Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

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	-	180.780	155.406	277.603	-	277.603	379.341	253.434	220.316	178.316	-	-
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	180.780	155.406	277.603	-	277.603	379.341	253.434	220.316	178.316	-	-

A. Mission Description and Budget Item Justification

The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Budget Activity because it addresses high pay-off opportunities to provide revolutionary new system capabilities for satisfying current and projected military mission requirements associated with advanced aeronautical systems at dramatically reduced costs. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Studies conducted under this project include examination and evaluation of emerging aerospace threats, technologies, concepts, and applications for missiles, munitions, and vehicle systems.

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	182.327	155.406	162.028	-	162.028
Current President's Budget	180.780	155.406	277.603	-	277.603
Total Adjustments	-1.547	0.000	115.575	-	115.575
• Congressional General Reductions	-3.000	0.000			
• 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	5.811	0.000			
• SBIR/STTR Transfer	-4.358	0.000			
• TotalOtherAdjustments	-	-	115.575	-	115.575

Change Summary Explanation

FY 2017: Decrease reflects Congressional reduction and the SBIR/STTR transfer offset by reprogrammings.
FY 2018: N/A
FY 2019: Increase reflects expanded focus in hypersonics initiatives, including Tactical Boost Glide, Advanced Full Range Engine, and Operational Fires.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Collaborative Operations in Denied Environment (CODE)	28.780	30.106	8.000
Description: The goal of the Collaborative Operations in Denied Environment (CODE) program is to enhance mission performance, reduce cost, confound adversaries, and reduce reliance on space assets for navigation and communication by			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
distributing mission functions such as sensing, communication, precision navigation, kinetic, and non-kinetic effects to small platforms and increasing their level of autonomy. Collaboration of multiple assets offers new possibilities to conduct military missions using smaller air platforms to enhance survivability, reduce overall acquisition cost, create new effects, increase communications range and robustness in denied environments, increase search area, increase areas held at risk, reduce target prosecution reaction time, and provide multi-mission capabilities by combinations of assets. This effort will specifically focus on developing and demonstrating approaches that will expand the mission capabilities of legacy air assets through autonomy and collaborative behaviors, within a standard based open architecture. Potential transition partners include the Air Force, Army, and Navy. ***FY 2018 Plans:*** - Validate next major software releases in flight with increasingly complex demonstration scenarios. - Demonstrate the ability of a single commander to plan and execute an end-to-end mission scenario, including insertion of new objectives, introduction and modification of flight restrictions, and providing authorization to engage simulated targets. - Demonstrate expanded CODE autonomy capability including collaborative strike, jamming, Electro-Optical/Infrared (EO/IR) and passive Radio Frequency (RF) search, battle damage assessment, track fusion, and communications-denied mission execution. - Demonstrate the ability to integrate independently developed software modules based on the published CODE software development toolkit. - Collaborate with operational system owners and other partners to develop early transition opportunities. ***FY 2019 Plans:*** - Perform capstone demonstration involving six live and multiple virtual aircraft executing a complex end-to-end mission scenario with multiple contingency events and limited advanced knowledge of red team positions and tactics. - Complete independent, fully-informed modeling, simulation, and analysis effort to validate final CODE software builds. - Produce final CODE software package with complete software development kit and simulation environment to facilitate technology transfer. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 decrease reflects completion of flight testing and program completion.			
Title: Hypersonic Air-breathing Weapon Concept (HAWC)	49.500	30.000	14.300
Description: The Hypersonic Air-breathing Weapon Concept (HAWC) program is a Joint DARPA / Air Force effort that will develop and demonstrate technologies for an effective and affordable air-launched hypersonic cruise missile. These technologies include advanced air vehicle configurations capable of efficient hypersonic flight, hydrocarbon scramjet-powered propulsion to enable sustained hypersonic cruise, thermal management approaches designed for high-temperature cruise, and affordable			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
system designs and manufacturing approaches. This is a joint program with the Air Force, and HAWC technologies are planned for transition to the Air Force after flight testing is complete. ***FY 2018 Plans:*** - Continue updating test-validated performance databases to anchor demonstration vehicle design. - Complete system critical design of flight demonstration system. - Conduct preliminary traceability assessment between the HAWC demonstration system and the HAWC operational system. - Begin software-in-the-loop testing for the demonstration vehicle. - Continue procurement of hardware for flight demonstration vehicle. - Continue safety of flight certification reviews with the test range. - Begin hardware-in-the-loop testing for the demonstration vehicle. - Continue propulsion testing. - Continue detailed plans for flight testing of the demonstration system. - Begin full-scale thermal-structural testing. - Begin procurement of test assets and test support equipment. - Begin assembly, integration, and test of the flight demonstration vehicle. ***FY 2019 Plans:*** - Complete software-in-the-loop testing for the demonstration vehicle. - Complete hardware-in-the-loop testing for the demonstration vehicle. - Complete flight certification reviews with the test range. - Complete full-scale thermal-structural testing. - Complete flight test planning for the demonstration system. - Continue procurement of test assets and test support equipment. - Continue assembly, integration, and test of demonstration vehicle. - Conduct range safety analysis. - Conduct mission readiness review. - Conduct first flight. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 decrease reflects increase in Air Force funding and commensurate decrease in DARPA funding as program progresses.			
Title: Tactical Boost Glide	22.800	37.600	139.400

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: The Tactical Boost Glide (TBG) program is a Joint DARPA / Air Force effort that will develop and demonstrate technologies to enable air-launched tactical range hypersonic boost glide systems, including flight demonstration of a vehicle that is traceable to an operationally relevant weapon that can be launched from current platforms. The program will also consider traceability, compatibility, and integration with the Navy Vertical Launch System (VLS). The metrics associated with this objective include total range, time of flight, payload, accuracy, and impact velocity. The program will address the system and technology issues required to enable development of a hypersonic boost glide system considering (1) vehicle concepts possessing the required aerodynamic and aero-thermal performance, controllability and robustness for a wide operational envelope, (2) the system attributes and subsystems required to be effective in relevant operational environments, and (3) approaches to reducing cost and improving affordability for both the demonstration system and future operational systems. TBG capabilities are planned for transition to the Air Force and the Navy. ***FY 2018 Plans:*** - Complete subsystem and system Critical Design Reviews (CDRs). - Begin aeroshell thermo-structural testing. - Conduct component aerothermal testing. - Continue procurement of hardware for demonstration vehicles. - Continue software in the loop (SIL) testing. - Begin hardware in the loop (HWIL) and qualification testing. - Begin Assembly, Integration, and Test (AI&T). - Continue detailed flight test and range safety planning, coordination, and documentation. - Update Technology Maturity Plans (TMPs) and Risk Management Plans (RMPs). ***FY 2019 Plans:*** - Complete procurement of hardware for demonstration vehicles. - Complete all risk reduction and qualification testing. - Complete AI&T of first flight article. - Complete test readiness review (TRR) for first flight. - Conduct first flight test and begin post-flight analysis. - Continue AI&T of remaining test articles. - Continue detailed flight test and range safety planning, coordination, and documentation. - Update TMPs and RMPs. - Develop acquisition study for second TBG performer to evolve an All-Up Round (AUR) design to a critical design level of maturity. - Select second TBG performer.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
- Plan and conduct additional aerodynamic and aero-thermodynamic risk reduction testing. - Plan and conduct additional material and thermo-structural risk reduction testing. - Plan and conduct additional materials arc-jet testing. - Update aerodynamics and materials databases based on post-risk reduction test analysis. - Plan additional flight tests for expanded risk reduction. - Procure hardware for additional flight tests and begin AI&T of test articles. - Develop preliminary requirements for a Navy variant AUR. - Conduct trade studies and assess booster and Vertical Launch System (VLS) integration development needs of a Navy variant AUR. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 increase reflects addition of funds for second performer as well as initiation of effort to develop Navy variant AUR.			
Title: Advanced Full Range Engine (AFRE)	13.500	35.000	53.028
Description: The Advanced Full Range Engine (AFRE) program will establish the feasibility of hypersonic aircraft propulsion through a two-pronged approach. AFRE will demonstrate turbine to Dual Mode Ramjet (DMRJ) transition of a Turbine-Based Combined Cycle (TBCC) propulsion system utilizing an off-the-shelf turbine engine. Large scale components of this complex propulsion system will be developed and demonstrated independently, followed by a full-scale freejet TBCC propulsion system mode transition ground test. Accomplishing these objectives will enable future hypersonic systems resulting in transformational changes in long range strike, high speed Intelligence, Surveillance and Reconnaissance (ISR) and Two-Stage-To-Orbit (TSTO) operations. The anticipated transition partner for this effort is the Air Force. ***FY 2018 Plans:*** - Complete integrated system conceptual design, initiate and complete preliminary design. - Complete design and initiate fabrication of common inlet. - Complete test facility startup assessment. - Complete design and initiate fabrication of full-scale combustor. - Complete design and initiate fabrication of full-scale nozzle. - Complete initial integrated propulsion controls architecture and finalize technology development plans. ***FY 2019 Plans:*** - Complete manufacturing and ground demonstrate full scale combustor. - Complete manufacturing and ground demonstrate turbine with water injection and full scale nozzle. - Complete manufacturing and ground demonstrate common inlet. - Integrated TBCC system Critical Design Review.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
- Initiate integrated TBCC system assembly. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 increase reflects performance of ground demonstrations and initiation of integrated system assembly work.			
Title: Vertical Take-Off and Landing (VTOL) Technology Demonstrator	47.700	14.700	4.000
Description: The Vertical Take-Off and Landing (VTOL) Technology Demonstrator program will demonstrate revolutionary improvements in (heavier than air) VTOL air vehicle capabilities and efficiencies through the development of subsystem and component technologies, aircraft configurations and system integration. The program will build and flight test an unmanned 10,000 - 12,000 lb. aircraft capable of sustained speeds in excess of 300 kt, demonstrate system level hover efficiency within 25 percent of the ideal power loading, and a lift-to-equivalent drag ratio no less than ten. Additionally, the demonstrator will be designed to have a useful load of no less than 40 percent of the gross weight with a payload capacity of at least 12.5 percent of the gross weight. A strong emphasis will be placed on the development of elegant, multi-functional subsystem technologies that demonstrate net improvements in aircraft efficiencies to enable new and vastly improved operational capabilities. Technologies developed under this program will be made available to all Services for application to future air systems development. The anticipated transition partners for this effort are the Army, Marine Corps, and Special Operations Forces. ***FY 2018 Plans:*** - Complete testing of aircraft propulsion power generator system to verify electro-mechanical system functionality. - Complete electro-mechanical subsystem testing (Copper Bird) to validate design of fan motors and synchronization with generators. - Initiate hardware/software-in-the-loop testing. - Complete subsystem testing of power generation and distribution system (Iron Bird) to include the turboshaft engine, driveshaft, gearbox, generators, electric power distribution, and electric motor functionality. ***FY 2019 Plans:*** - Complete vehicle management system development and avionics requirements, as well as all elements of ground control and operator/pilot stations. - Select ground and flight test site location(s) and finalize ground and flight test plans. - Complete fabrication and assembly of the full, complete aircraft with integrated systems and subsystems. - Complete all air-worthiness considerations and required documentation. - Complete ground and tie-down testing. - Disassemble aircraft and ship to flight test location. - Initiate flight testing. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
The FY 2019 decrease reflects completion of flight testing and program completion.			
Title: Advanced Aerospace System Concepts	3.000	3.000	3.000
Description: Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact and improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems. ***FY 2018 Plans:*** - Conduct enabling technology and sub-system feasibility experiments. - Conduct modeling and simulation of boundary layer transition physics. ***FY 2019 Plans:*** - Perform ground and flight experiments to characterize boundary layer transition physics. - Initiate studies of novel concepts. - Perform technology risk assessments to identify critical enabling technologies.			
Title: Operational Fires	-	-	50.000
Description: The goal of the Operational Fires (OpFires) program is to develop and demonstrate a novel ground-launched system enabling advanced 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. OpFires will leverage and integrate ongoing investments in hypersonic tactical boost glide vehicles (e.g., DARPA s Tactical Boost Glide (TBG) program) to achieve these objectives. In FY18, this program was funded from PE 0602702E, Project TT-07. ***FY 2019 Plans:*** - Complete ground launch platform Systems Requirements Review (SRR) and Conceptual Design Review (CoDR). - Complete booster propulsion system Preliminary Design Review (PDR).			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
- Conduct early propulsion system risk reduction testing. - Complete payload trade studies. - Begin Operational Fires integrated system trade studies. - Complete military utility assessment and wargames. - Begin development of technology maturation plans and risk management plans (TMPs and RMPs). - Begin flight test and range safety planning, coordination, and documentation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY19 increase reflects performance of risk reduction testing and initiation of integrated trade studies and critical design of the system.			
Title: Aircraft and Vehicle IntegrAted Team (AVIATE) ***Description:*** The Aircraft and Vehicle IntegrAted Team (AVIATE) program will design, develop and demonstrate an advanced capability Unmanned Air System (UAS) that is an organic extension of tactical ground vehicles. Current fielded UAS systems require significant infrastructure and manpower to launch and recover, exposing friendly troops to threats while stationary. As a result, small units suffer degraded situational awareness with no overhead capability or delays in air support. A UAS that is an integrated subsystem of a ground vehicle with features to autonomously land, attach, stow, detach, and take-off from its parent ground vehicle while it is on the move would enable on-demand capabilities and drastically improved protection. Ground vehicles could perform traditional UAS missions such as intelligence, surveillance and reconnaissance (ISR) and fires support, as well as unique missions such as electronic attack, sensor emplacement, infrastructure attack, and active protection without having to rely on brigade and theater level assets. This effort will explore design interfaces between the air and ground vehicle, attributes to allow for launch and recovery on the move, and design considerations to enable operations in contested environments. The Army, Navy and Marines are all seeking UAS designs to meet their expeditionary needs and provide runway independence. ***FY 2019 Plans:*** - Explore airframe design concepts of flight demonstration vehicle. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 increase reflects program initiation.	-	-	5.875
Title: Tactically Exploited Reconnaissance Node (TERN) ***Description:*** The goal of the Tactically Exploited Reconnaissance Node (TERN) program, a joint effort with the Office of Naval Research, is to develop a systems approach for, and perform technical demonstration of, a Medium-Altitude, Long-Endurance Unmanned Aerial Vehicle (MALE UAV) capability from smaller ships. The program will demonstrate the technology for launch and recovery of large unmanned aircraft capable of providing persistent 24/7 Intelligence, Surveillance, and Reconnaissance	12.000	5.000	-

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
(ISR) and strike capabilities at long radius orbits. By extending the ISR/strike radius and simultaneously increasing time on station beyond current capabilities from smaller ships, TERN will enable novel operational concepts including maritime surveillance and responsive, persistent deep overland ISR and strike, without requirement for forward basing. To achieve these goals, the program will create new concepts for aircraft launch and recovery, aircraft logistics and maintenance, and aircraft flight in regimes associated with maritime operating conditions. The program will culminate in a launch and recovery demonstration. Application of TERN technologies and operational concepts will enable a novel and cost efficient approach for multiple mission sets. The transition partner is the Navy. ***FY 2018 Plans:*** - Conduct integrated propulsion system testing. - Conduct demonstrator system ground checkout. - Conduct demonstrator system airworthiness assessment. - Conduct demonstrator system instrumentation calibration. - Conduct demonstrator system first flight. - Analyze demonstrator flight test data. - Refine demonstrator system flight control. - Conduct TERN objective system requirements review. - Conduct land-based demonstrator system flight testing. - Update TERN objective system performance models based on demonstrator system performance. - Conduct TERN objective system requirements review. - Conduct demonstrator system envelope expansion flight testing. - Conduct demonstrator transition to and from wing-borne flight testing. - Conduct relative navigation take-off and landing operations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The FY 2019 decrease reflects program completion.			
Title: Aerial Reconfigurable Embedded System (ARES) ***Description:*** Current and future land and ship-to-shore operations require rapid and distributed employment of U.S. forces on the battlefield. The Aerial Reconfigurable Embedded System (ARES) program developed a vertical take-off and landing (VTOL), modular unmanned air vehicle that can carry a 3,000 lb. useful load at a range of 250 nautical miles on a single tank of fuel. ARES will enable distributed operations and access to compact, high altitude landing zones to reduce warfighter exposure to hostile threats and bypass ground obstructions. ARES modular capability allows for mission modules to be quickly interchanged and deployed at the company level. This enables the flexible employment of many different capabilities including: cargo resupply, casualty evacuation, reconnaissance, weapons platforms, and other types of operations. ARES vehicles could be dispatched to	3.500	-	-

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
resupply isolated small units. ARES is well suited for enhanced company operations concepts that would provide the warfighter/ team increased situational awareness for operations in an urban environment. The enabling technologies of interest developed under the ARES program included vertical and translational flight, conversion between powered lift and wing borne lift, ducted fan propulsion systems, lightweight materials, tailless configuration, modularity, and advanced over-actuated flight controls for stable transition from vertical to horizontal flight. Additionally, the program explored opportunities for the design, development, and integration of new, key technologies and capabilities. These included adaptable landing gear concepts to enable operations from irregular landing zones and moving launch/recovery platforms, and autonomous take off and landing. ARES is transitioning to the Marine Corps.			
Accomplishments/Planned Programs Subtotals	180.780	155.406	277.603

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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