.598	-			
• Other Program Adjustments	-0.010	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Office of Secretary Of Defense			Date: March 2014
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603662D8Z / *Networked Communications Capability*	Project (Number/Name) P663 / *Network Communications Analysis*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
P663: *Network Communications Analysis*	-	21.476	5.000	-	-	-	-	-	-	-	Continuing	Continuing

The FY 2015 OCO Request will be submitted at a later date.

A. Mission Description and Budget Item Justification

Tactical Mobile Networking - As studies have suggested, for instance, the National Research Council's Network Science Report (2005) and Army Mobile Ad-hoc Network (MANET) JASON's Report (January 2006), the type of networking projected to meet military tactical requirements is not supported by network theory, network design, and analysis tools. This research will define those technical parameters important to military tactical mobile networking environments, investigate the status of network design and analysis tools, and evaluate how modeling and simulation is conducted to support tactical mobile networking environments. The role of network experimentation with respect to network modeling will be explored. Further development and analysis will be conducted to improve the awareness of the condition of tactical mobile networking technologies. Design tools, architectures, and technical approaches will be recommended to acquisition programs as a result of this research.

Network Management Tools and Analysis - Network management in the commercial world is a highly organized, synchronized activity that has excellent tools to monitor activity and repair disrupted networks as needed. These same tools are ill-matched for management in the wireless world, and specifically for military tactical mobile networking. In addition, the military tactical mobile networking environment lacks the infrastructure (connectivity) and support (helpdesk) because resources (spectrum, people, and equipment) are scarce (not in harm's way). As the complexity of networking grows and as network capabilities are introduced, improved network management is required. For military operations, assured delivery may be needed for specific information and operations. This requires management tools to be in place to ensure continued secure and robust operations, which is not achieved with commercial wireless technologies. This research will assess network management tools in place for the military tactical mobile networking environment and develop technology and tools to address shortfalls with the goal to transition technology to operational systems.

Spectrum Management Tools and Analysis - For wireless, tactical mobile networking, the management of the use of spectrum effects network operations. The demand for spectrum is increasing due to the expanded use of sensors, imagery, and voice. This demand increases the pressure on the limited shared radio frequency (RF) spectrum for military tactical networking. The current Department of Defense (DoD) frequency planning and management infrastructure will have a limited ability to cope with this demand through operational planning, Coalition Joint Spectrum Management Planning Tool (CJSMPT) Joint Capability Technology Demonstration (JCTD), and the Global Electromagnetic Spectrum Information System (GEMSIS). Advanced spectrum management concepts such as sense and adapt, spectrum sharing, and dynamic reallocation are under investigation but not yet mature support operations. This research will evaluate opportunities for more efficient and effective use of the frequency spectrum within DoD. Technology advances are expected to advance the concept of cognitive radio and cognitive antenna devices to sense and adapt operations based on spectrum policy and usage, the management of multi-band and multifunction apertures, and the use of spectrum efficient waveforms for use in military environments. This research will develop the models and tools to demonstrate capabilities for operational planning and monitoring of spectrum as these technologies are introduced.

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Integrated Network Management Capability - Network management becomes more complex as more and different types of networking capability become available. Integrated network management across heterogeneous systems, especially wireless systems, requires definition, design, and development. Operationally, network management assumes all functions required to share networking resources and ensure proper operation for participants. This research will define integrated network operations tools for all aspects of network resource management and to prioritize across operational spectrum management, security management, network management, and information management. This research will also develop test beds especially to validate models and simulations used to develop and test network management tools, and conduct experimentation on approaches developed.

Tactical Networking Evolution and Expansion - Fielded and about-to-be-fielded tactical networks can be vastly expanded and evolved from their current capabilities by developing and applying new techniques (or existing techniques developed in basic research) to the existing systems, providing modern capability to the warfighter without the large expense to the DoD of developing new systems. This research will focus on developing and applying new DoD specific techniques to create leap-ahead approaches to Anti-Jam resistance of tactical networks, larger, more fully exploited networks, and expanded capabilities for signal/data processing and data compression in radios and across the networks. This research will take advantage of new software defined radios about to be fielded by the Department, as well as focus on the existing legacy systems, using the successful approach we developed when fielding the Netted Iridium capability.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Tactical Mobile Networking	5.513	0.700	-
Description: This project is for the development of new applications and standards that can be used on existing tactical networks to improve data retrieval and discovery by the tactical warfighter. In addition, research is conducted into tactical communications architectures to develop models useful for optimizing and exploiting tactical networks. New applications and architectures will be tested in a joint federated experimental emulation test bed being developed within this program. Project collaboratively executed by the Navy and Air Force. Results planned for transition to programs of record as maturity of models allow. Research efforts include Wireless Computational Networking Architectures (WCNA), Tactical Edge Protocol Evaluation and Experimentation (TEPEE), Mission Aware Reasoning for Tactical Edge Network Services (MARTENS)/Semantically Augmented Resource Manager (SARM), Dynamic Transport Protocol, Satellite Communications (SATCOM) and Tactical NetOps, MANET Project (with the National Security Agency [NSA]), Cooperative Heterogeneous Communications, Inter-domain Routing, Communications for Autonomous Systems, Network Visualization, Tactical Edge Group-Wise Networking, Advanced Tactical Data Links, Reliable Data Transport, Channel Modeling for Software Defined Radios in Real Atmospheric Environments, and Loss Tolerant Transmission Control Protocol (LT-TCP) for Mobile Wireless Networks. Overall goals: Increase understanding of the condition of tactical mobile networking technologies. Improve specification of technical standards and policy for tactical mobile networking. Refine fidelity modeling and simulation to support operations analysis and the articulation of operational requirements and performance parameters. ***FY 2013 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Office of Secretary Of Defense		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603662D8Z / *Networked Communications Capability*	**Project (Number/Name)** P663 / *Network Communications Analysis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Performed distributed spectrum sensing Small Unmanned Aircraft System (SUAS) experiments. Investigated integration of compressive sensing based compression and encryption. Demonstrated Capability Enabler Network enabling advanced collaborative/secure networks. - Continued extension of the system for operation in tactical environments. Developed enhanced user interface functionality. Integrated MARTENS capability into Network Agent Technology for Management (NATM) (Air Force Research Laboratory (AFRL)) and Joint Integrated Network Management System Exchange (JINX) (Communications-Electronics Research, Development and Engineering Center (CERDEC)) systems. - Developed location and path aware protocol tuning mechanisms. Designed basic protocol architecture integrating multiple transport protocols. Emulated protocol architecture to analyze performance in realistic tactical environments. - Began SATCOM planning and control software early prototypes. Evaluated design architectures for using the Mobile User Objective Systems (MUOS). Developed implementation methods to apply Precision Polarization for Terrestrial SATCOM. - Tested and matured prototype software code and standards. Analyzed, modeled and designed prototype server-less Voice over Internet Protocol (VOIP) systems. Evaluated and developed new Stochastic Routing protocols for Disruption Tolerant Networking (DTN). - Explored opportunities to transition advances in the protocol development to programs or services. Extended the network coding protocols to different scenarios. - Explored alternatives to Border Gateway Protocol (BGP) that can handle the dynamics of mobile tactical networks, with potential applications to emerging networks across programs and services (Warfighter Information Network-Tactical (WIN-T), JALN, etc.). - Defined communication risk environment. Developed autonomous decision making algorithms. - Collected feedback on the initial prototypes from networking research staff. Expanded visualization prototypes which hold the most promise. Defined specifications for a full-featured Network Visualization Toolkit. - Conducted initial field experiment at Naval Post-graduate School (NPS) Tactical Network Testbed (TNT) facility. Continued development of network protocol mechanisms to support distributed, autonomous group-wise communication. Enhanced the Adaptive Reliable Video Service (ARVIS). - Performed science and technology (S&T) in efficient dissemination backbones and adaptive ad hoc routing. Investigated performance trade-off of reliable multicast and unicast transport methods for mobile tactical edge communications. Researched decentralized mobile service discovery mechanisms. Researched serverless group messaging. ***FY 2014 Plans:*** - Complete research for Adaptive Rate Video Service (ARViS), Nack-oriented Reliable Multicast (NORM) and NORM Proxy (NORP), Distributed Service Discovery (iNDI/ProtoSD), and Extendable Mobile Ad-hoc Network Emulator (EMANE). - Produce final reports and documentation.			
Title: Network Management Tools and Analysis	2.816	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: This project is for the development of joint standards and tools for policy-based and measurement-based tactical network management. New standards and applications will be tested in a joint federated experimental emulation test bed being developed within this program. This project is jointly executed by the Navy, Air Force and Army, with technology transition agreements being pursued with programs of record. Research efforts include NATM, JINX, Tiger Team Analysis, Tactical Resource Management and Control, End-to-End Network Management (NEEMO), Naval Research Laboratory (NRL) Information Assurance, Optimal Scheduling in Time Division Multiple Access (TDMA) Networks, and Dynamic Policy Management (DPM). Overall goals: Increased understanding of the complexity of the tactical network management. Determination of the support required for tactical network operations. Evaluation of technology to support transition and fielding to operational capability. ***FY 2013 Accomplishments:*** - Developed Enhanced Anomaly Detection. Augmented system to support Dynamic Spectrum Access decisions. Initialized integration with Net Design capability. - Evaluated requirements for integrating physical layer and networking layer designs for the multifunctional waveform to provide a complete solution. Evaluated results of integration studies for implementing Mobile User Objective System (MUOS) satellite systems into tactical networks. - Integrated real radios and networks into emulation environment to demonstrate operation of a universal interface and verify the feasibility of configuring and monitoring real communications equipment. - Researched requirements and develop capabilities to provide mobile tactical warfighters with automated indications of network health, and research requirements for deployment into heterogeneous tactical network environments. Researched methods for obtaining network topologies from flow-based monitoring techniques, and research implementation of methods for dynamic analysis and mapping of cross-domain quality of service (QoS) requirements. Researched utilizing network data analysis to optimize network bandwidth usage. - Researched solutions to address the fair negotiation human factor problem. Matured the Dynamic Policy Management (DPM) algorithm and software. Integrated policy negotiation to Policy-based Network Management (PBNM) systems.			
Title: Spectrum Management Tools and Analysis ***Description:*** This project is for the development of measurement-based spectrum management tools. Applications will be developed and tested in a laboratory environment. Project is executed by the Army and results are available to the Navy and Air Force through the Joint NETOPS Integrated Collaborative Working Group. Research efforts include Spectrum Analysis and Experimentation in Dynamic Operational Environments (SAEDOE), Agile Spectrum and Network Testbench (ASPECT), Dynamic Spectrum Access (DSA) Spectrum Analysis Software, Cognitive Networking Radio Algorithmic Fusion, Integrating Comm and Electronic Attack, SIGINT-assisted Spectrum Management and Control, Cognitive Radio Technology, Networking for Spectrum	5.130	1.000	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Aware Cognitive Radios, DSA Enhancements, Spectrum Sharing Trade Study, and Directional Ad hoc Networking Technology - 2 (DANTE - 2). Overall goal: Develop the technical basis to support changes regarding the operational use of spectrum both within the military and among spectrum regulatory bodies. ***FY 2013 Accomplishments:*** - Continued airborne spectrum data collection. Implemented DSA algorithm hardware. Validated previously simulated DSA techniques via experiments. - Continued prototype RF control software development. Implemented three node prototype controllable spectrum capability. Conducted experimentation utilizing framework. - Completed development of measurement-based DSA and policy management software. Developed and tested on a radio emulation test bed negotiated spectrum access algorithms and evaluated its inclusion into current tactical waveforms. Tested and demonstrate real time DSA algorithm. Developed spectrum sharing mechanisms with commercial providers/systems to address the limitation imposed on tactical networks by the National Broadband Plan. - Investigated generalized media access control (MAC) layer electronic attack techniques. Researched joint networked comm/ jammer waveform. Demonstrated promising capabilities. Continued investigations of joint Network comm/jamming architectures. - Completed Signals Intelligence (SIGINT) -assisted Spectrum Management and Control project. - Developed a set of spectral scenarios to evaluate DSA radios, including individual and environmental radios. Expanded and increased the fidelity of the modeled environment and explore Electronic Attack (EA) effectiveness against cognitive jammers. Created cooperative sensing strategies for heterogeneous environment and real-time RF channel emulation interface RF with propagation models to Extendable Mobile Ad-hoc Network Emulator (EMANE). - Developed scheduling mechanisms in wireless networks that employ multi-user detection (MUD) for allowing simultaneous transmissions. Analyzed the multicast throughput and stability for a two-user cognitive radio system and analyzed the capacity-delay tradeoffs in cognitive radio networks. Developed throughput maximization schemes for secondary nodes in a cognitive network under the transparent co-existence paradigm, and continued to develop a protocol framework of bandwidth exchange (BE)-based networking. - Developed alternate spectrum architectures. Estimated incumbent and entrant implementation and recurring costs for each architecture. Developed test plan to validate key assumptions and results. - Extended DANTE-2 to other frequencies. Extended network topology automation to multiple frequencies. ***FY 2014 Plans:*** - Integrate spectrum sensing effort, Advanced Real-Time Global Surveillance User Surveillance (ARGUS), with both NEEMO and SATCOM Planning and Execution Services (SPES).			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Transition spectrum sharing demonstrations for with ongoing LTE Test and the Soldier Radio Waveform (SRW) Real-Time Frequency Management (SRFM) effort. - Conduct at least one additional transition demonstration at the AFRL Stockbridge Spectrum Testing Facility.			
Title: Integrated Network Management Capability	5.073	-	-
Description: This project is for the development of joint integrated network management tools, and three federated experimental test beds for the development and evaluation of integrated tactical network management and spectrum management. The project is executed jointly by the Navy, Army and Air Force. The plan is to also establish a Joint Network Operations (NETOPS) Integrated Collaborative Working Group for the establishments of standards and joint development in support of all projects in this program. Membership includes the research community from the Navy, Marine Corps, Army and Air Force as well as developers from acquisition programs such as Warfighter Information Network-Tactical (WIN-T) and Joint Tactical Radio System (JTRS). Future plans call for further joint infrastructure test bed development to include DoD PlanetLab as well as joint networking tools in support of NETOPS. The results of this research will transition to future increments of JTRS and WIN-T, and if successful, to the field through a joint integrated tactical NETOPS program. Research efforts include Measurement Lab (M-Lab) Characterization of the Unmanned aerial vehicle [UAV] Network Environment (CUNE)/Edge Network Visualization and Emulation (ENVE), Tactical Edge Network Integration and Operational Environment Testbed, Joint Network Management Interoperability, Wireless Networking Library (WNL), Network Emulation and Experimentation, and Tactical Edge Wireless Experimentation. Overall goals: Common integrating framework to support interoperability among various aspect of developmental network operations and management to include spectrum management, network management, security management, and information management. Reduce the cost to develop, procure, and support networks through the integration across networks and functions within networks. ***FY 2013 Accomplishments:*** - Conducted routine administration and maintenance of the WNL. Demonstrated WNL at targeted conferences. Examined technology refresh and additional software features. - Worked on verification and validation (V&V) of waveforms and protocols in the scalable emulation. Improved the ability to set up and operate large scale emulations. Transitioned capability to other DoD programs. - Continued Common Open Research Emulator (CORE) and EMANE development. Matured Network Modeling Framework (NMF) and additional wireless models. Collected and analyzed field test data to validate emulation modeling through various test, visualization, and data analysis tools.			
Title: Tactical Networking Evolution and Expansion	2.944	3.300	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: This project is for the development of new applications and approaches that can be used on existing tactical networks to improve the physical and networking layers for the tactical warfighter. It will explore new ways to build architectures, antennas, and signal and data processing or exploit waveforms to improve Anti-Jam resistance, network throughput and scale, or network packet routing, and improve these metrics at low cost and without sacrificing interoperability. Research efforts include Joint Aerial Layer Network (JALN) Network Management/Control Concept Analysis, Advanced Tactical High-Performance Network Architecture (ATHENA), Network Radio Characterization Limited Objective Experiment (LOE), Multi-Function Wave Form (Resilient Electronic Warfare [EW] /Communications[Comms]), and the Asymmetric Broadcast Command and Control System (ABC2) Anti-Access/Area Denial (A2/AD) Demonstration. Overall goal: Next generation tactical networking in the fielded tactical systems, with vastly increased capabilities, at the lowest cost possible to the DoD. ***FY 2013 Accomplishments:*** - Tested Joint Concept process inserts. Completed Joint Concept analysis documentation. - Began algorithmic and architectural improvements to the ATHENA physical, MAC, and network layer designs, incorporating feedback from network simulation and emulation performance experiments. Began a hardware implementation of the ATHENA algorithms and architectures as an integrated air tactical domain solution. - Conducted a field demonstration of various application layer tools and network services in a heterogeneous tactical network. - Developed a Multifunctional Electronic Warfare & Communications Waveform components capable of providing simultaneous communications and EW functions. Developed hardware interface and software architectures. Developed scheduling algorithms advanced routing features and Physical/Media Access features. Developed integrated comms/EW models. ***FY 2014 Plans:*** - Transition ATHENA to the Robust TDL Modernization (RTDLM) effort. - Transition Networks Program network management and situational awareness Tools to the Joint Multilayer Command and Control at the Tactical Edge (JMC2TE) effort. - Transfer network management testbeds and CORE/EMANE Tools to the Joint Assessment Research Testbed (JART) in support of JALN-Asia Pacific (JALN-AP) and JALN-NarrowBand (JALN-NB) efforts.			
Accomplishments/Planned Programs Subtotals	21.476	5.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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D. Acquisition Strategy

The Netted Iridium (NI) capability was transitioned directly to production and sustainment to the Distributed Tactical Communications System (DTCS)-Army program by the Army for use in the U.S. Central Command Area of Responsibility. Other program capabilities were transitioned to appropriate acquisition programs.

E. Performance Metrics

Strategic Goals Supported: Net-Centric Warfare/Joint Interoperable Communication. Meet current needs of tactical warfighter.

Existing Baseline: Prototype relays and gateways; initial federated, laboratory test beds; and prototype joint network management tools.

Planned Performance Improvement / Requirement Goal: Link expansion in prototype relays and gateways; and continued integration in federated test beds; demonstration of prototypes and software tools.

Actual Performance Improvement: Prototype and transition able relays and gateways; usage of federated test beds; and demonstration of prototypes and software tools.

Planned Performance Metric / Methods of Measurement: Utilization of federated test beds; and demonstration of prototypes and software tools.

Actual Performance Metric / Methods of Measurement: Progress on test bed development; prototype software demonstrated; and prototype architectures developed.