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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Defense Advanced Research Projects Agency **Date:** March 2019

Appropriation/Budget Activity 0400: <i>Research, Development, Test & Evaluation, Defense-Wide / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602702E / <i>TACTICAL TECHNOLOGY</i>
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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	-	292.957	309.466	337.602	-	337.602	283.854	256.281	280.592	289.652	-	-
TT-03: <i>NAVAL WARFARE TECHNOLOGY</i>	-	32.535	44.771	42.859	-	42.859	10.534	11.059	29.059	34.059	-	-
TT-04: <i>ADVANCED LAND SYSTEMS TECHNOLOGY</i>	-	80.428	109.286	138.040	-	138.040	118.783	83.948	76.891	75.951	-	-
TT-07: <i>AERONAUTICS TECHNOLOGY</i>	-	60.151	50.799	53.119	-	53.119	47.328	59.119	47.528	47.528	-	-
TT-13: <i>INFORMATION ANALYTICS TECHNOLOGY</i>	-	119.843	104.610	103.584	-	103.584	107.209	102.155	127.114	132.114	-	-

A. Mission Description and Budget Item Justification

The Tactical Technology Program Element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology Program Element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Aeronautics Technology and Information Analytics Technology.

The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities such as improved situational awareness over large maritime environments, ship self-defense techniques, novel underwater propulsion modalities, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, and high bandwidth communications.

The Advanced Land Systems Technology project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire. This project will also develop methods that fundamentally change the calculus of battle including consideration of a mix of assets, potentially disposable or with limited lifespans, with increased levels of autonomy are included.

The Aeronautics Technology project addresses high payoff opportunities that dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion and vehicle concepts, sophisticated fabrication methods, and examination of novel materials for aeronautic system applications.

The Information Analytics Technology project develops technology for analyzing data and information arising from: 1) intelligence networks; 2) open and other external sources; 3) sensors and signal/image processors; and 4) collection platforms and weapon systems. Technical challenges include the need to process huge volumes

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of diverse, incomplete, and uncertain data in tactically-relevant timeframes. Benefits sought include deeper understanding of the evolving operational environment tailored to the needs of commanders at every echelon; an enhanced capability to plan, monitor, and control diverse military operations ranging from stability operations to combat; and improvements to the efficiency of core military functions such as national and homeland security, warfighter health and readiness, and defense support of law enforcement and civil authorities. Promising technologies are evaluated in the laboratory and demonstrated in the field to facilitate transition.

B. Program Change Summary (\$ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	343.776	335.466	344.387	-	344.387
Current President's Budget	292.957	309.466	337.602	-	337.602
Total Adjustments	-50.819	-26.000	-6.785	-	-6.785
• Congressional General Reductions	-32.966	-26.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-5.689	0.000			
• SBIR/STTR Transfer	-12.164	0.000			
• TotalOtherAdjustments	-	-	-6.785	-	-6.785

Change Summary Explanation

FY 2018: Decrease reflects Congressional reduction, SBIR/STTR transfer and reprogrammings.

FY 2019: Decrease reflects Congressional reduction.

FY 2020: Decrease reflects minor program repricing.

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Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY				Project (Number/Name) TT-03 / NAVAL WARFARE TECHNOLOGY			
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
TT-03: NAVAL WARFARE TECHNOLOGY	-	32.535	44.771	42.859	-	42.859	10.534	11.059	29.059	34.059	-	-

A. Mission Description and Budget Item Justification

The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities to include the entire sea column such as improved situational awareness over large maritime environments, ship self-defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, methods and techniques for servicing assets throughout the sea column, and high bandwidth communications. This project will also examine methods and architectures for distributing maritime operations to enable a more agile, survivable, and cost-effective fleet.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2018	FY 2019	FY 2020
<p>Title: Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES)</p> <p>Description: The Multi-Azimuth Defense Fast Intercept Round Engagement (MAD-FIRES) program seeks to develop a point defense system against today's most stressing threats by developing a highly maneuverable, medium caliber, guided projectile, fire sequencing and control system capable of neutralizing large threat raids of high speed, highly maneuverable targets. Leveraging recent advancements in gun hardening, miniaturization of guided munition components, and long range sensors, MAD-FIRES advances fire control technologies, medium caliber gun technologies, and guided projectile technologies enabling the multiple, simultaneous target kinetic engagement mission at greatly reduced costs. MAD-FIRES seeks to achieve lethality overmatch through accuracy rather than size, thus expanding the role of smaller combat platforms into missions where they have been traditionally outgunned. MAD-FIRES, sized as a medium caliber system, enhances flexibility for installment as a new system and as an upgrade to existing gun systems with applications to various domain platforms across a multitude of missions to include: ship self-defense, precision air to ground combat, precision ground to ground combat, counter unmanned air vehicles (C-UAV), and counter rocket and artillery and mortar (C-RAM).</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Begin detailed design of system prototype that includes projectile, gun system, and fire control system. - Update projectile design based on previous year flight test results. - Validate sensor modeling and simulation through realistic environment testing. - Verify projectile compatibility with high speed gun feed system. - Verify fire control system ability to acquire and track surrogate threats. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Verify fire control system ability to guide rounds to target. 	32.535	32.771	29.859

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<ul style="list-style-type: none"> - Perform end-to-end demonstration of gun launched guided flight. - Begin detailed planning for end-to-end system demonstration against surrogate targets. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 decrease reflects completion of design and fabrication activities.</p>			
<p>Title: Angler*</p> <p>Description: *Formerly Lobster</p> <p>The undersea domain has significant importance to national security and military operations. Yet it is a challenging domain in which to operate due to extreme water pressures, restricted communications, ever changing bottom environments, marine fouling and corrosion. The Angler program seeks to improve U.S. operations in this domain by enabling underwater robotic systems significantly ahead of the state of the art. These robotic systems would be able to search and manipulate objects autonomously, even in dark, turbulent, and semi-opaque sea conditions without the need for human control and without reliance on the Global Positioning System (GPS). Key Angler technical challenges include sensing techniques that provide high-resolution navigation without GPS, perception and manipulation strategies for objects with unknown parameters, long duration autonomy approaches to support mission execution, and autonomy approaches that do not rely on human intervention. In FY 2020, this program is also funded in PE 0603766E, Project NET-02. The anticipated transition is to the Navy.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct exploratory trade studies to establish feasibility of technical approaches. - Initiate systems engineering and begin design of prototype architecture for autonomous, undersea manipulation operations. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Complete Conceptual Design Review (CDR). - Conduct Preliminary Design Review (PDR). - Test robot subsystems in laboratory or simulation environments. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects initiation of PDR and testing activities.</p>	-	12.000	13.000
Accomplishments/Planned Programs Subtotals	32.535	44.771	42.859

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C. Other Program Funding Summary (\$ in Millions)

<u>Line Item</u>	<u>FY 2018</u>	<u>FY 2019</u>	<u>FY 2020</u> <u>Base</u>	<u>FY 2020</u> <u>OCO</u>	<u>FY 2020</u> <u>Total</u>	<u>FY 2021</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
• ACTUV: Office of Naval Research MOA	3.917	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY				Project (Number/Name) TT-04 / ADVANCED LAND SYSTEMS TECHNOLOGY			
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
TT-04: ADVANCED LAND SYSTEMS TECHNOLOGY	-	80.428	109.286	138.040	-	138.040	118.783	83.948	76.891	75.951	-	-

A. Mission Description and Budget Item Justification

The Advanced Land Systems Technology project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. Programs seek to break the relative symmetry of land combat to give U.S. forces a decided advantage in the current and future ground battlefield. The emphasis is on developing affordable technologies that reduce reliance on consolidated forward-operating bases and required lines of communication, and provide small units and individual warfighters with hyper-mobility and hyper-lethality. This project will develop methods and technologies to expand the maneuver trade space to include the vertical dimension, including subterranean environments, and will leverage advances in artificial intelligence to enable integrated manned-unmanned operations and decrease warfighter exposure through the use of autonomous agents.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2018	FY 2019	FY 2020
Title: Squad X	27.928	28.286	26.040
<p>Description: The U.S. military achieves overmatch against its adversaries in certain regimes; however, this level of overmatch is not enjoyed at the squad to individual dismounted warfighter level. The goal of the Squad X program is to leverage advances in real-time situational awareness and mission command; organic three-dimensional dismount mobility; extended range tracking, targeting, and response; and unmanned mobility and perception in order to create a squad with substantial combat overmatch. The concept of overmatch at the squad level includes increased human stand-off, a smaller force density, and adaptive sensing to allow for responses at multiple scales. Squad X will explore advanced wearable force protection, advanced organic squad level direct and indirect trajectory precision weaponry, and non-kinetic precision capabilities. The end result of the Squad X program is an individual dismount unit outfitted with sensors, weaponry, and supporting technology to achieve unit level overmatch as well as the overall integration of unmanned assets alongside the dismounts to create an advanced, dismounted small unit.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Complete initial technology development efforts focusing on human machine interfaces, the squad common operating picture in three dimensions, and the synchronization of kinetic and non-kinetic engagement capabilities. - Complete initial squad-system development efforts focusing on an automatic, augmenting system to increase squad performance and the integration of previously developed technology to enhance dismounted operations. - Conduct system-level experimentation and evaluation in relevant conditions with operational units with increased number of humans and unmanned systems in the squad. - Demonstrate mission planning, rehearsal, and playback capabilities using the squad-leader-in-the-loop (SLIL) 3D simulation environment. 			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<ul style="list-style-type: none"> - Initiate expanded squad-system development efforts with focus on increased squad performance against threat capabilities analogous to near-peer/peer states. - Design and develop integrated systems, to include addition of new sensors, unmanned systems, engagement capabilities, and improved decision algorithms. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Continue expanded squad system development efforts focusing on enhanced situational awareness and engagement capabilities. - Continue to develop and optimize the squad common world model and intelligent decision engine. - Continue to leverage the SLIL environment to plan and rehearse missions with increased squad system/subsystem and threat capabilities. - Optimize autonomous cross-cuing of squad assets and sensor nodes, and integrated kinetic and non-kinetic engagement capabilities. - Integrate multiple unmanned nodes into the squad system, with enhanced mobility and/or payload capabilities. - Conduct increasingly complex system-level experimentation and evaluation with operational units, to include: increased number of humans and unmanned systems in the squad and new squad technologies/capabilities. - Experiment with system performance in multiple locations, terrains and environments. - Experiment with system performance against multiple, technology-enabled adversaries with capabilities analogous to near-peer/peer states. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY2020 decrease reflects completion of integrated system development and transition to testing and experimentation of systems.</p>				
<p>Title: Mobile Force Protection (MFP)</p> <p>Description: The goal of the Mobile Force Protection (MFP) program is to develop and demonstrate an integrated system capable of defeating a raid of self-guided small unmanned aircraft (sUAS) attacking a high value convoy on the move. By focusing on protecting mobile assets, the program will emphasize low footprint solutions, in terms of size, weight, power (SWaP), and manning, which will benefit other counter UAS missions and result in more affordable systems. Defending in a variety of operating environments against these sUAS threats and associated concept of operations requires several breakthroughs in affordable technology to sense, decide and act on a compressed timeline while mitigating collateral damage. The program seeks to develop solutions applicable to the defense of mobile ground and naval forces that can also potentially defeat more conventional threats. The solution will be scalable and modular such that it can be deployed in multiple defense applications and does not become obsolete with evolving threat capability.</p>		30.500	37.000	19.000

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Update affordability and unit cost analysis. - Complete preliminary and critical designs of end-to-end objective demonstration system. - Conduct two open air demonstrations of limited capability configuration systems that include advanced airborne threats and complex environmental factors. - Select the end-to-end configuration for development and demonstration, addressing convoy on the move against a large raid of variously configured, self-guided sUAS using multiple layered neutralization techniques. - Perform advanced modeling and simulation to validate system performance in operational environment. - Modify and finalize the end-to-end system design to enable operations while on the move by reducing size, weight and power. - Validate graphic user interface that reduces manning false alarm rate, and reaction time. - Conduct final update of affordability and cost analysis. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Fabricate and integrate on the move end-to-end demonstration system. - Integrate 3rd party sensors and interceptors to demonstrate interoperability and software openness. - Validate and complete MFP system engagement modeling and simulation tool for transition. - Complete affordability and unit cost analysis for transition. - Conduct open air demonstration that includes realistic threats, performance models, signatures, networks, and environmental factors. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 decrease reflects transition from iterative design phase to final testing.</p>			
<p>Title: Urban Reconnaissance through Supervised Autonomy (URSA)*</p> <p>Description: *Formerly PDUE: Autonomous Building Search Persistent Deterrence in Urban Environments</p> <p>The goal of the Urban Reconnaissance through Supervised Autonomy (URSA) program is to develop and demonstrate new autonomous agents and techniques that can rapidly discriminate hostile intent and filter out threats during missions ranging from minutes to hours, leveraging natural or created stimuli to elicit behavioral responses among humans in an area. The program seeks to create a system of autonomous ground and air platforms operating in conjunction with U.S. ground forces that monitor an area overtly to detect hostile forces and establish Positive Identification (PID) before any U.S. troops come into contact. Military units follow strict rules of engagement (ROEs) that prescribe an escalation of force appropriate with the level of hostilities and confidence that an individual is engaged in nefarious behavior. This program will establish a Legal, Moral, Ethical (LME) working group comprising multiple individuals (technologists, military, university professors, ethicists, legal experts) to develop an understanding of how escalation of force can and should be appropriately applied in the context of supervised autonomous</p>	5.000	19.000	23.000

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<p>systems. URSA will explore scenarios and probing behaviors that will enable identifying innocent civilians and individuals with hostile intent. This mission will require the integration and maturation of novel sensors, and unmanned ground and air vehicles which leverage current techniques in perspective and reactive autonomy to navigate cluttered urban environments. URSA will develop new search and probing behaviors to expose human intent and serve as evidence that a potential target is a threat. It will implement new dimensions of evidence such as the human reactions to these probing actions to improve confidence in its decisions, and will build a novel framework for escalating nonlethal force.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct trade space analysis regarding sensors, unmanned systems, human behaviors and other dimensions of evidence, and iterative instigation activities. - Initiate development of URSA system architectures. - Initiate development of URSA Integrated Testbed (UIT). - Hold quarterly LME working group meetings and facilitate engagements with technology performers. - Use UIT to perform initial evaluation of URSA system operation and functionality. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Demonstrate initial URSA system capabilities in limited, controlled, performer-selected environments. - Continue to develop URSA system architectures. - Assess URSA system capabilities and use cases through UIT environments. - Demonstrate improved URSA system capabilities in limited, controlled, performer-selected environments. - Continue quarterly LME working group meetings and facilitate engagements with technology performers. - Identify URSA end-to-end system capabilities to inform future prototype system development and field experimentation campaign. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects transition from initial development and limited testing to iterative development of capabilities and testing in more challenging environments.</p>				
<p>Title: Subterranean (SubT) Challenge</p> <p>Description: The DARPA Subterranean (SubT) Challenge will develop novel integrated solutions capable of mapping and navigating complex and dynamic terrains (tunnel systems, urban underground and cave networks); sensors and computation for perception in austere conditions; distributed information sharing in degraded communications environments; and collaborative autonomy enabling extended operations with minimal human interventions. The core objective of the SubT Challenge is to find the solution(s) which best outperforms current approaches for manually and laboriously mapping and searching subterranean environments. Newly developed capabilities will span across four technology focus areas in autonomy, perception, networking,</p>		6.000	22.000	34.000

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<p>and mobility technologies. The program will increase the diversity, versatility, and robustness of relevant system technologies, capable of addressing the multi-faceted needs of a wide range of environments. Innovations will be explored in the context of a public-facing, broadly inclusive DARPA Challenge.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct baseline design, development, and integration, of proposed solutions in the sub-domain of tunnel systems. - Conduct circuit competition in the sub-domain of tunnel systems. - Assess technology maturity and predicted technology trends to identify research and development needs and gaps. - Continue development and refinement of the virtual test bed. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Conduct baseline design, development, and integration of proposed solutions in the sub-domain of urban underground. - Conduct circuit competition in the sub-domain of urban underground. - Conduct baseline design, development, and integration of proposed solutions in the sub-domain of cave networks. - Conduct circuit competition in the sub-domain of cave networks. - Continue development and refinement of the virtual test bed. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects execution of multiple vice single sub-domain circuits.</p>				
<p>Title: Rapunzel</p> <p>Description: Urban combat demands that riflemen also serve as combat engineers manipulating their local environment to gain tactical advantage. The urban environment creates unique challenges in providing solutions for mobility, counter-mobility, survivability, and concealment. Every pound that a warfighter wears or carries reduces their mobility and mission effectiveness, and, particularly in urban combat, reduced mobility paradoxically reduces their survivability. The Rapunzel program seeks to enable warfighters to manipulate the urban environment through the application of novel materials research. Rapunzel envisions soldier-borne or vehicle-borne utility-belt style packaged containers, reels, and spools of material that can perform urban engineering tasks such as create bridges between building rooftops, pull down enemy barriers, or provide false targets and concealment. The program will identify those mass-manufactured materials, such as extremely high-tensile strength monofilament that can both provide novel mobility between buildings but also provide novel counter-mobility to enemy vehicles due to their electrical conductance properties. The Rapunzel program will leverage extensive existing research into early developmental materials and invest in the task-based development and packing to provide these materials at appropriate length and size scales for immediate tactical use.</p> <p>FY 2020 Plans:</p>		-	-	10.000

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<ul style="list-style-type: none"> - Conduct trade space analysis and technical assessments regarding novel materials that are quickly field assembled and fabricated into lightweight components. - Initiate development of mobility, counter-mobility, survivability, and concealment core requirements and systems architectures. - Initiate development of critical manufacturing technologies/approaches and perform baseline demonstrations of existing technologies that can be leveraged to refine program metrics. - Develop operational and technical performance models. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects program initiation.</p>				
<p>Title: Highly-Networked Dissemination of Relevant Data (3HNDRED)</p> <p>Description: The goal of the Highly-Networked Dissemination of Relevant Data (3HNDRED) program is to develop and demonstrate an integrated system capable of disseminating relevant, actionable information to the ground warfighter to enable effective accomplishment of mission objectives in a dynamic environment. Heterogeneous sensors, including soldier-borne, vehicle-borne, and manned or unmanned ground/air assets, may be netted together to form a complete picture of an area of interest. A tactical decision engine will receive and process incoming sensor data to form an understanding of mission context, environment, and individual agent role and posture. Based on this knowledge, the tactical decision engine will establish a contextually-relevant personalized operating picture for each node/individual in accordance with their current status and mission goal and then guide action (e.g. heading and urgency) via interface modalities appropriate to the current state. 3HNDRED will assess and integrate hands-free, heads-up interfaces to convey information to the warfighter that can be quickly detected and intuitively understood without cognitive burden, enabling rapid response. 3HNDRED will enable collaborative actions between dismounted and mounted elements across manned and unmanned teams, and support on-the-fly force re-composition, providing an asymmetric advantage to U.S. ground forces.</p> <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Initiate trade studies to assess 3HNDRED use cases, sensor suite, and interface modalities. - Evaluate multi-modal interface solutions to assess effectiveness across multiple states and posture. - Initiate 3HNDRED tactical decision engine architecture development. - Complete preliminary design and demonstration of tactical decision engine to infer battlefield context and make decisions at scale. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects program initiation.</p>		-	-	10.000
<p>Title: Tactical Networks of Tunnels (TNT)</p>		-	3.000	10.000

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>Description: The Tactical Networks of Tunnels (TNT) effort, an outgrowth of the Subterranean Challenge program, will explore the development and integration of technologies to investigate, create, and employ technologies that drill/bore, build, and use the underground environment for tactical operations in rapid, secure resupply. TNT will explore creation and utilization of tunneling, drilling, and boring capabilities for systems at multiple scales. The program will examine multiple concepts of operation and will consider creation and use of both temporary tunnels as well as rapid creation of tunnel networks.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Initiate trade studies in drilling/boring methods, geological assessments of an underground route, methods, manpower, and infrastructure. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Complete initial trade studies. - Initiate development of TNT concept of operation, system architecture, and demonstration test plans. - Begin development of enabling technologies. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects completion of initial studies and transition to development of specific technologies.</p>			
<p>Title: Small Unit Lethality</p> <p>Description: The Small Unit Lethality program objective is to develop technologies that allow warfighters to clear or empty spaces - manmade or natural - from high standoff distances without destroying them or entering them. The effort will investigate the ability to fill voids of similar space to deny occupation. Materials allowing permanent or temporary denial will both be explored. The program will also develop next generation urban weapon systems organic to dismounted units that provide extended range and tunable effects with greatly minimized impact to a warfighter operator.</p> <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Conduct trade space analysis and technical assessments regarding effects that fill, neutralize, and clear an intended interior space without destroying structure. - Initiate development of core requirements and systems architectures. - Begin development of Small Unit Lethality critical subsystem technologies. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY2020 increase reflects program initiation.</p>	-	-	6.000
<p>Title: Precision Kinetic Light Strike</p>	5.000	-	-

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Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-04 / ADVANCED LAND SYSTEMS TECHNOLOGY

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>Description: The Precision Kinetic Light Strike program sought to develop a small, lightweight, guided kinetic weapon for lightweight maneuver forces. Current short-range weapons are used against a variety of target sets using different munitions without the benefit of active guidance. Current long-range weapons are highly effective against a specific target set at range, but are too large or heavy to employ in needed numbers, have a high cost per shot/procurement cost, and often require burdensome logistics or dedicated specialized systems to use. The program goal was to improve on the existing, lightweight unguided munition systems by increasing range, accuracy, and lethality, while reducing cost. These improvements leveraged advances in miniaturization, precision guidance and warheads. Precision Kinetic Light Strike sought to take advantage of commercial technologies whenever possible to provide a low-cost, multi-use, and multi-function precision engagement capability. The Precision Kinetic Light Strike program will significantly increase the combat power of small units with reduced burden, while significantly reducing cost relative to near-peer and peer adversaries.</p>			
<p>Title: Operational Fires</p> <p>Description: The goal of the Operational Fires (OpFires) program is to develop and demonstrate a novel ground-launched system enabling advanced tactical weapons to penetrate modern enemy air defenses and rapidly and precisely engage critical time sensitive targets. This program seeks to develop an advanced booster capable of delivering a variety of payloads at a variety of ranges. Additional considerations include the need for compatible mobile ground launch platforms enabling integration with existing ground forces and infrastructure, and specific system attributes required for rapid deployment and redeployment. The OpFires program will conduct a series of subsystem tests designed to evaluate component design and system compatibility, and culminate in integrated end-to-end flight tests. Beginning in FY 2019 this effort is funded under PE 0603286E, Project AIR-01.</p>	6.000	-	-
Accomplishments/Planned Programs Subtotals	80.428	109.286	138.040

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency **Date:** March 2019

Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY				Project (Number/Name) TT-07 / AERONAUTICS TECHNOLOGY			
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
TT-07: AERONAUTICS TECHNOLOGY	-	60.151	50.799	53.119	-	53.119	47.328	59.119	47.528	47.528	-	-

A. Mission Description and Budget Item Justification

Aeronautics Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical and aerospace systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion, vehicle, and launch concepts, sophisticated fabrication methods, and examination of novel materials and enabling technologies for aeronautic and aerospace system applications. Studies that also fundamentally change the calculus of battle including consideration of a mix of assets, potentially disposable or with limited lifespans, with increased levels of autonomy are included.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2018	FY 2019	FY 2020
<p>Title: Gremlins</p> <p>Description: The goal of the Gremlins program is to develop platform technologies that enable a new class of distributed warfare. The Gremlins concept envisions small air-launched unmanned systems that can be responsively dispatched in volley quantity from commodity platforms, fly into contested airspace, conduct a moderate duration mission, and ultimately be recovered. Key enabling technologies for the concept include smaller developmental payloads that benefit from multiple collaborating host platforms. The Gremlins program will conduct risk reduction and development of the host platform launch and recovery capability and develop and demonstrate a recoverable Unmanned Air Vehicle (UAV) platform concept. Enabling platform technologies will include precision relative navigation, advanced computational modeling, variable geometry stores, compact propulsion systems, and high speed digital flight control. The program will leverage these technologies, perform analytic trade studies, conduct incremental development, and ultimately demonstrate the potential for an integrated air-launched Gremlins unmanned platform.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct flight validation for launch and recovery capability. - Fabricate and ground test flight-worthy assets. - Conduct flight test demonstrating Gremlins mission objectives. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Conduct final flight test demonstrating full recovery capability. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY2020 decrease reflects completion of program following final flight testing.</p>	31.000	21.799	12.119
<p>Title: Advanced Aeronautics Technologies</p>	2.000	3.000	3.000

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-07 / AERONAUTICS TECHNOLOGY

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>Description: The Advanced Aeronautics Technologies program will examine and evaluate aeronautical technologies and concepts through applied research. These may include the feasibility studies of novel or emergent materials, devices and tactics for both fixed and rotary wing air vehicle applications, launch vehicles, as well as manufacturing and implementation approaches. The areas of interest range from propulsion to control techniques to solutions for aerospace mission requirements. The result of these studies may lead to the development of new programs or improvement of existing systems.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Perform studies to support development of innovative prototypes. - Initiate new studies of novel approaches to improve operating envelopes. - Conduct trade studies of candidate technologies. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Perform studies to support development of innovative prototypes. - Initiate new studies of novel technologies to improve speed and range. 			
<p>Title: OFFensive Swarm-Enabled Tactics (OFFSET)</p> <p>Description: The OFFSET program will design, develop, and demonstrate a swarm system architecture to advance the innovation, interaction, and integration of novel swarm tactics. The program will examine enabling technologies for collaborative autonomy for large teams of unmanned systems, including unmanned ground and air capabilities through the use of both virtual, game-based and physical, live-fly testbeds. Key research thrusts include the development of advanced swarm tactics-centered autonomy and development of human-swarm teaming interface technologies. These combined enhancements will facilitate insights and enable employment of these collective systems to address current needs and defeat future threats. The program will consider technologies supporting U.S. ground and air operations, extensible to other operating environments, requiring organic and/or tactical swarm capabilities, and leveraging low-cost, rapidly deploy-able, autonomous system technologies.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct capability-based field experimentation events that demonstrate swarm tactics for scaled missions of relevance to urban combat operations. - Explore human-swarm interaction and immersive interfaces of autonomous teams to improve system performance and swarm operator situational awareness. - Integrate systems enablers for enhanced swarm autonomy with advances in associated tactics, primitives, and algorithms. - Initiate swarm sprints for specific technology thrust areas relevant to human-swarm teaming. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Demonstrate interfaces for and execution of viable swarm tactics-based courses-of-action. - Continue integration of advanced swarm tactics for capability-based experimentation. 	10.000	16.000	20.000

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency	Date: March 2019
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Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-07 / AERONAUTICS TECHNOLOGY
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>- Commence swarm sprints focusing on advancing the virtual environment and augmenting the physical testbed to enable operationally relevant objectives.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects progression to more challenging swarm sprints involving greater experimentation support.</p>			
<p>Title: Control of Revolutionary Aircraft with Novel Effectors (CRANE)</p> <p>Description: The Control of Revolutionary Aircraft with Novel Effectors (CRANE) program will demonstrate revolutionary improvements in aircraft controls technology. The program will design, build, and flight test an aircraft that is able to fly and maneuver at altitude with no moving control surfaces; relying on state of the art Active Flow Control (AFC) technology. AFC is a broad term that encompasses a range of technology approaches; broadly defined, it is a control mechanism which alters the aerodynamic flow field thru ejection or suction of fluid via an orifice on a lifting body. An emphasis of the program will be on assessing AFC component technologies, risk reduction and experimentation, integrated testing, fabrication and demonstration of a relevant scale novel and innovative aircraft. Technologies, design tools and models developed and demonstrated under this program will be made available to all Services as well as the civilian aerospace sector for application to future air systems development.</p> <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Conduct technology analysis of AFC components and control scheme. - Complete conceptual design. - Perform risk reduction and experimentation. - Initiate preliminary design of technology demonstrator. <p>FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increase reflects program initiation.</p>	-	-	13.000
<p>Title: CounterSwarmAI</p> <p>Description: The objective of the CounterSwarmAI program is to develop systems for anticipating and defeating autonomous systems threats of the future. These adversary systems will likely employ advanced artificial intelligence (AI) and machine learning techniques which will inevitably lead to increased complexity and unpredictability of these advanced threats. CounterSwarmAI envisions the development of disruptive technologies across the engagement kill chain, themselves AI-empowered, which directly combat these challenges. CounterSwarmAI decision software will directly interface with future and legacy defensive systems (kinetic and non-kinetic) to rapidly assess, optimally exploit, and efficiently defeat enemy autonomous systems threats. Innovative solutions will enable (a) autonomous systems which provide understanding and vulnerability exploitation through machine learning, (b) an integrated AI-equipped open architecture for multi-faceted swarm defense, and (c) integration and experimentation with live surrogate swarm threats against current fielded defensive systems.</p>	-	-	5.000

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-07 / AERONAUTICS TECHNOLOGY

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Demonstrate the applicability of artificial intelligence advances in large-scale autonomous system threats. - Initiate research and development in machine learning advances and adversarial games to identify salient swarm attributes. - Establish baseline technology advances needed for counter swarm engagement decisions. <p>FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increase reflects program initiation.</p>			
<p>Title: Aircrew Labor In-cockpit Automation System (ALIAS)</p> <p>Description: The Aircrew Labor In-cockpit Automation System (ALIAS) program will design, develop, and demonstrate a kit enabling affordable, rapid automation of selected aircrew functions across a broad range of aircraft. ALIAS intends to enable reduction of aircrew workload and/or the number of on-board aircrew to improve performance. The program will develop hardware and software to automate select aircrew functions and will employ novel, low impact approaches to interface with existing aircraft monitoring and control systems. The program will also develop tractable approaches to rapidly capture crew-station specific skills and aircraft unique behaviors. To accomplish this, ALIAS will leverage recent advances in perception, manipulation, machine learning, reusable software architectures, autonomous systems architecture, and verification and validation. ALIAS will culminate in a demonstration of the ability to rapidly adapt a single system to multiple aircraft and execute simple missions. This reliability enhancement capability will enable new operational concepts for reuse of existing air assets and allow a reduction in the number of aircrew required.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Conduct integrated system flight demonstration on operationally representative aircraft with reduced crew operations. - Proceed with system installation and integration on a commercial aircraft with enhanced capabilities. - Continue civil certification process of a commercial aircraft to support flight demonstrations that provide input for reduced crew operations. - Refine human machine interface to support multiple operational mission scenarios. - Conduct optionally piloted vehicle demonstrations on aircraft using integrated system. - Conduct uninhabited flight demonstration with aircraft using integrated system. - Complete system installation and integration on multiple aircraft. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 decrease reflects program completion.</p>	17.151	10.000	-
Accomplishments/Planned Programs Subtotals	60.151	50.799	53.119

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency **Date:** March 2019

Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)
0400 / 2	PE 0602702E / <i>TACTICAL TECHNOLOGY</i>	TT-07 / <i>AERONAUTICS TECHNOLOGY</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency										Date: March 2019		
Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY				Project (Number/Name) TT-13 / INFORMATION ANALYTICS TECHNOLOGY			
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
TT-13: INFORMATION ANALYTICS TECHNOLOGY	-	119.843	104.610	103.584	-	103.584	107.209	102.155	127.114	132.114	-	-

A. Mission Description and Budget Item Justification

The Information Analytics Technology project develops technology for analyzing data and information arising from: 1) intelligence networks; 2) open and other external sources; 3) sensors and signal/image processors; and 4) collection platforms and weapon systems. Technical challenges include the need to process huge volumes of diverse, incomplete, and uncertain data in tactically-relevant timeframes. Benefits sought include deeper understanding of the evolving operational environment tailored to the needs of commanders at every echelon; an enhanced capability to plan, monitor, and control diverse military operations ranging from stability operations to combat; and improvements to the efficiency of core military functions such as national and homeland security, warfighter health and readiness, and defense support of law enforcement and civil authorities. Promising technologies are evaluated in the laboratory and demonstrated in the field to facilitate transition.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2018	FY 2019	FY 2020
Title: Causal Exploration of Complex Operational Environments	21.000	22.000	25.000
<p>Description: The Causal Exploration of Complex Operational Environments program is developing advanced modeling, analysis, simulation, and visualization tools to enable command staffs to rapidly and effectively design, plan, and manage missions in complex operational environments. The U.S. military increasingly operates in remote and unstable parts of the world where mission success depends heavily on cooperation with a wide variety of stakeholder groups on civil, economic, and military matters. These groups typically include host nation government organizations, local civilian groups, and non-governmental organizations, each of which has priorities, sensitivities, and concerns that may differ significantly. Current mission design and planning technologies do not adequately model the range of options or the inherent uncertainties. This program will develop tools to create causal, computational models that represent the most significant relationships, dynamics, interactions, and uncertainties of the operational environment including political, military, economic, and social factors. These tools will enable command staffs to design and quantitatively assess potential courses of action in complex operational environments.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Produce an initial prototype system and collaborate with transition partners to assess models for operational environments with complexities such as tribal rivalries, resource shortages, and insurgent activities. - Develop and demonstrate techniques to quantify uncertainty in inputs and models, and refine methodologies and measurements to address dynamically changing models and enable component comparisons. - Expand visualizations and user interfaces to support exploration and refinement of models. 			

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Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-13 / INFORMATION ANALYTICS TECHNOLOGY		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<p>- Conduct a collaborative experiment in which Army planners and program developers work together to validate and refine the technology on simulated operations.</p> <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Demonstrate techniques to propagate uncertainty through all parts of the system and enable users to quickly assess the robustness of operational designs. - Develop and demonstrate techniques for maintaining and updating models of operational environments as new information arrives and constraints and guidance evolve. - Integrate language processing and social network analysis technologies to enable real-time sentiment analysis of local populations and quantitative assessment of information operations campaigns. - Conduct collaborative experiments in which military planners and program developers work together to further refine the technology on simulated operations, and an operational evaluation to measure usability and suitability of the system. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase is due to continued work to develop and evaluate technologies, and additional experimentation with military users.</p>				
<p>Title: Data-Driven Discovery of Models (D3M)</p> <p>Description: The Data-Driven Discovery of Models (D3M) program is developing automated model discovery techniques and tools that enable non-expert users to create empirical models of real, complex processes, and phenomena. The ability to understand the battlespace is driven increasingly by analysis of sensor and open source data. The DoD and the Intelligence Community (IC) are fundamentally limited by a shortage of expert data scientists to construct empirical models that predict behaviors and anticipate contingencies during tactical and strategic planning. D3M will address this need by creating technologies that automate the construction of complex empirical models. D3M technologies will include a library of data modeling primitives that are automatically selectable; automated approaches for composition of complex models from modeling primitives; and intuitive mechanisms for human-model interaction that enable curation of models by non-experts. D3M will focus on the types of empirical modeling problems commonly encountered by the DoD and IC.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Enhance modeling primitives and incorporate in integrated toolkits. - Develop and synthesize multi-modal predictive models for unsolved problems, including automated data collection for data augmentation. - Develop question formalization frameworks and specifications for question decomposition to support user-model interaction. - Demonstrate automated composition of complex models in coordination with operators from multiple domains. <p>FY 2020 Plans:</p>		21.000	18.310	17.580

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Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-13 / INFORMATION ANALYTICS TECHNOLOGY

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<ul style="list-style-type: none"> - Extend modeling primitives to handle heterogeneous and unstructured data from disparate sources and integrate into toolkits. - Extend composability techniques to enable the construction of data analytic pipelines for complex problems, such as predicting events utilizing a combination of open source intelligence data and data from protected sources. - Formulate measures and models for normal/anomalous behavior of financial markets, and propose indications and warnings to quickly detect and characterize attacks on financial infrastructure. - Collaborate with transition partners from the DoD and IC to perform quantitative assessments of automatically-generated models and to compare these with their internal-expert-developed models on real-world data. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 decrease is the result of development work ramping down and the focus shifting to demonstrations in collaboration with transition partners.</p>			
<p>Title: Modeling Adversarial Activity (MAA)</p> <p>Description: The Modeling Adversarial Activity (MAA) program is developing technologies for generating high-confidence indications and warnings for weapons of mass terror (WMT) activities. WMT pathways consist of networks or links among individuals, groups, organizations, and other entities that act to promote or enable the development, procurement, possession, transportation, or proliferation of WMTs and related capabilities. Monitoring and controlling WMT pathways is essential to denying access to WMT technology, knowledge, materials, expertise, and weapons. MAA will create graph models reflecting prototypical WMT pathways, develop methods for creating merged activity graphs by aligning entities across multiple intelligence modalities, develop algorithms to match empirical activity graphs with pathway models, and create synthetic data sets at scale to support development and testing of WMT activity detection techniques. MAA technology will transition to the Defense Threat Reduction Agency (DTRA) and the Department of Homeland Security (DHS).</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Implement graph alignment techniques, and assess strengths and weaknesses of alternative approaches on synthetic data while improving performance and scalability. - Apply techniques for approximate matching of activity graphs, and demonstrate pathway detection on synthetic data. - Create an initial prototype pathway recognizer, and demonstrate the capability to detect modeled WMT activity sequences in synthetic data. - Collaborate with DTRA and DHS to implement techniques in their environments, and to optimize techniques for efficient and timely execution on their computational infrastructure. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Explore and evaluate methods to support partial pathway matching and to adapt pathway models. - Develop scaling methods to enable calculations on realistically large graph models. 	13.900	17.800	22.000

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019		
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / TACTICAL TECHNOLOGY	Project (Number/Name) TT-13 / INFORMATION ANALYTICS TECHNOLOGY		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<ul style="list-style-type: none"> - Develop mechanisms for refining prototype pathway recognizers that are generating high rates of false alarms. - Explore methods to tune the end-to-end system to maximize detection and graph matching performance within the DTRA and DHS computational infrastructures. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 increase reflects continued development of techniques and software for WMT pathway discovery and additional work to integrate these in a prototype pathway recognition system and to evaluate the system on realistically large synthetic data.</p> <p>Title: Warfighter Analytics using Smartphones for Health (WASH)</p> <p>Description: The Warfighter Analytics using Smartphones for Health (WASH) program is developing analytic techniques for continuous and real-time assessment of warfighter physiological health and cognitive state based on the multiple sensor data streams generated by modern smartphones. Recent research in the area of smartphone biometrics has shown the feasibility of measuring user physiological and behavioral parameters for purposes of user authentication. WASH will extend these smartphone biometrics to reliably measure additional user physiological and behavioral parameters relevant to health assessment and the diagnosis of disease. If successful, WASH will produce a mobile application that continuously and reliably assesses warfighter health and combat/mission readiness. WASH is coordinated with the Naval Health Research Center.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Develop secure, privacy-preserving, cloud-based data ingest and storage technologies for collecting, organizing, and associating user smartphone, physiological health, and behavioral data. - Develop a mobile application to capture user smartphone data passively and securely, and to compute digital biomarkers. - Perform laboratory assessments of sensitivity and specificity of smartphone-based digital biomarkers for detection and diagnosis of physiological disease and assessment of cognitive state. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Conduct periodic audits of the security and privacy controls of the cloud-based data ingest and storage infrastructure, and perform upgrades/improvements as appropriate. - Refine digital biomarker computation to enable discrimination of noise based on context, for example, vehicular versus behavioral movement/vibration. - Perform field assessments of sensitivity and specificity of smartphone-based digital biomarkers for detection and diagnosis of physiological disease and assessment of cognitive state in collaboration with Naval Health Research Center. <p>FY 2019 to FY 2020 Increase/Decrease Statement:</p>		15.000	16.000	18.300

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
The FY 2020 increase is due to continued work to develop and integrate techniques to analyze user smartphone data, and additional work to evaluate the performance of techniques to assess user physiological health and cognitive state.				
<p>Title: Media Forensics (MediFor)</p> <p>Description: The Media Forensics (MediFor) program is creating technologies for analyzing media content to determine trustworthiness for military and intelligence purposes. Current approaches to media forensics are labor intensive, requiring analysts and investigators to undertake painstaking analyses to establish context and provenance. The program will develop, integrate, and extend image and video analytics to provide forensic information that can be used by analysts and automated systems to quickly determine the integrity of open source and captured images and video. Technologies will transition to operational commands and the Intelligence Community (IC).</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Enhance the effectiveness of forensic algorithms that must operate at large scales and in near-real time. - Develop association methods to track and assess related media assets that are subject to coordinated manipulation by adversaries. - Develop quantitative measures of integrity relevant to diverse needs of government users and specific missions. - Evaluate the effectiveness of the integrated integrity-assessment platform on relevant operational data provided by potential transition partners from the DoD and IC. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Scale association algorithms to operate at large scales and in near-real time. - Enhance integrity approaches to be robust to maturing adversarial attack and generative technologies. - Harden integrity indicators to increase robustness, accuracy, and efficiency on large scale datasets. - Demonstrate the full platform prototype in collaboration with government transition partners from the DoD and IC. <p>FY 2019 to FY 2020 Increase/Decrease Statement: The FY 2020 decrease is the result of development work ramping down, and the focus shifting to testing media integrity-assessment techniques and platforms in collaboration with transition partners.</p>		20.880	17.500	5.304
<p>Title: Adapting Cross-domain Kill-Webs (ACK)</p> <p>Description: The Adapting Cross-domain Kill-Webs (ACK) program will assist military decision makers with rapidly identifying and selecting options for tasking and re-tasking assets within and across organizational boundaries. Based on technologies developed in the Resilient Synchronized Planning and Assessment for the Contest Environment (RSPACE) program (budgeted in PE 0603766E, Project NET-01), ACK will assist users with selecting sensors, effectors, and support elements across military domains (space, air, land, surface, subsurface, and cyber) to form and adapt kill chains to deliver desired effects on targets.</p>		-	8.000	15.400

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	
<p>Today's Command and Control (C2) organizations and processes cannot support multi-domain warfighting concepts, especially during joint operations. ACK will address this challenge by utilizing a decentralized approach to allocating resources to tasks and assigning mission orders to assets, motivated by ideas developed in online commerce, sourcing, and supply chain management, such as bid requests and offers. The impact of ACK will be to accelerate asset re-allocation and assignment decision timelines to be on the order of minutes, and the output of ACK will be automated tools and decision aids to support the selection of the elements of a kill-chain and assignment of roles and responsibilities to each of the elements. Technology developed under this program will be transitioned to the Services.</p> <p>FY 2019 Plans:</p> <ul style="list-style-type: none"> - Begin development of the bid request and offer language and message sets for C2 node and virtual liaison coordination across domains. - Create multi-domain capability models as digital artifacts to support evaluations. <p>FY 2020 Plans:</p> <ul style="list-style-type: none"> - Develop capability (sensors, weapons, communications, etc.) representations necessary to support the ACK program concept. - Begin development of the supplier-side, virtual liaison offer generation algorithms, and the consumer-side, C2 node algorithms for adjudicating amongst the offered capabilities. - Begin development of a supporting user interface that enables an operator to visualize recommendations and select a final plan. - Begin development of the evaluation test bed. <p>FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increase is due to the implementation of multi-domain modeling and simulation.</p>				
<p>Title: Distributed Battle Management (DBM)</p> <p>Description: The Distributed Battle Management (DBM) program will develop mission-driven architectures, protocols, and algorithms for battle management (BM) in contested environments. The military is turning to networked weapons and sensors onboard a heterogeneous mix of multi-purpose manned and unmanned systems. In contested environments, it is a challenge for BM networks to communicate with subordinate platforms due to extensive adversarial cyber and electronic warfare operations, anti-satellite attacks, and the need for emissions control in the face of a formidable integrated air defense system. The DBM program will seek to develop a distributed command architecture with decentralized control of mission-focused asset teams. The architecture will enable rapid reaction to ephemeral engagement opportunities and maintain a reliable BM structure, despite limited communications and platform attrition in continuously evolving threat environments. The program will incorporate highly automated decision making capability while maintaining vital human-in-the-loop operator approval. DBM technologies are expected to transition to the Services.</p>		18.063	5.000	-

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
<p><i>FY 2019 Plans:</i></p> <ul style="list-style-type: none"> - Use DBM components in a live-fly experiment in support of transition to the services (Navy or Air Force). - Use DBM components (fusion and resource management) in support of multiple live-fly events for the System of Systems Integration Technology and Experimentation (SoSITE) program (budgeted in PE 0603766E, Project NET-01) incorporating increased complexity in terms of new platforms and payloads and overall scale. - Expand the number of flight systems modeled in DBM system. - Demonstrate the capability to support air-to-air and air-to-ground tactics simultaneously. <p><i>FY 2019 to FY 2020 Increase/Decrease Statement:</i> The FY 2020 decrease reflects program completion.</p>			
<p><i>Title:</i> Memex</p> <p><i>Description:</i> The Memex program developed search technologies to revolutionize the discovery, organization, and presentation of domain-specific content. Earlier search technologies were limited in search query format, retrieved content organization, and infrastructure support, and they imposed an iterative search process that was time-consuming and inefficient, producing only a fraction of the available information. Memex created a new domain-specific search paradigm that discovers relevant content and organizes it in ways that are more immediately useful to specific missions and tasks. In addition, Memex domain-specific search engines extend the reach of current search capabilities to the deep web and non-traditional content. Memex technologies enable the military, government, and commercial enterprises to find and organize mission-critical information on the Internet and in large intelligence repositories. Mission areas addressed by Memex included counter-terrorism, counter-drug, anti-money-laundering, and anti-human-trafficking, with transition partners from DoD and other U.S. Government activities.</p>	5.000	-	-
<p><i>Title:</i> Network Defense</p> <p><i>Description:</i> The Network Defense program developed technologies to detect network attacks. U.S. computer networks are continually under attack, and these attacks are typically handled by individual organizations as they occur. Analyzing network summary data across a wide array of networks can make it possible to identify trends and patterns visible only when the data is viewed as a whole. Network Defense developed novel algorithms and analysis tools that enable a big picture approach for identifying illicit behavior in networks. This analysis and subsequent feedback to system administrators, security engineers, and decision makers can enhance information security in both the government and commercial sectors.</p>	5.000	-	-
Accomplishments/Planned Programs Subtotals	119.843	104.610	103.584

C. Other Program Funding Summary (\$ in Millions) N/A

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / <i>TACTICAL TECHNOLOGY</i>	Project (Number/Name) TT-13 / <i>INFORMATION ANALYTICS TECHNOLOGY</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy
N/A

E. Performance Metrics
Specific programmatic performance metrics are listed above in the program accomplishments and plans section.