Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Office of the Secretary Of Defense	Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
Total Program Element	-	9.123	12.661	12.696	-	12.696	2.866	2.920	2.973	3.027	Continuing	Continuing
663: *Network Communications Analysis*	-	9.123	12.661	12.696	-	12.696	2.866	2.920	2.973	3.027	Continuing	Continuing

Note

Service Requirements Review Board (SRRB) efficiencies are included.

A. Mission Description and Budget Item Justification

Currently fielded satellite communications (SATCOM), terrestrial, and Tactical Data Links (TDLs) will be adversely affected during operations in contested Anti-Access/ Area-Denial (A2/AD) environments. The primary threat is from sophisticated electronic warfare capable of advanced jamming and signal collection techniques that are rapidly evolving to be more capable and agile. Department of Defense (DoD) advances in smart sensors and smart weapons have an urgent need for more resilient networks than tactical data links of today. In FY 2016, the Network Communications Capability Program (NCCP) returned with a new focus on developing enabling technologies for Joint assured communications networks. The goals of this program are: to mitigate degradation across battlespace tiers and domains and to provide agility that will support the mission needs of Joint Functional Component Commanders, Joint Force Commanders, and deployed forces.

The DoD's current TDLs platforms and capabilities are not sufficiently protected from emerging adversary threats and contain insufficient capacity for future needs. In order to enable the promise of net-centric operations for the warfighter, the next generation of airborne, surface, and ground tactical networks must provide greater affordability, higher network capacity, greater durability against electronic attack, better network connectivity, and faster response times to the changing demands from airborne, maritime, and ground users. Many line-of-sight (LOS), beyond LOS, and SATCOM waveforms have been integrated onto platforms for various missions. These waveforms necessarily exhibit tradeoffs in target performance attributes including capacity, latency, protection, and complexity. As a result, no single waveform capability will be able to satisfy all emerging mission needs emphasizing the need for interoperability and software defined waveforms. The challenge is to understand the essential needs of the users, avoid needless redundancy, develop affordable capabilities, and integrate separate capabilities into a cohesive network. This research will develop transformative technologies to ensure performance in contested A2/AD environments by focusing on future communications networks that are a "leap ahead" of today's capabilities.

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Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603662D8Z *I Networked Communications Capability*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	9.331	12.661	7.779	-	7.779
Current President's Budget	9.123	12.661	12.696	-	12.696
Total Adjustments	-0.208	0.000	4.917	-	4.917
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.197	-			
• FFRDC Transfer	-0.010	-	-	-	-
• Other Program Adjustments	-0.001	-	5.002	-	5.002
• Economic Assumption	-	-	-0.085	-	-0.085

Change Summary Explanation

FY 2019 adjustments are reflective of higher priority DoD requirements.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense											Date: February 2018	
Appropriation/Budget Activity 0400 / 3					R-1 Program Element (Number/Name) PE 0603662D8Z / *Networked Communications Capability*				Project (Number/Name) 663 / *Network Communications Analysis*			
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
663: *Network Communications Analysis*	-	9.123	12.661	12.696	-	12.696	2.866	2.920	2.973	3.027	Continuing	Continuing

A. Mission Description and Budget Item Justification

In a contested environment, especially when conducting forward operations, platforms face a significant electronic warfare threat. The primary threat is from advanced jamming, signal collection, and geolocation techniques that are rapidly evolving to be more capable and agile. DoD advances in smart sensors and weapons demand robust tactical waveforms and networks with greater capacity but lower cost than communication links of today.

The Future Autonomous Battlespace RF with Integrated Communications (FABRIC) (formerly referred to as Robust Tactical Data Links Modernization (RTDLM)) program will develop next generation communications layer architecture for tactical networks for operations in anti-access/area denial (A2/AD) threat environments. This architecture will deliver capacity and affordability to enable future smart sensors and smart weapons. The network architecture will be flexible enough to support Commander's Intent in any mission, environment, operating tactical platform, and weapon system under various threat conditions. FABRIC's efforts will focus on developing the advanced component technologies, such as Anti-Jam(AJ), Low Probability of Interference (LPI), Low Probability of Detection (LPD), and Low Probability of Exploitation (LPE) waveforms; adaptive processing algorithms; adaptive antenna technologies (transmit/receive/nulling); adaptive power control; Dynamic Spectrum Access (DSA)/Dynamic Spectrum Management (DSM) techniques; self-healing mechanisms and cyber hardening; and advanced routing to ensure Quality of Service. The guiding tenets for creating this new Command, Control, Communications, Computers, & Intelligence (C4I) capability encompass enabling new missions, i.e. providing resilient tactical data links, communications and networking "service level" capabilities, interoperation, cost (affordable), and improved performance in terms of military value.

Based on the developed thresholds and objectives for the required network architecture, the specific advanced component technologies were prioritized and form the foundation of the FABRIC design. Through simulation and field experimentation, FABRIC will verify the technology in operationally relevant environments against representative threats, and facilitate the migration and transition of these technologies to service platforms, radios, and other combat mission systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Future Autonomous Battlespace RF with Integrated Communications (FABRIC)	9.123	12.661	12.696
Description: The FABRIC program develops hardware, software, and algorithms to advance network technologies creating a robust tactical network to operate in contested A2/AD environments. The project will investigate and develop flexible, high performance, and affordable technologies for the tactical network, supporting capability changes as a mission progresses from phase to phase. The project will develop and mature technologies to support direct transition of the algorithms, prototype implementations, waveform improvements, and system design improvements to radio, waveform, and weapon systems programs managed by each military department.			
FY 2018 Plans:			

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Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603662D8Z / *Networked Communications Capability*	**Project (Number/Name)** 663 / *Network Communications Analysis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
System Integration - Define the overall system architecture. - Determine integration benchmarks; design and execute integration tests. - Conduct modeling and simulation of aperture and platform interactions. Transition Planning - Identify and consolidate transition paths including performance requirements and constraints. - Continue to modify and mature variations of the A2/AD related scenarios to identify performance parameters and potential transition opportunities. - Define and execute scenarios in a mega-city environment and those that involve Electronic Warfare (EW), signals intelligence (SIGINT), RADAR or Precision/Navigation/Timing (PNT) functions interacting with FABRIC to include red electromagnetic interactions. Modeling and Simulation - Leverage and integrate into the ns-3 network simulator, the Joint Semi-Automated Forces high level architecture framework, to allow utilization of the “Mega-city/Jakarta” model. - Extend network protocols and modem performance into ns-3. Aperture Development - Design program baseline aperture(s) that provide directional 360° coverage by mid FY 2018. - Develop thermal and electrical model of intended electronically steerable antennas with no power amplifiers. - Conduct a study focusing on the low-cost manufacturing of an electronically scanned array (ESA). Prototyping and experimentation - Code and refine FABRIC directional networking functionality to enable measurements of performance in realistic mission environments. - Lab-bench prototyping of the directional networking functionality (radio frequency (RF)) front-end and the ESA. Hardware and Software Development - Complete detailed design of chip processor and fabricate through 14 nanometer trusted foundry. - Continue software and firmware development (development, optimization, verification & validation) to include completion of software modeling on the instruction set simulator. - Create emulation framework in Defense Advanced Research Projects Agency's (DARPA) Arrays at Commercial Timescales (ACT) common module.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
- Develop FABRIC software architecture. Directional Networking Functionality - Code and refine FABRIC directional networking functionality to enable measurements of performance in realistic mission environments. - Conduct performance and scalability analysis to inform upgrade recommendations. - Baseline upgrades (waveform, networking concepts, antenna management). - Complete ns-3 integration of channel, beamforming, modem, and other directional networking functionalities. - Complete modeling of system level controls, interfaces, and DARPA ACT modules. ***FY 2019 Plans:*** System Integration - Complete integration of the DARPA ACT chips with the chip processor emulation board. - Complete integration of major functional system elements and hardware/software components (such as ESA, RF, and processing). - Construct and exercise preliminary FABRIC network for system integration and validation. Scenarios and Transition Planning - Complete implementation of the mega city scenario. - Continue to refine joint demonstration plans. - Modify and mature variations of the A2/AD related scenarios to match realistic performance parameters to align with Service transition partners. - Explore dynamic mission adjustments and communication interactions with realistic EW/SIGINT/RADAR/PNT functions on various platforms. Prototyping, Lab, and Field Testing - Complete physical, low cost (with size, weight, and power considerations) phased array prototype. - Design and execute lab and controlled field testing of beam forming capability at the Air Force Research Laboratory's Stockbridge Controlled Contested Environment site. - Evaluate performance results during field testing against planned performance parameters and adjust accordingly. - Plan for a system field testing of the network supporting links to unmanned aerial vehicle platforms and nearby units operating in an urban/dense environment. - Identify deficiencies in hardware.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Hardware/Software - Probe test processor chips for functionality. - Deliver processor chip design for fabrication (second run on trusted foundry). - Complete and maintain suite of software development tools such as libraries, compiler, assembler, linker, profiler, debugger, mission developer, executable code, and loader. - Deliver full baseline software stack; validate execution speed, latency, and operational resilience of software. - Code and port EW/SIGINT/RADAR/PNT functions into software architecture. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 adjustments are reflective of higher priority DoD requirements.			
Accomplishments/Planned Programs Subtotals	9.123	12.661	12.696

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

The FABRIC project will address capability gaps for Joint tactical data link networks by developing the technologies that the Military can incorporate in future platform and radio acquisitions. The proposed experimentation, with field demonstrations and modeling, will increase the Technology Readiness Level (TRL) of critical technology components, suitable for transition to acquisition programs. This will also provide DoD leadership with the supporting technical and cost details to identify candidate "building blocks" for timely incremental improvements.

E. Performance Metrics

The Research, Development, Test, and Evaluation (RDT&E) goal for FABRIC is capability improvements that achieve greater than 70 percent “Buy-Back” of the tactical data link operational range and 80 percent of the area of operation lost in the A2/AD environment.

- Enhanced Link Capacity: 10X-100X Faster
- Enhanced Connectivity: 4X-10X Network Neighbor Connections
- Enhanced Spatial/Time Filtering: 4-7 Adaptive Nulls (Scenario Dependent)
- Receiver Based Mitigation: 20-30dB per Jammer Type (Scenario Dependent)
- Enhanced LPI/LPD: 4X-10X Closer Range to Target with Same Percent LPI/LPD
- Enhanced Network Scalability: 300-1000 nodes
- Low cost AESA systems: <$25K each

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Achieve significant DoD savings for radio modifications or integration into new terminals or platforms (economies of scale) as services share non-recurring development costs for common and successful TDL enhancements.