Exhibit R-2, **RDT&E Budget Item Justification:** PB 2020 Office of the Secretary Of Defense | **Date:** February 2019

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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	-	12.369	12.667	2.858	-	2.858	2.912	2.964	3.016	3.081	Continuing	Continuing
663: *Network Communications Analysis*	-	12.369	12.667	2.858	-	2.858	2.912	2.964	3.016	3.081	Continuing	Continuing

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 become 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* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603662D8Z / *Networked Communications Capability*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	12.661	12.696	2.866	-	2.866
Current President's Budget	12.369	12.667	2.858	-	2.858
Total Adjustments	-0.292	-0.029	-0.008	-	-0.008
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.268	-			
• FFRDC Reduction	-0.024	-0.029	-	-	-
• Other Program Adjustments	-	-	-0.008	-	-0.008

Exhibit R-2A, RDT&E Project Justification: PB 2020 Office of the Secretary Of Defense		**Date:** February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
663: *Network Communications Analysis*	-	12.369	12.667	2.858	-	2.858	2.912	2.964	3.016	3.081	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 become 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 Radio Frequency with Integrated Communications (FABRIC) program is developing 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 is flexible enough to support Commander's Intent in any mission, environment, operating tactical platform, and weapon system under various threat conditions. FABRIC's efforts focus on developing the advanced component technologies, such as Anti-Jam (AJ), Low Probability of Intercept(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 is verifying the technology in operationally relevant environments against representative threats, and facilitates the migration and transition of these technologies to service platforms, radios, and other combat mission systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Future Autonomous Battlespace RF with Integrated Communications (FABRIC) ***Description:*** The FABRIC program develops hardware (HW), software (SW), and algorithms to advance network technologies creating a robust tactical network to operate in contested A2/AD environments. The project investigates and develops flexible, high performance, and affordable technologies for the tactical network, supporting capability changes as a mission progresses from phase to phase. The project develops and matures 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 2019 Plans:*** HW and SW Development	12.369	12.667	2.858

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Deliver Cyber Hardened Embedded and Exascale Trusted Architecture Processor (CHEETAH) processor design and fabricate through 14 nanometer trusted foundry. - Deliver full baseline software stack; validate execution speed, latency, and operational resilience of software. - Design proof of concept High Frequency (HF) capability that enables the propagation of electromagnetic waves. Design concept will address four major technology areas: software defined, wideband antennas, mesh networking, and ionosphere nowcasting. Prototyping, Lab, and Field Testing - Complete physical/low cost (with Size, weight, and power considerations) phased array prototype effort. - Design and execute lab and controlled field testing of beam forming capability at the Air Force Research Lab's Stockbridge Controlled Contested Environment site. - Design a system field testing of the network supporting links to unmanned aerial vehicle (UAV) platforms and nearby units operating in an urban/dense environment. System Integration - Complete integration of major functional system elements and HW/SW components (such as electronically steerable aperture (ESA), Radio Frequency (RF), and processing). - Construct and exercise preliminary FABRIC network for system integration and validation. - Modeling & simulation and testing of FABRIC system performance against electromagnetic pulse. Scenarios and Transition Planning - Continue to modify and mature variations of the A2/AD related scenarios to identify performance requirements and firm up transition plans - Explore dynamic mission adjustments and communication interactions with realistic multi-modality (precision-navigation-timing (PNT), electro-optical (EO), etc.) functions on various platforms. ***FY 2020 Plans:*** HW and SW Development - Design and fabric CHEETAH printed circuit board (PCB) with DARPA's Arrays on Commercial Timescale Multi-Chip Modules. System Integration - Software integration on PCB including beamforming, modems, networking functions. - Integration and test of PCB with the aperture. - Port and test EO and RADAR code.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Scenarios and Transition Planning - Continue to modify and mature variations of scenarios to assess and validate performance requirements and firm up transition plans. - Continue to explore dynamic mission adjustments and communication interactions with realistic multi-modality (PNT, EO, etc.) functions on various platforms. Prototyping, Lab, and Field Testing - Complete prototype ready for integration. - Continue planning for System Field testing of the fully prototyped network. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 to FY 2020 adjustments are reflective of higher priority DoD requirements.			
Accomplishments/Planned Programs Subtotals	12.369	12.667	2.858

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

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- Low cost AESA systems: <$25K each

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.