Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Defense Advanced Research Projects Agency	Date: May 2021
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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	266.646	223.478	174.043	-	174.043	-	-	-	-	-	-
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	266.646	223.478	174.043	-	174.043	-	-	-	-	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Advanced Aerospace Systems program element, budgeted in the Advanced Technology Budget Activity, is focused on exploiting high pay-off opportunities to provide revolutionary new system capabilities, as opposed to incremental or evolutionary advancements, in order to achieve undeterrable air presence at dramatically reduced costs. Rapid prototyping and experimentation of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Programs will explore new architectural concepts that employ a mix of weapon technologies that achieve lethality through a combination of overwhelming performance and overwhelming numbers rather than through the use of singular and costly high value assets. Studies conducted under this program element include examination and evaluation of emerging aerospace threats, technologies, concepts, use of autonomy to minimize risk, and applications for missiles, munitions, and vehicle systems.

B. Program Change Summary ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	279.741	230.978	191.443	-	191.443
Current President's Budget	266.646	223.478	174.043	-	174.043
Total Adjustments	-13.095	-7.500	-17.400	-	-17.400
• Congressional General Reductions	0.000	-10.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	2.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.454	0.000			
• SBIR/STTR Transfer	-13.549	0.000			
• TotalOtherAdjustments	-	-	-17.400	-	-17.400

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: AIR-01: *ADVANCED AEROSPACE SYSTEMS*		
Congressional Add: *Advanced Full Range Engine (AFRE) Congressional Add*	-	2.500
Congressional Add Subtotals for Project: AIR-01	-	2.500
Congressional Add Totals for all Projects	-	2.500

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Change Summary Explanation

FY 2020: Decrease reflects the SBIR/STTR transfer offset by reprogrammings.
FY 2021: Decrease reflects congressional adjustments.
FY 2022: Decrease reflects completion of the Advanced Full Range Engine (AFRE) program.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Tactical Boost Glide	152.100	81.858	50.043

Description: The Tactical Boost Glide (TBG) program is a Joint DARPA / Air Force effort that is developing and demonstrating 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 2021 Plans:

- Continue detailed planning and execution of additional tests for expanded risk reduction.
- Complete Assembly, Integration, and Test (AI&T) of first and second flight-test vehicles.
- Conduct test readiness reviews (TRRs) for first and second flight, conduct two flight tests, and complete post-flight analyses.
- Continue AI&T of third flight vehicle.
- Complete materials arc-jet testing.
- Complete Static Test Article aeroshell thermo-structural testing.
- Complete test of Engineering Development Unit.
- Continue procurement of hardware for additional tests and continue AI&T of test articles.
- Continue second TBG performer's aerodynamic and aero-thermodynamic risk reduction testing.
- Continue second TBG performer's material and thermo-structural risk reduction testing.
- Continue second TBG performer's materials arc-jet testing.
- Complete second TBG performer's engineering component and system-level testing and design verification testing.
- Complete second TBG performer's material and thermo-structural risk reduction testing, including structural model validation test, and full-scale hot structure test.
- Conduct static firing of Navy variant rocket motor.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Derive Navy variant guidance electronic unit (GEU) system requirements, and complete GEU preliminary and critical designs. - Derive Navy variant weapon datalink (WDL) system requirements, and complete WDL preliminary and critical designs. ***FY 2022 Plans:*** - Complete AI&T of third flight-test vehicle. - Conduct TRR for third flight, conduct flight test, and complete post-flight analysis. - Conduct Navy variant WDL lab verification test. - Conduct two Navy variant GEU captive flight tests and complete post-test analysis. - Conduct Navy variant WDL over-the-air field test and complete post-test analysis. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease reflects program progression from risk reduction activities, hardware procurements, and vehicle builds across both TBG performers to: completion of flight vehicle build and execution of two flight tests, execution of two Navy variant GEU flight tests and Navy variant WDL over-the-air field test.			
Title: Operational Fires	50.000	47.575	45.000
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 program will conduct an engineering flight test to demonstrate the critical technologies in a relevant environment. Those lessons will be captured in an integrated weapon system critical design review for a potential follow-on effort developing a full prototype. OpFires will leverage and integrate ongoing investments in hypersonics to achieve these objectives. ***FY 2021 Plans:*** - Develop integrated weapon system technology maturation plan and initial flight test plan. - Conduct integrated weapon system risk reduction testing. - Complete integrated weapon system Preliminary Design Review (PDR). - Begin Engineering Test (ET-1) Test Readiness Review for canister egress test. - Conduct full-scale propulsion system static hot-fire testing. ***FY 2022 Plans:*** - Complete booster separation, and missile control system testing. - Complete flight test configuration assembly, integration, and test plans. - Complete ET-1 Test Readiness Review and flight (canister egress) test.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Complete integrated weapon system Critical Design Review (CDR). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease is due to completion of static hot fire testing and ramping down to finish Critical Design Review.			
Title: Glide Breaker ***Description:*** Glide Breaker is developing a critical component technology to support a lightweight vehicle designed for precise engagement of hypersonic threats at very long range. Glide Breaker focuses on a single, critical, long-lead technology with applicability to a variety of interceptor concepts and designs. ***FY 2021 Plans:*** - Complete critical design review for technology demonstration. - Begin materials and component level bench testing. - Complete component level bench testing. - Complete test readiness review and procurement for critical, long-lead technology demonstration. - Complete feasibility study for Sounding Rocket Flight Test. ***FY 2022 Plans:*** - Conduct critical, long-lead technology demonstration.	10.000	7.000	7.000
Title: Series Hybrid Electric Propulsion AircRaft Demonstrator (SHEPARD)* ***Description:*** *Formerly Air-Ground Autonomous VEhicles (AGAVE) The result of efforts conducted under AGAVE evolved into more focused research in novel approaches to hybrid-electric propulsion (HEP) systems. The Series Hybrid Electric Propulsion AircRaft Demonstrator (SHEPARD) program will design and develop an efficient HEP system and integrate it into a unique military aircraft application. The innovative aircraft design will include essential operational considerations and mission system components. The program employs a rapid development framework that capitalizes on maturing mission-enabling technologies to quickly meet emergent mission needs while overcoming significant system-level technical challenges. The result will be a flight-demonstrated system with a minimal viable mission capability that is developed quickly and at relatively low cost. ***FY 2021 Plans:*** - Define systems requirements. - Conduct conceptual design activities. - Conduct preliminary design activities.	4.000	16.770	23.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Order long-lead items. ***FY 2022 Plans:*** - Conduct propulsion component testing. - Execute aircraft fabrication. - Integrate and test platform. - Conduct a flight test series. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase reflects a shift from design activities to fabrication and system testing.			
Title: Advanced Aerospace System Concepts ***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 prototype development programs or refocus ongoing work. Topics 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 2021 Plans:*** - Conduct modeling of concept system designs. - Perform sub-system viability experiments. - Demonstrate enabling technologies that support sub-system components. ***FY 2022 Plans:*** - Examine operational utility of novel aerospace system concepts. - Assess feasibility and practicality of developmental aerospace subsystems. - Perform modeling and simulation that support future concepts and novel architectures.	3.000	3.000	3.000
Title: Hypersonic Air-breathing Weapon Concept (HAWC) ***Description:*** The Hypersonic Air-breathing Weapon Concept (HAWC) program is a Joint DARPA / Air Force effort that is developing and demonstrating 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,	19.900	30.880	10.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
and affordable system designs and manufacturing approaches. Investments may lead into developments in aerodynamics, propulsion, and payload capacity, and algorithms that support maneuvering and target recognition. 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 2021 Plans:*** - Conduct flight tests. - Conduct flight test data analysis. ***FY 2022 Plans:*** - Conduct flight tests. - Complete flight test data analysis and final program review. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease reflects completion of flight tests and program completion.			
Title: LongShot ***Description:*** The goal of the LongShot program is to develop and flight demonstrate a weapon system using multi-mode propulsion that significantly increases engagement range and weapon effectiveness against adversary air threats. LongShot will explore new engagement concepts for multi-modal, multi-kill systems that can engage more than one target. LongShot can be deployed either externally from existing fighters or internally from existing bombers. An air system using multi-modal propulsion could capitalize on a slower speed, higher fuel-efficient air vehicle for ingress, while retaining highly energetic air-to-air missiles for end-game target engagements. This approach provides several key benefits, which ultimately increase weapon effectiveness. First, the weapon system will have a much-increased range over their legacy counterparts for transit to an engagement zone. Second, launching air-to-air missiles closer to the adversary increases energy in terminal flight, reduces reaction time, and increases probability of kill. The program will also evaluate other applications of multi-mode propulsion. Potential transition partners include the Navy and Air Force. ***FY 2021 Plans:*** - Initiate conceptual design of vehicle and begin operational analysis showing mission utility of performer design approaches. - Complete conceptual design of the Objective System and derived Demonstration System and conduct conceptual design review. - Conduct system requirements review of the Demonstration System. - Conduct risk reduction studies in support of design activity.	-	24.000	36.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
- Mature operational analysis showing mission utility of performer design approaches and conduct independent Government operational analysis. ***FY 2022 Plans:*** - Complete preliminary design of the Demonstration System and conduct preliminary design review. - Complete Wind Tunnel Testing of a Demonstration Air Vehicle. - Conduct missile separation test. - Initiate System Integration Laboratory setup and testing. - Complete critical design of the demonstration system and conduct critical design review. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 increase is due to completion of preliminary design and increasing efforts on testing of a Demonstration System.			
Title: Advanced Full Range Engine (AFRE) ***Description:*** The Advanced Full Range Engine (AFRE) program is demonstrating turbine-based combined cycle (TBCC) technologies to establish the feasibility of a hypersonic reusable propulsion system. Specifically, AFRE will demonstrate key components of the TBCC propulsion system at low speed where turbine propulsion is used, at high speed where a dual-mode ramjet (DMRJ) is used, and at turbine-to-DMRJ transition conditions. Large-scale components of this complex propulsion system will be developed and demonstrated independently and experimentation will focus on regimes where the propulsion system smoothly transitions from low-speed turbine only operation to high-speed DMRJ only operation. AFRE will enable future airfield-based hypersonic systems to operate without special logistics considerations, 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 2021 Plans:*** - Complete ignitor and combustor ignition risk reduction test. - Complete testing of common inlet aerodynamic model. - Complete full-scale combustor (DMRJ) ground test demonstrations at transition and high Mach conditions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The FY 2022 decrease is due to program completion.	27.646	9.895	-
Accomplishments/Planned Programs Subtotals	266.646	220.978	174.043

	FY 2020	FY 2021
Congressional Add: Advanced Full Range Engine (AFRE) Congressional Add	-	2.500

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	FY 2020	FY 2021
FY 2021 Plans: - Complete ignitor and combustor ignition risk reduction test. - Complete testing of common inlet aerodynamic model. - Complete full-scale combustor (DMRJ) ground test demonstrations at transition and high Mach conditions.		
Congressional Adds Subtotals	-	2.500

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A