# Department of Defense
# Fiscal Year (FY) 2022 Budget Estimates

May 2021

## Air Force

*Justification Book Volume 1 of 3*

## *Research, Development, Test & Evaluation, Air Force*

## Vol−I

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# Volume 1 Table of Contents

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**Fiscal Year (FY) 2022 Budget Estimates**
**RDT&E Descriptive Summaries**
**Budget Activities**
**May 2021**

## INTRODUCTION AND EXPLANATION OF CONTENTS

GENERAL

- This document has been prepared to provide information on the United States Air Force (USAF) Research, Development, Test and Evaluation (RDT&E) program elements and projects in the FY 2022 President's Budget (PB).
    - All exhibits in this document have been assembled in accordance with DoD 7000.14R, Financial Management Regulation, Volume 2B, Chapter 5.
    - Other comments on exhibit contents in this document:
        - Exhibits R-2/2a and R-3 provide narrative information for all RDT&E program elements and projects within the USAF FY 2022 RDT&E program with the exception of classified program elements. The format and contents of this document are in accordance to the guidelines and requirements of the Congressional committees in so far as possible.
        - The "Other Program Funding Summary portion of the R-2 includes, in addition to RDTE& funds, Procurement funds and quantities, Military Construction appropriation funds on specific development programs, Operations and Maintenance appropriation funds where they are essential to the development effort described, and where appropriate, Department of Energy (DOE) costs.

CLASSIFICATION

- All exhibits contained in Volumes I, II, and III are unclassified. Classified exhibits are not included in the submission due to the level of security classification and necessity of special security clearances.

## Exhibit footnotes for FY 2020 actuals and FY 2021 Enacted:

a. FY 2020 Actuals: **"Includes Division A, Title IX and X of the Consolidated Appropriations Act, 2020 (P.L. 116-93), Division F, Title IV and V from the Further Consolidated Appropriations Act, 2020 (P.L. 116-94) and the Coronavirus Aid, Relief, and Economic Security Act (P.L. 116-136)."**

b. FY 2021 Enacted (for every appropriation except O&M, Army, O&M, Navy, and O&M, AF): **"Includes Division C, Title IX and Division J, Title IV of the Consolidated Appropriations Act, 2021 (P.L. 116-260)."**

c. FY 2021 Enacted (for O&M, Army, O&M, Navy, and O&M, AF): "Includes Division C, Title IX and Division J, Title IV of the Consolidated Appropriations Act, 2021 (P.L. 116-260) and funds provided by the Congress as OCO to Base Requirements in O&M Army, O&M Navy, and O&M AF."

Department of Defense
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Total Obligational Authority
(Dollars in Thousands)

05 May 2021

| Summary Recap of Budget Activities | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request |
|---|---|---|---|
| Basic Research | 517,217 | 536,314 | 490,706 |
| Applied Research | 1,687,989 | 1,777,710 | 1,488,286 |
| Advanced Technology Development | 956,409 | 1,000,257 | 810,639 |
| Advanced Component Development & Prototypes | 8,137,663 | 8,794,661 | 10,516,657 |
| System Development & Demonstration | 6,521,351 | 6,197,754 | 5,909,640 |
| Management Support | 3,911,806 | 3,153,492 | 3,371,430 |
| Operational Systems Development | 24,069,528 | 25,290,981 | 27,290,550 |
| Software and Digital Technology Pilot Programs | | 149,742 | 572,807 |
| Total Research, Development, Test & Evaluation | 45,801,963 | 46,900,911 | 50,450,715 |

| Summary Recap of FYDP Programs | | | |
|---|---|---|---|
| Strategic Forces | 783,840 | 1,000,079 | 1,173,877 |
| General Purpose Forces | 3,638,050 | 3,811,478 | 4,488,007 |
| Intelligence and Communications | 1,187,219 | 1,127,255 | 1,013,665 |
| Mobility Forces | 883,396 | 1,010,820 | 844,787 |
| Research and Development | 15,377,077 | 14,184,508 | 15,653,055 |
| Central Supply and Maintenance | 35,898 | 113,472 | 86,648 |
| Training Medical and Other | 8,302 | 7,061 | 10,944 |
| Administration and Associated Activities | 87,640 | 69,398 | 35,212 |
| Support of Other Nations | 3,922 | 3,592 | 2,420 |

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Department of Defense
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Total Obligational Authority
(Dollars in Thousands)

05 May 2021

| | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request |
|---|---|---|---|
| Space | 6,114,555 | 6,892,677 | 6,798,318 |
| Classified Programs | 17,682,064 | 18,680,571 | 20,343,782 |
| Total Research, Development, Test & Evaluation | 45,801,963 | 46,900,911 | 50,450,715 |

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Department of the Air Force
FY 2022 President's Budget
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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 1 | 0601102F | Defense Research Sciences | 01 | 331,102 | 324,755 | 328,303 | U |
| 2 | 0601103F | University Research Initiatives | 01 | 172,379 | 196,502 | 162,403 | U |
| 3 | 0601108F | High Energy Laser Research Initiatives | 01 | 13,736 | 15,057 | | U |
| | Basic Research | | | 517,217 | 536,314 | 490,706 | |
| 4 | 0602020F | Future AF Capabilities Applied Research | 02 | | 79,854 | 79,901 | U |
| 5 | 0602102F | Materials | 02 | 212,551 | 237,847 | 113,460 | U |
| 6 | 0602201F | Aerospace Vehicle Technologies | 02 | 148,176 | 164,426 | 163,032 | U |
| 7 | 0602202F | Human Effectiveness Applied Research | 02 | 128,434 | 133,877 | 136,273 | U |
| 8 | 0602203F | Aerospace Propulsion | 02 | 214,814 | 201,048 | 174,683 | U |
| 9 | 0602204F | Aerospace Sensors | 02 | 210,940 | 232,876 | 193,514 | U |
| 10 | 0602212F | Defense Laboratories R&D Projects (10 U.S.C, Sec 2358) | 02 | 100,519 | | | U |
| 11 | 0602298F | Science and Technology Management - Major Headquarters Activities | 02 | 8,346 | 8,910 | 8,891 | U |
| 12 | 0602602F | Conventional Munitions | 02 | 132,090 | 127,193 | 151,757 | U |
| 13 | 0602605F | Directed Energy Technology | 02 | 114,297 | 130,375 | 121,869 | U |
| 14 | 0602788F | Dominant Information Sciences and Methods | 02 | 214,376 | 215,275 | 169,110 | U |
| 15 | 0602890F | High Energy Laser Research | 02 | 47,462 | 29,155 | | U |
| 16 | 1206601F | Space Technology | 02 | 155,984 | | | U |
| | Applied Research | | | 1,687,989 | 1,560,836 | 1,312,490 | |
| 17 | 0603032F | Future AF Integrated Technology Demos | 03 | | 147,350 | 131,643 | U |
| 18 | 0603112F | Advanced Materials for Weapon Systems | 03 | 58,657 | 60,059 | 31,905 | U |
| 19 | 0603199F | Sustainment Science and Technology (S&T) | 03 | 14,376 | 16,902 | 21,057 | U |

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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 20 | 0603203F | Advanced Aerospace Sensors | 03 | 40,116 | 35,274 | 44,730 | U |
| 21 | 0603211F | Aerospace Technology Dev/Demo | 03 | 95,730 | 62,117 | 70,486 | U |
| 22 | 0603216F | Aerospace Propulsion and Power Technology | 03 | 161,352 | 144,229 | 75,273 | U |
| 23 | 0603270F | Electronic Combat Technology | 03 | 45,882 | 35,841 | 46,591 | U |
| 24 | 0603401F | Advanced Spacecraft Technology | 03 | 75,405 | 87,608 | | U |
| 25 | 0603444F | Maui Space Surveillance System (MSSS) | 03 | 11,343 | 12,068 | | U |
| 26 | 0603456F | Human Effectiveness Advanced Technology Development | 03 | 32,827 | 31,667 | 24,589 | U |
| 27 | 0603601F | Conventional Weapons Technology | 03 | 202,048 | 133,900 | 157,423 | U |
| 28 | 0603605F | Advanced Weapons Technology | 03 | 32,578 | 31,388 | 28,258 | U |
| 29 | 0603680F | Manufacturing Technology Program | 03 | 133,059 | 138,748 | 45,259 | U |
| 30 | 0603788F | Battlespace Knowledge Development and Demonstration | 03 | 53,036 | 63,106 | 56,772 | U |
| | | Advanced Technology Development | | 956,409 | 1,000,257 | 733,986 | |
| 31 | 0603260F | Intelligence Advanced Development | 04 | 5,672 | 4,312 | 5,795 | U |
| 32 | 0603742F | Combat Identification Technology | 04 | 31,367 | 26,348 | 21,939 | U |
| 33 | 0603790F | NATO Research and Development | 04 | 4,774 | 3,640 | 4,114 | U |
| 34 | 0603851F | Intercontinental Ballistic Missile - Dem/Val | 04 | 29,881 | 32,899 | 49,621 | U |
| 35 | 0603859F | Pollution Prevention - Dem/Val | 04 | 2,890 | | | U |
| 36 | 0604001F | NC3 Advanced Concepts | 04 | | | 6,900 | U |
| 37 | 0604002F | Air Force Weather Services Research | 04 | 747 | 2,234 | 986 | U |
| 38 | 0604003F | Advanced Battle Management System (ABMS) | 04 | 139,203 | 158,492 | 203,849 | U |
| 39 | 0604004F | Advanced Engine Development | 04 | 647,850 | 665,280 | 123,712 | U |

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| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 40 | 0604006F | Architecture Initiatives | 04 | | | 82,438 | U |
| 41 | 0604015F | Long Range Strike - Bomber | 04 | 2,878,798 | 2,843,214 | 2,872,624 | U |
| 42 | 0604032F | Directed Energy Prototyping | 04 | 42,390 | 19,429 | 10,820 | U |
| 43 | 0604033F | Hypersonics Prototyping | 04 | 566,935 | 386,157 | 438,378 | U |
| 44 | 0604201F | PNT Resiliency, Mods, and Improvements | 04 | 120,267 | | 39,742 | U |
| 45 | 0604257F | Advanced Technology and Sensors | 04 | 23,145 | 24,702 | 23,745 | U |
| 46 | 0604288F | Survivable Airborne Operations Center | 04 | 12,205 | 59,390 | 133,253 | U |
| 47 | 0604317F | Technology Transfer | 04 | 37,269 | 16,980 | 15,768 | U |
| 48 | 0604327F | Hard and Deeply Buried Target Defeat System (HDBTDS) Program | 04 | 111,506 | 52,825 | 15,886 | U |
| 49 | 0604414F | Cyber Resiliency of Weapon Systems-ACS | 04 | 54,676 | 69,656 | 71,229 | U |
| 50 | 0604776F | Deployment & Distribution Enterprise R&D | 04 | 27,618 | 25,788 | 40,103 | U |
| 51 | 0604858F | Tech Transition Program | 04 | 322,793 | 305,943 | 343,545 | U |
| 52 | 0605230F | Ground Based Strategic Deterrent | 04 | 538,643 | 1,447,113 | 2,553,541 | U |
| 53 | 0207100F | Light Attack Armed Reconnaissance (LAAR) Squadrons | 04 | 1,982 | | | U |
| 54 | 0207110F | Next Generation Air Dominance | 04 | 872,539 | 902,440 | 1,524,667 | U |
| 55 | 0207455F | Three Dimensional Long-Range Radar (3DELRR) | 04 | 22,469 | 19,321 | | U |
| 56 | 0207522F | Airbase Air Defense Systems (ABADS) | 04 | | 8,721 | 10,905 | U |
| 57 | 0208030F | War Reserve Materiel - Ammunition | 04 | | | 3,943 | U |
| 58 | 0208099F | Unified Platform (UP) | 04 | 9,634 | 5,979 | | U |
| 59 | 0305236F | Common Data Link Executive Agent (CDL EA) | 04 | 36,893 | 39,221 | 43,881 | U |
| 60 | 0305251F | Cyberspace Operations Forces and Force Support | 04 | | 20,000 | | U |

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Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 61 | 0305601F | Mission Partner Environments | 04 | 8,237 | 11,409 | 16,420 | U |
| 62 | 0306250F | Cyber Operations Technology Support | 04 | 194,958 | 234,395 | 242,499 | U |
| 63 | 0306415F | Enabled Cyber Activities | 04 | 16,024 | 10,541 | 16,578 | U |
| 64 | 0401310F | C-32 Executive Transport Recapitalization | 04 | | 6,197 | | U |
| 65 | 0708051F | Rapid Sustainment Modernization (RSM) | 04 | 5,802 | 19,964 | | U |
| 66 | 0901410F | Contracting Information Technology System | 04 | 22,266 | 5,662 | 20,343 | U |
| 67 | 1203164F | NAVSTAR Global Positioning System (User Equipment) (SPACE) | 04 | 308,215 | | | U |
| 68 | 1203710F | EO/IR Weather Systems | 04 | 121,723 | | | U |
| 69 | 1206422F | Weather System Follow-on | 04 | 195,495 | | | U |
| 70 | 1206425F | Space Situation Awareness Systems | 04 | 29,013 | | | U |
| 71 | 1206427F | Space Systems Prototype Transitions (SSPT) | 04 | 137,470 | | | U |
| 72 | 1206438F | Space Control Technology | 04 | 56,270 | | | U |
| 73 | 1206730F | Space Security and Defense Program | 04 | 56,385 | | | U |
| 74 | 1206760F | Protected Tactical Enterprise Service (PTES) | 04 | 101,583 | | | U |
| 75 | 1206761F | Protected Tactical Service (PTS) | 04 | 154,237 | | | U |
| 76 | 1206855F | Evolved Strategic SATCOM (ESS) | 04 | 161,882 | | | U |
| 77 | 1206857F | Space Rapid Capabilities Office | 04 | 25,957 | | | U |
| | | Advanced Component Development & Prototypes | | 8,137,663 | 7,428,252 | 8,937,224 | |
| 78 | 0604200F | Future Advanced Weapon Analysis & Programs | 05 | 4,993 | 22,894 | 23,499 | U |
| 79 | 0604201F | PNT Resiliency, Mods, and Improvements | 05 | 202,354 | 38,494 | 167,520 | U |
| 80 | 0604222F | Nuclear Weapons Support | 05 | 4,249 | 26,057 | 30,050 | U |

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| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 81 | 0604270F | Electronic Warfare Development | 05 | 1,994 | 2,094 | 2,110 | U |
| 82 | 0604281F | Tactical Data Networks Enterprise | 05 | 182,691 | 121,188 | 169,836 | U |
| 83 | 0604287F | Physical Security Equipment | 05 | 11,122 | 6,740 | 8,469 | U |
| 84 | 0604329F | Small Diameter Bomb (SDB) - EMD | 05 | 44,530 | | | U |
| 85 | 0604602F | Armament/Ordnance Development | 05 | 29,505 | 23,034 | 9,047 | U |
| 86 | 0604604F | Submunitions | 05 | 3,043 | 3,085 | 2,954 | U |
| 87 | 0604617F | Agile Combat Support | 05 | 31,133 | 18,980 | 16,603 | U |
| 88 | 0604618F | Joint Direct Attack Munition | 05 | | 6,806 | | U |
| 89 | 0604706F | Life Support Systems | 05 | 14,137 | 28,608 | 25,437 | U |
| 90 | 0604735F | Combat Training Ranges | 05 | 52,678 | 23,854 | 23,980 | U |
| 91 | 0604800F | F-35 - EMD | 05 | 7,420 | 5,413 | | U |
| 92 | 0604932F | Long Range Standoff Weapon | 05 | 701,866 | 384,727 | 609,042 | U |
| 93 | 0604933F | ICBM Fuze Modernization | 05 | 155,476 | 156,693 | 129,709 | U |
| 94 | 0605030F | Joint Tactical Network Center (JTNC) | 05 | 2,326 | | | U |
| 95 | 0605056F | Open Architecture Management | 05 | 28,902 | 30,491 | 37,109 | U |
| 96 | 0605221F | KC-46 | 05 | 52,623 | | 1 | U |
| 97 | 0605223F | Advanced Pilot Training | 05 | 328,414 | 248,216 | 188,898 | U |
| 98 | 0605229F | HH-60W | 05 | 238,457 | 63,054 | 66,355 | U |
| 99 | 0605931F | B-2 Defensive Management System | 05 | 224,358 | | | U |
| 100 | 0101125F | Nuclear Weapons Modernization | 05 | 10,157 | 9,665 | | U |
| 101 | 0207171F | F-15 EPAWSS | 05 | 46,040 | 170,368 | 112,012 | U |

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(Dollars in Thousands)

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Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 102 | 0207328F | Stand In Attack Weapon | 05 | 151,534 | 150,371 | 166,570 | U |
| 103 | 0207701F | Full Combat Mission Training | 05 | 11,238 | 9,405 | 7,064 | U |
| 104 | 0305176F | Combat Survivor Evader Locator | 05 | | 971 | | U |
| 105 | 0401221F | KC-46A Tanker Squadrons | 05 | | 76,023 | 73,458 | U |
| 106 | 0401310F | C-32 Executive Transport Recapitalization | 05 | 62 | | | U |
| 107 | 0401319F | VC-25B | 05 | 730,183 | 799,429 | 680,665 | U |
| 108 | 0701212F | Automated Test Systems | 05 | 2,685 | 10,654 | 15,445 | U |
| 109 | 0804772F | Training Developments | 05 | | 4,471 | 4,482 | U |
| 110 | 0901299F | AF A1 Systems | 05 | | 7,453 | | U |
| 111 | 1203176F | Combat Survivor Evader Locator | 05 | 1,949 | | | U |
| 112 | 1203269F | GPS III Follow-On (GPS IIIF) | 05 | 427,210 | | | U |
| 113 | 1203940F | Space Situation Awareness Operations | 05 | 51,749 | | | U |
| 114 | 1206421F | Counterspace Systems | 05 | 26,246 | | | U |
| 115 | 1206422F | Weather System Follow-on | 05 | 2,155 | | | U |
| 116 | 1206425F | Space Situation Awareness Systems | 05 | 349,612 | | | U |
| 117 | 1206431F | Advanced EHF MILSATCOM (SPACE) | 05 | 111,023 | | | U |
| 118 | 1206432F | Polar MILSATCOM (SPACE) | 05 | 385,665 | | | U |
| 119 | 1206433F | Wideband Global SATCOM (SPACE) | 05 | 1,855 | | | U |
| 120 | 1206441F | Space Based Infrared System (SBIRS) High EMD | 05 | 1 | | | U |
| 121 | 1206442F | Next Generation OPIR | 05 | 1,470,278 | | | U |
| 122 | 1206445F | Commercial SATCOM (COMSATCOM) Integration | 05 | 4,817 | | | U |

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(Dollars in Thousands)

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Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 123 | 1206853F | National Security Space Launch Program (SPACE) - EMD | 05 | 414,621 | | | U |
| | | System Development & Demonstration | | 6,521,351 | 2,449,238 | 2,570,315 | |
| 124 | 0604256F | Threat Simulator Development | 06 | 58,906 | 57,620 | 41,909 | U |
| 125 | 0604759F | Major T&E Investment | 06 | 106,014 | 208,299 | 130,766 | U |
| 126 | 0605101F | RAND Project Air Force | 06 | 33,968 | 35,738 | 36,017 | U |
| 127 | 0605502F | Small Business Innovation Research | 06 | 884,237 | | | U |
| 128 | 0605712F | Initial Operational Test & Evaluation | 06 | 13,288 | 13,532 | 12,582 | U |
| 129 | 0605807F | Test and Evaluation Support | 06 | 795,626 | 761,307 | 811,032 | U |
| 130 | 0605826F | Acq Workforce- Global Power | 06 | 256,906 | 270,781 | | U |
| 131 | 0605827F | Acq Workforce- Global Vig & Combat Sys | 06 | 264,506 | 254,768 | 243,796 | U |
| 132 | 0605828F | Acq Workforce- Global Reach | 06 | 159,011 | 157,964 | 435,930 | U |
| 133 | 0605829F | Acq Workforce- Cyber, Network, & Bus Sys | 06 | 241,623 | 254,838 | 435,274 | U |
| 134 | 0605830F | Acq Workforce- Global Battle Mgmt | 06 | 166,552 | 177,811 | | U |
| 135 | 0605831F | Acq Workforce- Capability Integration | 06 | 239,728 | 219,467 | 243,806 | U |
| 136 | 0605832F | Acq Workforce- Advanced Prgm Technology | 06 | 38,517 | 58,477 | 103,041 | U |
| 137 | 0605833F | Acq Workforce- Nuclear Systems | 06 | 135,770 | 179,318 | 226,055 | U |
| 138 | 0605898F | Management HQ - R&D | 06 | 5,932 | 5,724 | 4,079 | U |
| 139 | 0605976F | Facilities Restoration and Modernization - Test and Evaluation Support | 06 | 88,445 | 70,856 | 70,788 | U |
| 140 | 0605978F | Facilities Sustainment - Test and Evaluation Support | 06 | 29,424 | 29,826 | 30,057 | U |
| 141 | 0606017F | Requirements Analysis and Maturation | 06 | 81,734 | 68,256 | 85,799 | U |
| 142 | 0606398F | Management HQ - T&E | 06 | 6,213 | 5,774 | 6,163 | U |

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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 143 | 0303166F | Support to Information Operations (IO) Capabilities | 06 | | | 537 | U |
| 144 | 0303255F | Command, Control, Communication, and Computers (C4) - STRATCOM | 06 | | 21,525 | 25,340 | U |
| 145 | 0308602F | ENTEPRISE INFORMATION SERVICES (EIS) | 06 | 10,239 | 9,865 | 28,720 | U |
| 146 | 0702806F | Acquisition and Management Support | 06 | 5,696 | 13,384 | 37,211 | U |
| 147 | 0804731F | General Skill Training | 06 | 6,238 | 1,260 | 1,506 | U |
| 148 | 0804772F | Training Developments | 06 | | | 2,957 | U |
| 149 | 0909999F | Financing for Cancelled Account Adjustments | 06 | 4,703 | | | U |
| 150 | 1001004F | International Activities | 06 | 3,922 | 3,592 | 2,420 | U |
| 151 | 1206116F | Space Test and Training Range Development | 06 | 14,515 | | | U |
| 152 | 1206392F | ACQ Workforce - Space & Missile Systems | 06 | 187,110 | | | U |
| 153 | 1206398F | Space & Missile Systems Center - MHA | 06 | 10,170 | | | U |
| 154 | 1206860F | Rocket Systems Launch Program (SPACE) | 06 | 15,613 | | | U |
| 155 | 1206862F | Tactically Responsive Launch | 06 | 21,965 | | | U |
| 156 | 1206864F | Space Test Program (STP) | 06 | 25,235 | | 3 | U |
| | | Management Support | | 3,911,806 | 2,879,982 | 3,015,788 | |
| 157 | 0604233F | Specialized Undergraduate Flight Training | 07 | 2,492 | 11,556 | 5,509 | U |
| 158 | 0604445F | Wide Area Surveillance | 07 | 19,268 | | 2,760 | U |
| 159 | 0604776F | Deployment & Distribution Enterprise R&D | 07 | 870 | 499 | | U |
| 160 | 0604840F | F-35 C2D2 | 07 | 624,973 | 695,869 | 985,404 | U |
| 161 | 0605018F | AF Integrated Personnel and Pay System (AF-IPPS) | 07 | 39,275 | 26,986 | 22,010 | U |
| 162 | 0605024F | Anti-Tamper Technology Executive Agency | 07 | 46,934 | 47,107 | 51,492 | U |

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05 May 2021

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| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 163 | 0605117F | Foreign Materiel Acquisition and Exploitation | 07 | 68,397 | 71,099 | 71,391 | U |
| 164 | 0605278F | HC/MC-130 Recap RDT&E | 07 | 16,523 | 19,491 | 46,796 | U |
| 165 | 0606018F | NC3 Integration | 07 | 25,414 | 26,308 | 26,532 | U |
| 166 | 0606942F | Assessments and Evaluations Cyber Vulnerabilities | 07 | | 3,000 | | U |
| 167 | 0101113F | B-52 Squadrons | 07 | 308,048 | 482,741 | 715,811 | U |
| 168 | 0101122F | Air-Launched Cruise Missile (ALCM) | 07 | 10,116 | 1,430 | 453 | U |
| 169 | 0101126F | B-1B Squadrons | 07 | 1,000 | 15,737 | 29,127 | U |
| 170 | 0101127F | B-2 Squadrons | 07 | 85,742 | 181,068 | 144,047 | U |
| 171 | 0101213F | Minuteman Squadrons | 07 | 90,595 | 89,306 | 113,622 | U |
| 172 | 0101316F | Worldwide Joint Strategic Communications | 07 | 25,312 | 31,166 | 15,202 | U |
| 173 | 0101324F | Integrated Strategic Planning & Analysis Network | 07 | 23,542 | 24,227 | | U |
| 174 | 0101328F | ICBM Reentry Vehicles | 07 | 63,484 | 112,547 | 96,313 | U |
| 176 | 0102110F | UH-1N Replacement Program | 07 | 165,844 | 41,388 | 16,132 | U |
| 177 | 0102326F | Region/Sector Operation Control Center Modernization Program | 07 | | 10,704 | 771 | U |
| 178 | 0102412F | North Warning System (NWS) | 07 | | 100 | 99 | U |
| 179 | 0102417F | Over-the-Horizon Backscatter Radar | 07 | | | 42,300 | U |
| 180 | 0202834F | Vehicles and Support Equipment - General | 07 | | | 5,889 | U |
| 181 | 0205219F | MQ-9 UAV | 07 | 122,919 | 106,885 | 85,135 | U |
| 182 | 0205671F | Joint Counter RCIED Electronic Warfare | 07 | 3,854 | 4,080 | 3,111 | U |
| 183 | 0207040F | Multi-Platform Electronic Warfare Equipment | 07 | | | 36,607 | U |
| 184 | 0207131F | A-10 Squadrons | 07 | 25,533 | 24,490 | 39,224 | U |

R-122BAS: FY 2022 President's Budget (Total Base Published Version), as of May 5, 2021 at 14:49:13

Department of the Air Force
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Total Obligational Authority
(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 185 | 0207133F | F-16 Squadrons | 07 | 179,655 | 202,498 | 224,573 | U |
| 186 | 0207134F | F-15E Squadrons | 07 | 640,124 | 288,381 | 239,616 | U |
| 187 | 0207136F | Manned Destructive Suppression | 07 | 15,044 | 14,933 | 15,855 | U |
| 188 | 0207138F | F-22A Squadrons | 07 | 537,232 | 663,825 | 647,296 | U |
| 189 | 0207142F | F-35 Squadrons | 07 | 94,731 | 114,621 | 69,365 | U |
| 190 | 0207146F | F-15EX | 07 | | 159,470 | 118,126 | U |
| 191 | 0207161F | Tactical AIM Missiles | 07 | 10,012 | 19,382 | 32,974 | U |
| 192 | 0207163F | Advanced Medium Range Air-to-Air Missile (AMRAAM) | 07 | 53,681 | 51,705 | 51,288 | U |
| 193 | 0207227F | Combat Rescue - Pararescue | 07 | 281 | 668 | 852 | U |
| 194 | 0207247F | AF TENCAP | 07 | 22,115 | 18,820 | 23,685 | U |
| 195 | 0207249F | Precision Attack Systems Procurement | 07 | 10,395 | 9,244 | 12,083 | U |
| 196 | 0207253F | Compass Call | 07 | 30,687 | 15,825 | 91,266 | U |
| 197 | 0207268F | Aircraft Engine Component Improvement Program | 07 | 108,446 | 125,666 | 103,715 | U |
| 198 | 0207325F | Joint Air-to-Surface Standoff Missile (JASSM) | 07 | 73,510 | 70,663 | 117,325 | U |
| 199 | 0207327F | Small Diameter Bomb (SDB) | 07 | | 20,780 | 27,109 | U |
| 200 | 0207410F | Air & Space Operations Center (AOC) | 07 | 110,651 | 51,094 | 3 | U |
| 201 | 0207412F | Control and Reporting Center (CRC) | 07 | 6,642 | 16,012 | 9,875 | U |
| 202 | 0207417F | Airborne Warning and Control System (AWACS) | 07 | 67,341 | 123,925 | 171,014 | U |
| 203 | 0207418F | AFSPECWAR - TACP | 07 | 2,372 | 4,215 | 4,598 | U |
| 205 | 0207431F | Combat Air Intelligence System Activities | 07 | 13,547 | 16,534 | 21,863 | U |
| 206 | 0207438F | Theater Battle Management (TBM) C4I | 07 | | 7,844 | 7,905 | U |

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Department of the Air Force
FY 2022 President's Budget
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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 207 | 0207439F | Electronic Warfare Integrated Reprogramming (EWIR) | 07 | | | 15,000 | U |
| 208 | 0207444F | Tactical Air Control Party-Mod | 07 | 4,019 | 12,882 | 13,081 | U |
| 209 | 0207452F | DCAPES | 07 | 19,180 | 14,789 | 4,305 | U |
| 210 | 0207521F | Air Force Calibration Programs | 07 | | 1,966 | 1,984 | U |
| 211 | 0207522F | Airbase Air Defense Systems (ABADS) | 07 | | | 7,392 | U |
| 212 | 0207573F | National Technical Nuclear Forensics | 07 | 1,723 | 395 | 1,971 | U |
| 213 | 0207590F | Seek Eagle | 07 | 28,175 | 29,626 | 30,539 | U |
| 214 | 0207601F | USAF Modeling and Simulation | 07 | 15,243 | 17,634 | 17,110 | U |
| 215 | 0207605F | Wargaming and Simulation Centers | 07 | 4,158 | 6,341 | 7,535 | U |
| 216 | 0207610F | Battlefield Abn Comm Node (BACN) | 07 | 25,960 | 6,815 | 32,008 | U |
| 217 | 0207697F | Distributed Training and Exercises | 07 | 4,146 | 3,384 | 4,007 | U |
| 218 | 0208006F | Mission Planning Systems | 07 | 69,232 | 91,601 | 92,557 | U |
| 219 | 0208007F | Tactical Deception | 07 | 7,173 | | 489 | U |
| 220 | 0208064F | OPERATIONAL HQ - CYBER | 07 | 7,335 | 5,493 | 2,115 | U |
| 221 | 0208087F | Distributed Cyber Warfare Operations | 07 | 67,725 | 68,154 | 72,487 | U |
| 222 | 0208088F | AF Defensive Cyberspace Operations | 07 | 37,309 | 30,108 | 18,449 | U |
| 223 | 0208097F | Joint Cyber Command and Control (JCC2) | 07 | 11,306 | 38,410 | 79,079 | U |
| 224 | 0208099F | Unified Platform (UP) | 07 | 90,002 | 84,491 | 101,893 | U |
| 228 | 0208288F | Intel Data Applications | 07 | 1,156 | 1,224 | 493 | U |
| 229 | 0301025F | GeoBase | 07 | 2,623 | 2,762 | 2,782 | U |
| 230 | 0301112F | Nuclear Planning and Execution System (NPES) | 07 | 42,719 | 32,699 | | U |

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Department of the Air Force
FY 2022 President's Budget
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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 231 | 0301113F | Cyber Security Intelligence Support | 07 | | | 5,224 | U |
| 238 | 0301401F | Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness | 07 | 3,575 | 1,382 | 2,463 | U |
| 239 | 0302015F | E-4B National Airborne Operations Center (NAOC) | 07 | 58,059 | 3,462 | 26,331 | U |
| 240 | 0303131F | Minimum Essential Emergency Communications Network (MEECN) | 07 | 13,132 | 44,640 | 20,700 | U |
| 241 | 0303133F | High Frequency Radio Systems | 07 | 15,689 | | | U |
| 242 | 0303140F | Information Systems Security Program | 07 | 26,732 | 10,351 | 8,032 | U |
| 243 | 0303142F | Global Force Management - Data Initiative | 07 | 2,129 | 1,344 | 452 | U |
| 244 | 0303248F | All Domain Common Platform | 07 | | | 64,000 | U |
| 246 | 0304260F | Airborne SIGINT Enterprise | 07 | 85,157 | 127,876 | 97,546 | U |
| 247 | 0304310F | Commercial Economic Analysis | 07 | 3,305 | 4,035 | 3,770 | U |
| 250 | 0305015F | C2 Air Operations Suite - C2 Info Services | 07 | 9,022 | | | U |
| 251 | 0305020F | CCMD Intelligence Information Technology | 07 | 1,121 | 1,646 | 1,663 | U |
| 252 | 0305022F | ISR Modernization & Automation Dvmt (IMAD) | 07 | 19,000 | 19,230 | 18,888 | U |
| 253 | 0305099F | Global Air Traffic Management (GATM) | 07 | 4,404 | 4,637 | 4,672 | U |
| 254 | 0305103F | Cyber Security Initiative | 07 | | 383 | 290 | U |
| 255 | 0305111F | Weather Service | 07 | 34,292 | 36,573 | 26,228 | U |
| 256 | 0305114F | Air Traffic Control, Approach, and Landing System (ATCALS) | 07 | 8,394 | 6,541 | 8,749 | U |
| 257 | 0305116F | Aerial Targets | 07 | 8,761 | 448 | 1,528 | U |
| 260 | 0305128F | Security and Investigative Activities | 07 | 409 | 431 | 223 | U |
| 261 | 0305145F | Arms Control Implementation | 07 | 40,177 | | | U |
| 262 | 0305146F | Defense Joint Counterintelligence Activities | 07 | 6,858 | 4,881 | 8,733 | U |

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Department of the Air Force
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 264 | 0305179F | Integrated Broadcast Service (IBS) | 07 | 8,728 | 8,848 | 21,335 | U |
| 265 | 0305202F | Dragon U-2 | 07 | 36,389 | 36,593 | 17,146 | U |
| 266 | 0305205F | Endurance Unmanned Aerial Vehicles | 07 | 15,000 | | | U |
| 267 | 0305206F | Airborne Reconnaissance Systems | 07 | 137,157 | 123,287 | 71,791 | U |
| 268 | 0305207F | Manned Reconnaissance Systems | 07 | 11,787 | 14,684 | 14,799 | U |
| 269 | 0305208F | Distributed Common Ground/Surface Systems | 07 | 25,009 | 14,126 | 24,568 | U |
| 270 | 0305220F | RQ-4 UAV | 07 | 191,733 | 163,291 | 83,124 | U |
| 271 | 0305221F | Network-Centric Collaborative Targeting | 07 | 10,757 | 15,022 | 17,224 | U |
| 272 | 0305238F | NATO AGS | 07 | 32,567 | 36,664 | 19,473 | U |
| 273 | 0305240F | Support to DCGS Enterprise | 07 | 37,774 | 33,486 | 40,421 | U |
| 274 | 0305600F | International Intelligence Technology and Architectures | 07 | 13,515 | 17,283 | 14,473 | U |
| 275 | 0305881F | Rapid Cyber Acquisition | 07 | 4,223 | 4,254 | 4,326 | U |
| 276 | 0305984F | Personnel Recovery Command & Ctrl (PRC2) | 07 | 2,057 | 2,203 | 2,567 | U |
| 277 | 0307577F | Intelligence Mission Data (IMD) | 07 | 8,614 | 6,266 | 6,169 | U |
| 278 | 0401115F | C-130 Airlift Squadron | 07 | 89,532 | 41,896 | 9,752 | U |
| 279 | 0401119F | C-5 Airlift Squadrons (IF) | 07 | 9,883 | 30,560 | 17,507 | U |
| 280 | 0401130F | C-17 Aircraft (IF) | 07 | 20,653 | 9,935 | 16,360 | U |
| 281 | 0401132F | C-130J Program | 07 | 6,919 | 10,656 | 14,112 | U |
| 282 | 0401134F | Large Aircraft IR Countermeasures (LAIRCM) | 07 | 5,247 | 5,497 | 5,540 | U |
| 283 | 0401218F | KC-135s | 07 | | 4,583 | 3,564 | U |
| 284 | 0401219F | KC-10s | 07 | 19 | | | U |

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Department of the Air Force
FY 2022 President's Budget
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(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 285 | 0401318F | CV-22 | 07 | 17,355 | 18,385 | 17,189 | U |
| 286 | 0408011F | Special Tactics / Combat Control | 07 | 3,543 | 7,659 | 6,640 | U |
| 287 | 0702207F | Depot Maintenance (Non-IF) | 07 | 1,821 | | | U |
| 288 | 0708055F | Maintenance, Repair & Overhaul System | 07 | 9,239 | 24,468 | 26,921 | U |
| 289 | 0708610F | Logistics Information Technology (LOGIT) | 07 | 10,133 | 33,186 | 7,071 | U |
| 290 | 0708611F | Support Systems Development | 07 | 522 | 11,816 | | U |
| 291 | 0804743F | Other Flight Training | 07 | 2,054 | 1,330 | 1,999 | U |
| 292 | 0808716F | Other Personnel Activities | 07 | 10 | | | U |
| 293 | 0901202F | Joint Personnel Recovery Agency | 07 | 1,985 | 2,088 | 1,841 | U |
| 294 | 0901218F | Civilian Compensation Program | 07 | 3,809 | 3,862 | 3,560 | U |
| 295 | 0901220F | Personnel Administration | 07 | 4,265 | 1,581 | 3,368 | U |
| 296 | 0901226F | Air Force Studies and Analysis Agency | 07 | 1,390 | 1,195 | 1,248 | U |
| 297 | 0901538F | Financial Management Information Systems Development | 07 | 8,983 | 6,993 | 4,852 | U |
| 298 | 0901554F | Defense Enterprise Acntng and Mgt Sys (DEAMS) | 07 | 40,239 | 40,564 | | U |
| 299 | 1201017F | Global Sensor Integrated on Network (GSIN) | 07 | 3,532 | | | U |
| 300 | 1201921F | Service Support to STRATCOM - Space Activities | 07 | 952 | 991 | | U |
| 301 | 1202140F | Service Support to SPACECOM Activities | 07 | 11,429 | 8,983 | 6,737 | U |
| 302 | 1203001F | Family of Advanced BLoS Terminals (FAB-T) | 07 | 173,903 | | | U |
| 303 | 1203110F | Satellite Control Network (SPACE) | 07 | 54,850 | | | U |
| 305 | 1203173F | Space and Missile Test and Evaluation Center | 07 | 5,322 | | | U |
| 306 | 1203174F | Space Innovation, Integration and Rapid Technology Development | 07 | 36,890 | | | U |

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Department of the Air Force
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Total Obligational Authority
(Dollars in Thousands)

05 May 2021

Appropriation: 3600F Research, Development, Test & Eval, AF

| Line No | Program Element Number | Item | Act | FY 2020 Actual* | FY 2021 Enacted** | FY 2022 Request | Sec |
|---|---|---|---|---|---|---|---|
| 307 | 1203182F | Spacelift Range System (SPACE) | 07 | 20,128 | | | U |
| 308 | 1203265F | GPS III Space Segment | 07 | 47,178 | | | U |
| 309 | 1203400F | Space Superiority Intelligence | 07 | 14,428 | | | U |
| 310 | 1203614F | JSpOC Mission System | 07 | 82,044 | | | U |
| 311 | 1203620F | National Space Defense Center | 07 | 2,649 | | | U |
| 312 | 1203873F | Ballistic Missile Defense Radars | 07 | 15,335 | | | U |
| 313 | 1203913F | NUDET Detection System (SPACE) | 07 | 49,300 | | | U |
| 314 | 1203940F | Space Situation Awareness Operations | 07 | 16,228 | | | U |
| 315 | 1206423F | Global Positioning System III - Operational Control Segment | 07 | 439,560 | | | U |
| 316 | 1206770F | Enterprise Ground Services | 07 | 114,824 | | | U |
| 9999 | 9999999999 | Classified Programs | | 17,682,064 | 15,023,205 | 15,868,973 | U |
| | | Operational Systems Development | | 24,069,528 | 20,505,963 | 21,705,541 | |
| 317 | 0608158F | Strategic Mission Planning and Execution System - Software Pilot Program | 08 | | | 96,100 | U |
| 318 | 0608410F | Air & Space Operations Center (AOC) - Software Pilot Program | 08 | | | 186,915 | U |
| 319 | 0608920F | Defense Enterprise Accounting and Management System (DEAMS) - Software Pilot Pro | 08 | | | 135,263 | U |
| | | Software and Digital Technology Pilot Programs | | | | 418,278 | |
| | | Total Research, Development, Test & Eval, AF | | 45,801,963 | 36,360,842 | 39,184,328 | |

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## Master Program Element Table of Contents (by Budget Activity then Line Item Number)

***Appropriation 3600: Research, Development, Test & Evaluation, Air Force***



***Appropriation 3600: Research, Development, Test & Evaluation, Air Force***

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***Appropriation 3600: Research, Development, Test & Evaluation, Air Force***

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## Master Program Element Table of Contents (Alphabetically by Program Element Title)

| AF, RDT&E Civilian Personnel: $ in Whole Numbers | | | Average Work Year Cost (AWYC) | | | Full Time Equivalents (FTEs) | | |
|---|---|---|---|---|---|---|---|---|
| **BLIN** | **BLI/PE** | **BLI/PE Title** | **FY20 EOY** | **FY21 Enacted** | **FY22PB** | **FY20 EOY** | **FY21 Enacted** | **FY22PB** |
| **BUDGET ACTIVITY 01: Basic Research** | | | | | | | | |
| 1 | 0601102F | Defense Research Sciences | 174,944 | 156,776 | 175,419 | 180 | 168 | 168 |
| **BUDGET ACTIVITY 02: Applied Research** | | | | | | | | |
| 5 | 0602102F | Materials | 159,230 | 154,727 | 162,552 | 449 | 433 | 433 |
| 6 | 0602201F | Aerospace Vehicle Technologies | 159,476 | 150,876 | 162,273 | 336 | 765 | 159 |
| 7 | 0602202F | Human Effectiveness Applied Research | 150,119 | 144,327 | 151,166 | 400 | 402 | 402 |
| 8 | 0602203F | Aerospace Propulsion | 153,146 | 154,790 | 159,252 | 513 | 468 | 468 |
| 9 | 0602204F | Aerospace Sensors | 161,615 | 157,980 | 163,754 | 580 | 596 | 596 |
| 11 | 0602298F | Science and Technology Management – Major Headquarters Activities | 144,217 | 143,032 | 147,473 | 58 | 60 | 60 |
| 12 | 0602602F | Conventional Munitions | 153,387 | 149,249 | 156,527 | 351 | 292 | 292 |
| 13 | 0602605F | Directed Energy Technology | 150,314 | 149,494 | 154,160 | 438 | 370 | 316 |
| 14 | 0602788F | Dominant Information Sciences and Methods | 131,327 | 130,731 | 134,299 | 745 | 706 | 722 |
| **BUDGET ACTIVITIY 04: Advanced Component Development & Prototypes** | | | | | | | | |
| 47 | 0604317F | Technology Transfer | - | - | 62,500 | 1 | - | 12 |
| 50 | 0604776F | Deployment & Distribution Enterprise R&D | - | - | 117,206 | - | - | 63 |

| AF, RDT&E Civilian Personnel: $ in Whole Numbers | | | Average Work Year Cost (AWYC) | | | Full Time Equivalents (FTEs) | | |
|---|---|---|---|---|---|---|---|---|
| **BLIN** | **BLI/PE** | **BLI/PE Title** | **FY20 EOY** | **FY21 Enacted** | **FY22PB** | **FY20 EOY** | **FY21 Enacted** | **FY22PB** |
| **BUDGET ACTIVITY 06: RDT&E Management Support** | | | | | | | | |
| 129 | 0605807F | Test and Evaluation Support | 127,720 | 125,226 | 130,275 | 2,776 | 2,786 | 2,978 |
| 130 | 0605826F | Acq Workforce - Global Power | 133,684 | 136,458 | - | 1,918 | 1,905 | - |
| 131 | 0605827F | Acq Workforce - Global Vig & Combat Sys | 130,279 | 132,982 | 135,742 | 2,073 | 1,959 | 1,959 |
| 132 | 0605828F | Acq Workforce - Global Reach | 128,874 | 131,549 | 134,278 | 1,256 | 1,178 | 3,111 |
| 133 | 0605829F | Acq Workforce - Cyber, Network, & Bus Sys | 135,658 | 138,473 | 141,346 | 1,772 | 1,669 | 3,002 |
| 134 | 0605830F | Acq Workforce - Global Battle Mgmt | 136,836 | 139,676 | - | 1,280 | 1,273 | - |
| 135 | 0605831F | Acq Workforce - Capability Integration | 149,499 | 137,919 | 159,410 | 1,516 | 1,282 | 1,587 |
| 136 | 0605832F | Acq Workforce - Advance Prgm Technology | 140,173 | 143,081 | 146,050 | 280 | 429 | 429 |
| 137 | 0605833F | Acq Workforce - Nuclear Systems (R1) | 147,568 | 141,000 | 152,954 | 959 | 1,267 | 1,447 |
| 138 | 0605898F | Management Headquarters (Research/Development) | 138,031 | 140,895 | 143,069 | 40 | 38 | 38 |
| 141 | 0606017F | Requirements Analysis and Maturation | 181,860 | 187,292 | 188,786 | 10 | 1 | 1 |
| 145 | 0606398F | Test and Evaluation HQ-MHA | 156,470 | 148,333 | 162,181 | 38 | 39 | 41 |

Footnotes

1. PE 0605826F was consolidated in FY22 to PE 0605828F.

2. PE 0605830F was consolidated in FY22 to PE 0605829F.

Research, Development, Test & Eval, AF

Date: May 2021

Department of the Air Force
TOTAL CIVILIAN PERSONNEL COSTS
FY 2022 President Biden Budget
(FY 2020)

| | a<br>Begin<br>Strength | b<br>End<br>Strength | c<br>FTEs | d<br>Basic<br>Comp | e<br>Overtime<br>Pay | f<br>Holiday<br>Pay | g<br>Other<br>O.C.11 | h<br>Total<br>Variables |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 20,071 | 20,046 | 20,046 | 1,974,141 | 7,294 | 1,459 | 56,532 | 65,285 |
| D1. US Direct Hire (USDH) | 20,069 | 20,044 | 20,044 | 1,973,832 | 7,294 | 1,459 | 56,532 | 65,285 |
| D1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| D1b. General Schedule | 16,472 | 16,495 | 16,495 | 1,703,634 | 1,931 | 1,261 | 39,464 | 42,656 |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 3,584 | 3,536 | 3,536 | 268,193 | 5,363 | 198 | 17,023 | 22,584 |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 20,069 | 20,044 | 20,044 | 1,973,832 | 7,294 | 1,459 | 56,532 | 65,285 |
| D4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 309 | | | | |
| Subtotal - Direct Funded (excludes OC 13) | 20,071 | 20,046 | 20,046 | 1,974,141 | 7,294 | 1,459 | 56,532 | 65,285 |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 2,211 | 3,643 | 3,643 | 321,347 | 364 | 238 | 7,444 | 8,046 |
| R1. US Direct Hire (USDH) | 2,211 | 3,643 | 3,643 | 321,347 | 364 | 238 | 7,444 | 8,046 |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 2,211 | 3,643 | 3,643 | 321,347 | 364 | 238 | 7,444 | 8,046 |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 2,211 | 3,643 | 3,643 | 321,347 | 364 | 238 | 7,444 | 8,046 |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 2,211 | 3,643 | 3,643 | 321,347 | 364 | 238 | 7,444 | 8,046 |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

Research, Development, Test & Eval, AF

Date: May 2021

Department of the Air Force
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(FY 2020)

| | i Comp O.C.11 | j Benefits O.C.12/13 | k Comp & Benefits | l Basic Comp | m Total Comp | n Comp & Benefits | o % BC Variables | p % BC Benefits |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 2,039,426 | 574,487 | 2,613,913 | 98,481 | 101,737 | 130,396 | 3.3% | 29.1% |
| D1. US Direct Hire (USDH) | 2,039,117 | 574,487 | 2,613,604 | 98,475 | 101,732 | 130,393 | 3.3% | 29.1% |
| D1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| D1b. General Schedule | 1,746,290 | 487,311 | 2,233,601 | 103,282 | 105,868 | 135,411 | 2.5% | 28.6% |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 290,777 | 86,556 | 377,333 | 75,846 | 82,233 | 106,712 | 8.4% | 32.3% |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 2,039,117 | 574,487 | 2,613,604 | 98,475 | 101,732 | 130,393 | 3.3% | 29.1% |
| D4. Indirect Hire Foreign Nationals (IHFN) | 309 | | 309 | 154,500 | 154,500 | 154,500 | | |
| Subtotal - Direct Funded (excludes OC 13) | 2,039,426 | 574,487 | 2,613,913 | 98,481 | 101,737 | 130,396 | 3.3% | 29.1% |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 329,393 | 91,928 | 421,321 | 88,209 | 90,418 | 115,652 | 2.5% | 28.6% |
| R1. US Direct Hire (USDH) | 329,393 | 91,928 | 421,321 | 88,209 | 90,418 | 115,652 | 2.5% | 28.6% |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 329,393 | 91,928 | 421,321 | 88,209 | 90,418 | 115,652 | 2.5% | 28.6% |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 329,393 | 91,928 | 421,321 | 88,209 | 90,418 | 115,652 | 2.5% | 28.6% |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 329,393 | 91,928 | 421,321 | 88,209 | 90,418 | 115,652 | 2.5% | 28.6% |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

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(FY 2020)

| | a Begin Strength | b End Strength | c FTEs | d Basic Comp | e Overtime Pay | f Holiday Pay | g Other O.C.11 | h Total Variables |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 22,282 | 23,689 | 23,689 | 2,295,488 | 7,658 | 1,697 | 63,976 | 73,331 |
| T1. US Direct Hire (USDH) | 22,280 | 23,687 | 23,687 | 2,295,179 | 7,658 | 1,697 | 63,976 | 73,331 |
| T1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| T1b. General Schedule | 18,683 | 20,138 | 20,138 | 2,024,981 | 2,295 | 1,499 | 46,908 | 50,702 |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 3,584 | 3,536 | 3,536 | 268,193 | 5,363 | 198 | 17,023 | 22,584 |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 22,280 | 23,687 | 23,687 | 2,295,179 | 7,658 | 1,697 | 63,976 | 73,331 |
| T4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 309 | | | | |
| Subtotal - Total Funded (excludes OC 13) | 22,282 | 23,689 | 23,689 | 2,295,488 | 7,658 | 1,697 | 63,976 | 73,331 |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

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Department of the Air Force
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| | i<br>Comp<br>O.C.11 | j<br>Benefits<br>O.C.12/13 | k<br>Comp<br>& Benefits | l<br>Basic<br>Comp | m<br>Total<br>Comp | n<br>Comp<br>& Benefits | o<br>% BC<br>Variables | p<br>% BC<br>Benefits |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 2,368,819 | 666,415 | 3,035,234 | 96,901 | 99,997 | 128,128 | 3.2% | 29.0% |
| T1. US Direct Hire (USDH) | 2,368,510 | 666,415 | 3,034,925 | 96,896 | 99,992 | 128,126 | 3.2% | 29.0% |
| T1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| T1b. General Schedule | 2,075,683 | 579,239 | 2,654,922 | 100,555 | 103,073 | 131,836 | 2.5% | 28.6% |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 290,777 | 86,556 | 377,333 | 75,846 | 82,233 | 106,712 | 8.4% | 32.3% |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 2,368,510 | 666,415 | 3,034,925 | 96,896 | 99,992 | 128,126 | 3.2% | 29.0% |
| T4. Indirect Hire Foreign Nationals (IHFN) | 309 | | 309 | 154,500 | 154,500 | 154,500 | | |
| Subtotal - Total Funded (excludes OC 13) | 2,368,819 | 666,415 | 3,035,234 | 96,901 | 99,997 | 128,128 | 3.2% | 29.0% |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

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(FY 2021)

| | a Begin Strength | b End Strength | c FTEs | d Basic Comp | e Overtime Pay | f Holiday Pay | g Other O.C.11 | h Total Variables |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 19,660 | 17,831 | 19,354 | 1,879,037 | 6,254 | 1,842 | 51,234 | 59,330 |
| D1. US Direct Hire (USDH) | 19,658 | 17,829 | 19,352 | 1,878,713 | 6,254 | 1,842 | 51,234 | 59,330 |
| D1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| D1b. General Schedule | 16,310 | 14,787 | 16,049 | 1,659,404 | 1,913 | 1,170 | 38,078 | 41,161 |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 3,335 | 3,029 | 3,290 | 217,304 | 4,341 | 672 | 13,111 | 18,124 |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 19,658 | 17,829 | 19,352 | 1,878,713 | 6,254 | 1,842 | 51,234 | 59,330 |
| D4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 324 | | | | |
| Subtotal - Direct Funded (excludes OC 13) | 19,660 | 17,831 | 19,354 | 1,879,037 | 6,254 | 1,842 | 51,234 | 59,330 |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 4,026 | 4,141 | 2,449 | 390,039 | 450 | 275 | 8,950 | 9,675 |
| R1. US Direct Hire (USDH) | 4,026 | 4,141 | 2,449 | 390,039 | 450 | 275 | 8,950 | 9,675 |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 4,026 | 4,141 | 2,449 | 390,039 | 450 | 275 | 8,950 | 9,675 |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 4,026 | 4,141 | 2,449 | 390,039 | 450 | 275 | 8,950 | 9,675 |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 4,026 | 4,141 | 2,449 | 390,039 | 450 | 275 | 8,950 | 9,675 |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

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| | i<br>Comp<br>O.C.11 | j<br>Benefits<br>O.C.12/13 | k<br>Comp<br>& Benefits | l<br>Basic<br>Comp | m<br>Total<br>Comp | n<br>Comp<br>& Benefits | o<br>% BC<br>Variables | p<br>% BC<br>Benefits |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 1,938,367 | 555,437 | 2,493,804 | 97,088 | 100,153 | 128,852 | 3.2% | 29.6% |
| D1. US Direct Hire (USDH) | 1,938,043 | 555,437 | 2,493,480 | 97,081 | 100,147 | 128,849 | 3.2% | 29.6% |
| D1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| D1b. General Schedule | 1,700,565 | 484,738 | 2,185,303 | 103,396 | 105,961 | 136,164 | 2.5% | 29.2% |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 235,428 | 70,079 | 305,507 | 66,050 | 71,559 | 92,859 | 8.3% | 32.2% |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 1,938,043 | 555,437 | 2,493,480 | 97,081 | 100,147 | 128,849 | 3.2% | 29.6% |
| D4. Indirect Hire Foreign Nationals (IHFN) | 324 | | 324 | 162,000 | 162,000 | 162,000 | | |
| Subtotal - Direct Funded (excludes OC 13) | 1,938,367 | 555,437 | 2,493,804 | 97,088 | 100,153 | 128,852 | 3.2% | 29.6% |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 399,714 | 113,937 | 513,651 | 159,265 | 163,215 | 209,739 | 2.5% | 29.2% |
| R1. US Direct Hire (USDH) | 399,714 | 113,937 | 513,651 | 159,265 | 163,215 | 209,739 | 2.5% | 29.2% |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 399,714 | 113,937 | 513,651 | 159,265 | 163,215 | 209,739 | 2.5% | 29.2% |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 399,714 | 113,937 | 513,651 | 159,265 | 163,215 | 209,739 | 2.5% | 29.2% |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 399,714 | 113,937 | 513,651 | 159,265 | 163,215 | 209,739 | 2.5% | 29.2% |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

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(FY 2021)

| | a Begin Strength | b End Strength | c FTEs | d Basic Comp | e Overtime Pay | f Holiday Pay | g Other O.C.11 | h Total Variables |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 23,686 | 21,972 | 21,803 | 2,269,076 | 6,704 | 2,117 | 60,184 | 69,005 |
| T1. US Direct Hire (USDH) | 23,684 | 21,970 | 21,801 | 2,268,752 | 6,704 | 2,117 | 60,184 | 69,005 |
| T1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| T1b. General Schedule | 20,336 | 18,928 | 18,498 | 2,049,443 | 2,363 | 1,445 | 47,028 | 50,836 |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 3,335 | 3,029 | 3,290 | 217,304 | 4,341 | 672 | 13,111 | 18,124 |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 23,684 | 21,970 | 21,801 | 2,268,752 | 6,704 | 2,117 | 60,184 | 69,005 |
| T4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 324 | | | | |
| Subtotal - Total Funded (excludes OC 13) | 23,686 | 21,972 | 21,803 | 2,269,076 | 6,704 | 2,117 | 60,184 | 69,005 |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

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| | i<br>Comp<br>O.C.11 | j<br>Benefits<br>O.C.12/13 | k<br>Comp<br>& Benefits | l<br>Basic<br>Comp | m<br>Total<br>Comp | n<br>Comp<br>& Benefits | o<br>% BC<br>Variables | p<br>% BC<br>Benefits |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 2,338,081 | 669,374 | 3,007,455 | 104,072 | 107,237 | 137,938 | 3.0% | 29.5% |
| T1. US Direct Hire (USDH) | 2,337,757 | 669,374 | 3,007,131 | 104,066 | 107,232 | 137,935 | 3.0% | 29.5% |
| T1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| T1b. General Schedule | 2,100,279 | 598,675 | 2,698,954 | 110,793 | 113,541 | 145,905 | 2.5% | 29.2% |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 235,428 | 70,079 | 305,507 | 66,050 | 71,559 | 92,859 | 8.3% | 32.2% |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 2,337,757 | 669,374 | 3,007,131 | 104,066 | 107,232 | 137,935 | 3.0% | 29.5% |
| T4. Indirect Hire Foreign Nationals (IHFN) | 324 | | 324 | 162,000 | 162,000 | 162,000 | | |
| Subtotal - Total Funded (excludes OC 13) | 2,338,081 | 669,374 | 3,007,455 | 104,072 | 107,237 | 137,938 | 3.0% | 29.5% |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

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| | a Begin Strength | b End Strength | c FTEs | d Basic Comp | e Overtime Pay | f Holiday Pay | g Other O.C.11 | h Total Variables |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 17,831 | 18,218 | 18,325 | 1,951,104 | 6,499 | 1,915 | 53,152 | 61,566 |
| D1. US Direct Hire (USDH) | 17,829 | 18,216 | 18,323 | 1,950,792 | 6,499 | 1,915 | 53,152 | 61,566 |
| D1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| D1b. General Schedule | 14,787 | 15,110 | 15,172 | 1,722,905 | 1,988 | 1,216 | 39,891 | 43,095 |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 3,029 | 3,093 | 3,138 | 225,882 | 4,511 | 699 | 13,216 | 18,426 |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 17,829 | 18,216 | 18,323 | 1,950,792 | 6,499 | 1,915 | 53,152 | 61,566 |
| D4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 312 | | | | |
| Subtotal - Direct Funded (excludes OC 13) | 17,831 | 18,218 | 18,325 | 1,951,104 | 6,499 | 1,915 | 53,152 | 61,566 |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 4,141 | 4,153 | 4,096 | 352,124 | 406 | 248 | 8,152 | 8,806 |
| R1. US Direct Hire (USDH) | 4,141 | 4,153 | 4,096 | 352,124 | 406 | 248 | 8,152 | 8,806 |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 4,141 | 4,153 | 4,096 | 352,124 | 406 | 248 | 8,152 | 8,806 |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 4,141 | 4,153 | 4,096 | 352,124 | 406 | 248 | 8,152 | 8,806 |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 4,141 | 4,153 | 4,096 | 352,124 | 406 | 248 | 8,152 | 8,806 |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

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| | i Comp O.C.11 | j Benefits O.C.12/13 | k Comp & Benefits | l Basic Comp | m Total Comp | n Comp & Benefits | o % BC Variables | p % BC Benefits |
|---|---|---|---|---|---|---|---|---|
| Direct Funded Personnel (includes OC 13) | 2,012,670 | 576,719 | 2,589,389 | 106,472 | 109,832 | 141,304 | 3.2% | 29.6% |
| D1. US Direct Hire (USDH) | 2,012,358 | 576,719 | 2,589,077 | 106,467 | 109,827 | 141,302 | 3.2% | 29.6% |
| D1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| D1b. General Schedule | 1,766,000 | 503,254 | 2,269,254 | 113,558 | 116,399 | 149,569 | 2.5% | 29.2% |
| D1c. Special Schedule | | | | | | | | |
| D1d. Wage System | 244,308 | 72,845 | 317,153 | 71,983 | 77,855 | 101,069 | 8.2% | 32.2% |
| D1e. Highly Qualified Experts | | | | | | | | |
| D1f. Other | | | | | | | | |
| D2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| D3. Total Direct Hire | 2,012,358 | 576,719 | 2,589,077 | 106,467 | 109,827 | 141,302 | 3.2% | 29.6% |
| D4. Indirect Hire Foreign Nationals (IHFN) | 312 | | 312 | 156,000 | 156,000 | 156,000 | | |
| Subtotal - Direct Funded (excludes OC 13) | 2,012,670 | 576,719 | 2,589,389 | 106,472 | 109,832 | 141,304 | 3.2% | 29.6% |
| D5. Other Object Class 13 Benefits | | | | | | | | |
| D5a. USDH - Benefits for Former Employees | | | | | | | | |
| D5b. DHFN - Benefits for Former Employees | | | | | | | | |
| D5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| D5d. Foreign National Separation Liability Accrual | | | | | | | | |
| Reimbursable Funded Personnel (includes OC 13) | 360,930 | 102,861 | 463,791 | 85,968 | 88,118 | 113,230 | 2.5% | 29.2% |
| R1. US Direct Hire (USDH) | 360,930 | 102,861 | 463,791 | 85,968 | 88,118 | 113,230 | 2.5% | 29.2% |
| R1a. Senior Executive Schedule | | | | | | | | |
| R1b. General Schedule | 360,930 | 102,861 | 463,791 | 85,968 | 88,118 | 113,230 | 2.5% | 29.2% |
| R1c. Special Schedule | | | | | | | | |
| R1d. Wage System | | | | | | | | |
| R1e. Highly Qualified Experts | | | | | | | | |
| R1f. Other | | | | | | | | |
| R2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| R3. Total Direct Hire | 360,930 | 102,861 | 463,791 | 85,968 | 88,118 | 113,230 | 2.5% | 29.2% |
| R4. Indirect Hire Foreign Nationals (IHFN) | | | | | | | | |
| Subtotal - Reimbursable Funded (excludes OC 13) | 360,930 | 102,861 | 463,791 | 85,968 | 88,118 | 113,230 | 2.5% | 29.2% |
| R5. Other Object Class 13 Benefits | | | | | | | | |
| R5a. USDH - Benefits for Former Employees | | | | | | | | |
| R5b. DHFN - Benefits for Former Employees | | | | | | | | |
| R5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| R5d. Foreign National Separation Liability Accrual | | | | | | | | |

Research, Development, Test & Eval, AF

Date: May 2021

Department of the Air Force
TOTAL CIVILIAN PERSONNEL COSTS
FY 2022 President Biden Budget
(FY 2022)

| | a Begin Strength | b End Strength | c FTEs | d Basic Comp | e Overtime Pay | f Holiday Pay | g Other O.C.11 | h Total Variables |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 21,972 | 22,371 | 22,421 | 2,303,228 | 6,905 | 2,163 | 61,304 | 70,372 |
| T1. US Direct Hire (USDH) | 21,970 | 22,369 | 22,419 | 2,302,916 | 6,905 | 2,163 | 61,304 | 70,372 |
| T1a. Senior Executive Schedule | 13 | 13 | 13 | 2,005 | | | 45 | 45 |
| T1b. General Schedule | 18,928 | 19,263 | 19,268 | 2,075,029 | 2,394 | 1,464 | 48,043 | 51,901 |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 3,029 | 3,093 | 3,138 | 225,882 | 4,511 | 699 | 13,216 | 18,426 |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 21,970 | 22,369 | 22,419 | 2,302,916 | 6,905 | 2,163 | 61,304 | 70,372 |
| T4. Indirect Hire Foreign Nationals (IHFN) | 2 | 2 | 2 | 312 | | | | |
| Subtotal - Total Funded (excludes OC 13) | 21,972 | 22,371 | 22,421 | 2,303,228 | 6,905 | 2,163 | 61,304 | 70,372 |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

Research, Development, Test & Eval, AF

Date: May 2021

Department of the Air Force
TOTAL CIVILIAN PERSONNEL COSTS
FY 2022 President Biden Budget
(FY 2022)

| | i Comp O.C.11 | j Benefits O.C.12/13 | k Comp & Benefits | l Basic Comp | m Total Comp | n Comp & Benefits | o % BC Variables | p % BC Benefits |
|---|---|---|---|---|---|---|---|---|
| Total Funded Personnel (includes OC 13) | 2,373,600 | 679,580 | 3,053,180 | 102,726 | 105,865 | 136,175 | 3.1% | 29.5% |
| T1. US Direct Hire (USDH) | 2,373,288 | 679,580 | 3,052,868 | 102,722 | 105,861 | 136,173 | 3.1% | 29.5% |
| T1a. Senior Executive Schedule | 2,050 | 620 | 2,670 | 154,231 | 157,692 | 205,385 | 2.2% | 30.9% |
| T1b. General Schedule | 2,126,930 | 606,115 | 2,733,045 | 107,693 | 110,387 | 141,844 | 2.5% | 29.2% |
| T1c. Special Schedule | | | | | | | | |
| T1d. Wage System | 244,308 | 72,845 | 317,153 | 71,983 | 77,855 | 101,069 | 8.2% | 32.2% |
| T1e. Highly Qualified Experts | | | | | | | | |
| T1f. Other | | | | | | | | |
| T2. Direct Hire Program Foreign Nationals (DHFN) | | | | | | | | |
| T3. Total Direct Hire | 2,373,288 | 679,580 | 3,052,868 | 102,722 | 105,861 | 136,173 | 3.1% | 29.5% |
| T4. Indirect Hire Foreign Nationals (IHFN) | 312 | | 312 | 156,000 | 156,000 | 156,000 | | |
| Subtotal - Total Funded (excludes OC 13) | 2,373,600 | 679,580 | 3,053,180 | 102,726 | 105,865 | 136,175 | 3.1% | 29.5% |
| T5. Other Object Class 13 Benefits | | | | | | | | |
| T5a. USDH - Benefits for Former Employees | | | | | | | | |
| T5b. DHFN - Benefits for Former Employees | | | | | | | | |
| T5c. Voluntary Separation Incentive Pay (VSIP) | | | | | | | | |
| T5d. Foreign National Separation Liability Accrual | | | | | | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0601102F / *Defense Research Sciences* | | | | | | | |
| **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 | - | 331.102 | 324.755 | 328.303 | 0.000 | 328.303 | - | - | - | - | - | - |
| 613001: *Physics and Electronics* | - | 80.668 | 91.504 | 95.387 | 0.000 | 95.387 | - | - | - | - | - | - |
| 613002: *Aerospace, Chemical and Material Sciences* | - | 109.588 | 96.084 | 100.415 | 0.000 | 100.415 | - | - | - | - | - | - |
| 613003: *Mathematics, Information and Life Sciences* | - | 105.513 | 90.911 | 96.060 | 0.000 | 96.060 | - | - | - | - | - | - |
| 613004: *Education and Outreach* | - | 35.333 | 46.256 | 36.441 | 0.000 | 36.441 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

Defense Research Sciences consists of extramural research activities in academia and industry along with in-house research performed in the Air Force Research Laboratory. This program supports basic broad-based scientific and engineering research in areas critical to Department of the Air Force weapon, sensor, and support systems. All research areas are subject to long-range planning and technical review by both DAF and tri-Service scientific planning groups. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

Funds in this PE may be used to investigate specified science advancements in air, space and/or cyber domains.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 356.107 | 315.348 | 331.452 | 0.000 | 331.452 |
| Current President's Budget | 331.102 | 324.755 | 328.303 | 0.000 | 328.303 |
| Total Adjustments | -25.005 | 9.407 | -3.149 | 0.000 | -3.149 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 10.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | 0.000 | 0.000 | | | |
| • Other Adjustments | -25.005 | -0.593 | -3.149 | 0.000 | -3.149 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 613004: *Education and Outreach* | | |
| Congressional Add: *Program increase - defense research sciences* | - | 10.000 |
| Congressional Add Subtotals for Project: 613004 | - | 10.000 |
| Congressional Add Totals for all Projects | - | 10.000 |

**Change Summary Explanation**

Increase in FY 2022 of $0.873 million is due to civilian pay reprice adjustments and added emphasis in Defense Research Sciences projects/efforts based on higher Department of Defense and Department of the Air Force priorities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102F / *Defense Research Sciences* | Project (Number/Name)<br>613001 / *Physics and Electronics* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 613001: *Physics and Electronics* | - | 80.668 | 91.504 | 95.387 | 0.000 | 95.387 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

Basic research in the Physics and Electronics Project seeks to enable revolutionary advances and expand the fundamental knowledge supporting technologies critical to the future of the Department of the Air Force. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability while simultaneously reducing component and system power, size, mass, and life cycle costs. Major areas being investigated in this project are complex electronics and fundamental quantum processes; plasma physics and high energy density non-equilibrium processes; and lasers and optics, electromagnetics, communication, and signal processing. While the following specific sub-areas are the focus of the project, there is interest in exploring novel ideas that may bridge these major efforts as well as those in the other projects within this program.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Complex Electronics and Fundamental Quantum Processes | 32.267 | 36.601 | 38.155 |
| ***Description:*** Scientific focus areas are atomic and molecular physics, photonics, quantum electronic solids, gigahertz-terahertz electronics and material, semiconductor and electromagnetic materials, and optoelectronics.<br><br>***FY 2021 Plans:***<br>Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, metamaterials, cathodes, dielectric and magnetic materials, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photonic systems, quantum dots and defects in solids, and ultracold atoms and molecules.<br><br>***FY 2022 Plans:***<br>Continue to explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, metamaterials, cathodes, dielectric and magnetic materials, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photonic systems, quantum dots and defects in solids, and ultracold atoms and molecules.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.554 million. Funding increased due to added emphasis in Complex Electronics and Fundamental Quantum Processes research. | | | |
| ***Title:*** Plasma Physics and High Energy Density Non-Equilibrium Processes | 16.134 | 18.301 | 19.077 |
| ***Description:*** Scientific focus areas are plasma, electro-energetic physics and space sciences.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613001 / *Physics and Electronics* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Explore a wide range of activities characterized by processes sufficiently energetic to require understanding and managing plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma discharges, radio frequency propagation, radio frequency-plasma interaction, and high-power, beam-driven microwave devices.<br>***FY 2022 Plans:***<br>Continue to explore a wide range of activities characterized by processes sufficiently energetic to require understanding and managing plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma discharges, radio frequency propagation, radio frequency-plasma interaction, and high-power, beam-driven microwave devices.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.776 million. Funding increased due to added emphasis in Plasma Physics and High Energy Density Non-Equilibrium Processes research. | | | |
| ***Title:*** Lasers and Optics, Electromagnetics, Communication and Signal Processing<br>***Description:*** Scientific focus areas are physical mathematics and applied analysis, novel computational methods, electromagnetics and wave propagation in complex media, ultra-fast dynamics, for revolutionary approaches to remote sensing and imaging physics, and surveillance and navigation.<br>***FY 2021 Plans:***<br>Explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.<br>***FY 2022 Plans:***<br>Continue to explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Continue to investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.553 million. Funding increased due to added emphasis in Lasers and Optics, Electromagnetics, Communication and Signal Processing research. | 32.267 | 36.602 | 38.155 |
| **Accomplishments/Planned Programs Subtotals** | 80.668 | 91.504 | 95.387 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613001 / *Physics and Electronics* |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102F / *Defense Research Sciences* | Project (Number/Name)<br>613002 / *Aerospace, Chemical and Material Sciences* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 613002: *Aerospace, Chemical and Material Sciences* | - | 109.588 | 96.084 | 100.415 | 0.000 | 100.415 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

Basic research in the Aerospace, Chemical, and Materials Sciences Project seeks to enable revolutionary advances and expand the fundamental knowledge supporting technologies critical to the future of the Department of the Air Force. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability while simultaneously reducing component and system power, size, mass, and life cycle costs. Research topics include: aero-structure interactions and control; energy, power, and propulsion; complex materials and structures; and cross-disciplinary research reflecting the highly integrated nature of future weapon systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Aero-Structure Interactions and Control | 32.876 | 28.825 | 30.125 |
| ***Description:*** Scientific focus areas are high temperature aerospace materials, non-equilibrium aerothermodynamics and chemistry, unsteady, compressible flow turbulence, multiscale fluid-material interactions, and flow control.<br><br>***FY 2021 Plans:***<br>Investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Department of the Air Force systems. Explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.<br><br>***FY 2022 Plans:***<br>Continue to investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Department of the Air Force systems. Continue to explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.300 million. Funding increased due to added emphasis in Aero-Structure Interactions and Control research. | | | |
| ***Title:*** Energy, Power, and Propulsion | 32.876 | 28.825 | 30.125 |
| ***Description:*** Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, power and propulsion, and combustion and diagnostics. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613002 / *Aerospace, Chemical and Material Sciences* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hydrodynamics, structural dynamics, and multi-fidelity simulations. Investigate processes associated with the generation, storage, and utilization of energy, specifically for Department of the Air Force systems. This includes developing novel energetic materials as well as understanding optimizing and controlling combustion processes.<br>***FY 2022 Plans:***<br>Continue to exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hydrodynamics, structural dynamics, and multi-fidelity simulations. Continue to investigate processes associated with the generation, storage, and utilization of energy, specifically for Department of the Air Force systems including developing novel energetic materials as well as understanding optimizing and controlling combustion processes.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.300 million. Funding increased due to added emphasis in Energy, Power and Propulsion research. | | | |
| ***Title:*** Complex Materials and Structures<br>***Description:*** Scientific focus areas are design, manufacturing, and dynamics and control of multifunctional materials and microsystems, multi-scale mechanics, diagnostics and prognosis, and physico-chemistry of novel organic materials.<br>***FY 2021 Plans:***<br>Investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that can adapt to environmental constraints or mission requirements. Explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the mesoscale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.<br>***FY 2022 Plans:***<br>Continue to investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that can adapt to environmental constraints or mission requirements. Continue to explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the mesoscale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 43.836 | 38.434 | 40.165 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613002 / *Aerospace, Chemical and Material Sciences* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $1.731 million. Funding increased due to added emphasis in Complex Materials and Structures research. | | | |
| **Accomplishments/Planned Programs Subtotals** | 109.588 | 96.084 | 100.415 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102F / *Defense Research Sciences* | Project (Number/Name)<br>613003 / *Mathematics, Information and Life Sciences* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 613003: *Mathematics, Information and Life Sciences* | - | 105.513 | 90.911 | 96.060 | 0.000 | 96.060 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

Basic research in the Mathematics, Information Sciences, and Life Sciences Project seeks to expand fundamental knowledge and enable revolutionary advances and supporting technologies critical to the future of the Department of the Air Force. Major areas being investigated in this project are data fusion, machine learning and artificial intelligence, information and complex networks, cyber-security, autonomous decision making, dynamical systems, optimization and control, and natural materials and systems. While the following are specific sub-areas within this project, there is a continuing interest to explore novel ideas to bridge disciplines within this program.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Information and Complex Networks | 26.378 | 22.728 | 24.015 |
| ***Description:*** Scientific focus areas are information operations and security, data and information fusion, advanced computing, artificial intelligence and complex networks.<br><br>***FY 2021 Plans:***<br>Design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems, including hardware and software interactions. This includes traditional aspects of information assurance, but with an emphasis on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Analyze, optimize and design multi-scale networks with resilient features against noise and corruption from difficult environments and adversarial operations, using rigorous mathematical models of information exchange, physical operations, and human-machine interactions. Develop new computing approaches and algorithms for network-of-network information processing at the speed of warfare. Develop new mathematical approaches for predictive, multi-scale and multi-physics simulations of Department of the Air Force systems and systems-of-systems in realistic environments.<br><br>***FY 2022 Plans:***<br>Continue to design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems, including hardware and software interactions, including traditional aspects of information assurance, but with an emphasis on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Continue to analyze, optimize and design multi-scale networks with resilient features against noise and corruption from difficult environments and adversarial operations, using rigorous mathematical models of information exchange, physical operations, and human-machine interactions. Continue to develop new computing approaches and algorithms for | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613003 / *Mathematics, Information and Life Sciences* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| network-of-network information processing at the speed of warfare and new mathematical approaches for predictive, multi-scale and multi-physics simulations of Department of the Air Force systems and systems-of-systems in realistic environments.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.287 million. Funding increased due to added emphasis in Information and Complex Networks research. | | | |
| ***Title:*** Decision Making<br><br>***Description:*** Scientific focus areas are mathematical modeling of cognition and decision making, development and testing of advanced representations and processes for higher-level artificial intelligence, trust between humans and autonomous agents, mixed human-machine decision making, and computational social science for asymmetric threat detection and predictive large-scale influence.<br><br>***FY 2021 Plans:***<br>Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision-making to achieve accurate real-time integration of human expertise and knowledge into a machine-based battlespace network. Develop new mathematical models for information capture; object, scene and relation identification; and multi-level reasoning and meta-learning. Advance the critical knowledge base in modeling of individual and group cognitive processing and decision making, and construct advanced methodologies for predictive, verifiable simulations of large-scale socio-cultural and human-machine hybrid networks.<br><br>***FY 2022 Plans:***<br>Continue to investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision-making to achieve accurate real-time integration of human expertise and knowledge into a machine-based battlespace network. Continue to develop new mathematical models for information capture; object, scene and relation identification; and multi-level reasoning and meta-learning. Continue to advance the critical knowledge base in modeling of individual and group cognitive processing and decision making, and construct advanced methodologies for predictive, verifiable simulations of large-scale socio-cultural and human-machine hybrid networks.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.030 million. Funding increased due to added emphasis in Decision Making research. | 21.103 | 18.182 | 19.212 |
| ***Title:*** Dynamical Systems, Optimization, and Control<br><br>***Description:*** Scientific focus areas are computer models of dynamical data and communication networks, data-fusion, dynamics and control theory for multi-scale and complex networks, and mathematics of distributed optimization in uncertain, variable, | 26.378 | 22.728 | 24.015 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613003 / *Mathematics, Information and Life Sciences* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| continuous and discrete networked systems. Includes the development of advanced computing architectures for solving optimization and data-fusion problems in real time and by embedded processors in autonomous or semi-autonomous platforms.<br><br>***FY 2021 Plans:***<br>Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.<br><br>***FY 2022 Plans:***<br>Continue to develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Continue to develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.287 million. Funding increased due to added emphasis in Dynamical Systems, Optimization, and Control research. | | | |
| ***Title:*** Natural Materials and Systems<br><br>***Description:*** Scientific focus areas are natural materials and nature inspired systems, human performance and biosystems, cognitive neuroscience and biophysics.<br><br>***FY 2021 Plans:***<br>Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems are built, assembled and organized, and functioning to accomplish their objectives. Develop fundamental understanding of biochemical mechanisms and control procedures for the production and manufacture of natural materials, and develop reverse engineering approaches to optimize the bio-chemical functionality. Develop approaches to adapt, blend and mimic existing natural sensory systems and neural systems of varying complexity, to add existing capabilities to these organisms and design in-silico replicas with similar or advanced capabilities.<br><br>***FY 2022 Plans:***<br>Continue to investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems are built, assembled and organized, and functioning to accomplish their objectives. Continue to develop fundamental understanding of bio-chemical mechanisms and control procedures for the production and manufacture of natural materials, and develop reverse-engineering approaches to optimize the bio-chemical functionality. Continue to develop approaches to adapt, | 31.654 | 27.273 | 28.818 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613003 / *Mathematics, Information and Life Sciences* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| blend and mimic existing natural sensory systems and neural systems of varying complexity, to add existing capabilities to these organisms and design in-silico replicas with similar or advanced capabilities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.545 million. Funding increased due to added emphasis in Natural Materials and Systems research. | | | |
| **Accomplishments/Planned Programs Subtotals** | 105.513 | 90.911 | 96.060 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102F / *Defense Research Sciences* | Project (Number/Name)<br>613004 / *Education and Outreach* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 613004: *Education and Outreach* | - | 35.333 | 46.256 | 36.441 | 0.000 | 36.441 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The major efforts in the Science and Technology (S&T) Education and Outreach Project are to facilitate interactions between the international and domestic research communities and Department of the Air Force (DAF) researchers, and to support and develop scientists and engineers with an awareness of DAF basic research priorities. These professional interactions and collaborations benefit the DAF by increasing awareness of DAF basic research priorities in the research community as a whole, and attracting talented scientists and engineers to address DAF needs. International interactions facilitate future interoperability of coalition systems and foster relationships with future coalition partners. This project also seeks to enhance interactions with Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Outreach to International S&T Community | 12.367 | 12.690 | 12.754 |
| ***Description:*** Foster international S&T cooperation by supporting direct interchanges with a broad range of key international researchers and communities. Identify and leverage international scientific advances when appropriate.<br><br>***FY 2021 Plans:***<br>Leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explore current foreign investments and influence world-class scientific research on specific topics of interest to the Department of the Air Force. Pursue access to technical information on foreign research capabilities within our interests. Support international visits by scientists and high-level DoD science and technology delegations, and provide primary interface to coordinate international science and technology participation among DoD organizations.<br><br>***FY 2022 Plans:***<br>Continue to leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Continue to explore current foreign investments and influence world-class scientific research on specific topics of interest to the Department of the Air Force. Continue to pursue access to technical information on foreign research capabilities within our interests. Continue to support international visits by scientists and high-level DoD science and technology delegations, and provide primary interface to coordinate international science and technology participation among DoD organizations.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.064 million. Funding decreased due to reduced emphasis in Outreach to International Research Community research. | | | |
| ***Title:*** Outreach to U.S. S&T Workforce | 22.966 | 23.566 | 23.687 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102F / *Defense Research Sciences* | **Project (Number/Name)**<br>613004 / *Education and Outreach* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Department of the Air Force S&T capabilities.<br><br>***FY 2021 Plans:***<br>Identifying, recruiting, and increasing opportunities for new investigators to participate in critical Department of the Air Force research. Support science, mathematics, and engineering research including Historically Black Colleges and Universities, Hispanic-Serving Institutions, and other minority institutions. Support science activities that encourage elementary/middle/ high school youths to develop an interest in and pursue higher education and employment in the science, mathematics, and engineering fields.<br><br>***FY 2022 Plans:***<br>Continue to identify, recruit, and increase opportunities for new investigators to participate in critical Department of the Air Force research. Continue to support science, mathematics, and engineering research including Historically Black Colleges and Universities, Hispanic-Serving Institutions, and other minority institutions. Continue to support science activities that encourage elementary/middle/high school youths to develop an interest in and pursue higher education and employment in the science, mathematics, and engineering fields.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.121 million. Funding decreased due to reduced emphasis in Outreach to United States S&T Workforce research. | | | |
| **Accomplishments/Planned Programs Subtotals** | 35.333 | 36.256 | 36.441 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - defense research sciences | - | 10.000 |
| ***FY 2021 Plans:*** Conduct Congressionally directed effort | | |
| **Congressional Adds Subtotals** | - | 10.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0601103F / *University Research Initiatives* | | | | | | | |
| **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 | - | 172.379 | 196.502 | 162.403 | 0.000 | 162.403 | - | - | - | - | - | - |
| 615094: *University Research Initiatives* | - | 172.379 | 196.502 | 162.403 | 0.000 | 162.403 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program supports defense-related basic research in a wide range of scientific and engineering disciplines relevant to maintaining U.S. military technology superiority. Research topics include, but are not limited to, transformational and high priority technologies such as nanotechnology, sensor networks, artificial intelligence and information fusion, smart materials and structures, quantum materials and processes for sensing, communication and computing, efficient energy and power conversion, and high-energy materials for propulsion and control. The program also enhances and promotes the education of U.S. scientists and engineers in disciplines critical to maintaining, advancing, and enabling future U.S. defense technologies. For example, the National Defense Science and Engineering Graduate program awards fellowships to train U.S citizens in science and engineering disciplines of military importance under a joint tri-Service and Office of the Assistant Secretary of Defense for Research and Engineering competitive scholarship program. Finally, this program assists universities in establishing superior instrumentation capabilities needed to improve the quality of defense-related research and education. A fundamental component of this program is the recognition that future technologies and technology exploitations require highly coordinated and concerted multi- and inter-disciplinary efforts. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F and 1206601SF.

Funds in this PE may be used to investigate specified science advancements in air, space and/or cyber domains.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601103F / *University Research Initiatives* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 178.859 | 161.861 | 165.083 | 0.000 | 165.083 |
| Current President's Budget | 172.379 | 196.502 | 162.403 | 0.000 | 162.403 |
| Total Adjustments | -6.480 | 34.641 | -2.680 | 0.000 | -2.680 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 35.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -6.480 | 0.000 | | | |
| • Other Adjustments | 0.000 | -0.359 | -2.680 | 0.000 | -2.680 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 615094: *University Research Initiatives* | | |
| Congressional Add: *Program Increase - Basic Research* | 19.488 | - |
| Congressional Add: *Program increase - university research initiatives* | - | 15.000 |
| Congressional Add: *Program increase - solar block research* | - | 5.000 |
| Congressional Add: *Program increase - hypersonic supply chain research* | - | 5.000 |
| Congressional Add: *Program increase - gigahertz - terahertz electronics and material research* | - | 10.000 |
| Congressional Add Subtotals for Project: 615094 | 19.488 | 35.000 |
| Congressional Add Totals for all Projects | 19.488 | 35.000 |

**Change Summary Explanation**

Decrease in FY 2022 of $0.077 million is due to civilian pay reprice adjustments and reduced emphasis in University Research Initiatives projects/efforts based on higher Department of Defense and Department of the Air Force priorities.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Multidisciplinary University Research Initiative | 84.090 | 88.826 | 89.322 |
| ***Description:*** Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principal investigators. | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601103F / *University Research Initiatives* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Fund competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Department of the Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Support and recognize superior academic researchers in the early stages of their careers through the Presidential Early Career Award for Scientists and Engineers program. Fund existing multi-year awards of multi-disciplinary programs.<br>***FY 2022 Plans:***<br>Enhance the program and continue funding competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Department of the Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Continue to support and recognize superior academic researchers in the early stages of their careers through the Presidential Early Career Award for Scientists and Engineers program. Continue funding of existing multi-year awards of multi-disciplinary programs.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.496 million. Funding increased due to added emphasis in Multidisciplinary University Research Initiative research. | | | |
| ***Title:*** Science and Engineering Education<br>***Description:*** Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities.<br>***FY 2021 Plans:***<br>Award highly competitive National Defense Science and Engineering Graduate fellowships. Support competitive awards for graduate and undergraduate research experiences, including those established under the Awards to Stimulate and Support Undergraduate Research Experiences program. Fund awards initiated under prior year DoD programs.<br>***FY 2022 Plans:***<br>Enhance the program and continue to award highly competitive National Defense Science and Engineering Graduate fellowships. Continue to support competitive awards for graduate and undergraduate research experiences, including those established under the Awards to Stimulate and Support Undergraduate Research Experiences program. Continue funding for awards initiated under prior year DoD programs.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.315 million. Funding increased due to added emphasis in Science and Engineering Education research. | 53.512 | 56.526 | 56.841 |
| ***Title:*** Research Instrumentation | 15.289 | 16.150 | 16.240 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601103F / *University Research Initiatives* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities.<br><br>***FY 2021 Plans:***<br>Award grants on a competitive basis under the Defense University Research Instrumentation Program to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities.<br><br>***FY 2022 Plans:***<br>Enhance the program and continue to award grants on a competitive basis under the Defense University Research Instrumentation Program to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.090 million. Funding increased due to added emphasis in Research Instrumentation research. | | | |
| **Accomplishments/Planned Programs Subtotals** | 152.891 | 161.502 | 162.403 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase - Basic Research<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed effort | 19.488 | - |
| ***Congressional Add:*** Program increase - university research initiatives<br>***FY 2021 Plans:*** Conduct Congressionally directed effort | - | 15.000 |
| ***Congressional Add:*** Program increase - solar block research<br>***FY 2021 Plans:*** Conduct Congressionally directed effort | - | 5.000 |
| ***Congressional Add:*** Program increase - hypersonic supply chain research<br>***FY 2021 Plans:*** Conduct Congressionally directed effort | - | 5.000 |
| ***Congressional Add:*** Program increase - gigahertz - terahertz electronics and material research<br>***FY 2021 Plans:*** Conduct Congressionally directed effort | - | 10.000 |
| **Congressional Adds Subtotals** | 19.488 | 35.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601103F / *University Research Initiatives* |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0601108F / *High Energy Laser Research Initiatives* | | | | | | | |
| **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 | - | 13.736 | 15.057 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 615097: *Joint Directed Energy Basic Research* | - | 13.736 | 15.057 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program funds basic research aimed at developing fundamental scientific knowledge to support future Department of Defense Directed Energy Weapon systems through the Joint Directed Energy Transition Office. This program funds multi-disciplinary research institutes to conduct research on laser, laser beam control and high power microwave technologies. In addition, this program supports educational grants to stimulate student interest in directed energy and encourage graduate research in topics related to high energy lasers and high power microwaves. These educational grants are used for educational tools, scholarships, and summer intern employees in military laboratories. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2021, Project 615097 is renamed from High Energy Research Initiatives to Joint Directed Energy Basic Research. This project name change reflects the direction in the 2017 and 2018 National Defense Authorization Acts.

For FY 2022 this effort is moving to OSD PE 601108D8Z.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 14.795 | 15.085 | 15.397 | 0.000 | 15.397 |
| Current President's Budget | 13.736 | 15.057 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | -1.059 | -0.028 | -15.397 | 0.000 | -15.397 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | -0.028 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.541 | 0.000 | | | |
| • Other Adjustments | -0.518 | 0.000 | -15.397 | 0.000 | -15.397 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601108F / *High Energy Laser Research Initiatives* |

**Change Summary Explanation**

Activities supporting Joint Directed Energy Basic Research decreased in FY 2022 from 15.057 million to zero. Planned activities transferred to the Office of the Secretary of Defense Program Element 0601108D8Z.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Directed Energy Sources and Devices<br>***Description:*** Improve the fundamental understanding and modeling of high energy laser and high power microwave sources and devices.<br>***FY 2021 Plans:***<br>Continue investigations into innovative laser technologies, in diode-pumped lasers, fiber, and solid state laser technologies. Continue investigations into innovative microwave technologies, in microwave sources, antennas, and related microwave component technologies. Continue overseas efforts to leverage international technology advancements. Continue investigations into innovative high power laser and high power microwave technologies.<br>***FY 2022 Plans:***<br>FY 2022 effort is moving to OSD PE 601108D8Z.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 effort is moving to OSD PE 601108D8Z | 6.236 | 6.910 | 0.000 |
| ***Title:*** Directed Energy Propagation Technologies<br>***Description:*** Improve the fundamental understanding and modeling of beam control technologies as they relate to high energy laser applications and high power microwaves. Conduct research in atmospheric characterization, metrology, control systems, algorithms, waveguides, antennas and beam control component technology.<br>***FY 2021 Plans:***<br>Conduct research of innovative high energy laser and high power microwave beam control architectures. Continue to leverage international research developments and technology advancements.<br>***FY 2022 Plans:***<br>FY 2022 effort is moving to OSD PE 601108D8Z.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 effort is moving to OSD PE 601108D8Z. | 6.250 | 6.897 | 0.000 |
| ***Title:*** Directed Energy Education<br>***Description:*** Fund educational grants to stimulate student interest in directed energy. | 1.250 | 1.250 | 0.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>PE 0601108F / *High Energy Laser Research Initiatives* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue to provide scholarships and internships to support college students studying in fields related to high energy lasers and high power microwaves. Continue to provide grants to the United States Service Academies to stimulate studies related to high energy lasers and high power microwaves among military cadets. Continue to fund publication of journals and support continuing education for professionals in the high energy laser and high power microwave fields.<br>***FY 2022 Plans:***<br>FY 2022 effort is moving to OSD PE 601108D8Z.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 effort is moving to OSD PE 601108D8Z. | | | |
| **Accomplishments/Planned Programs Subtotals** | 13.736 | 15.057 | 0.000 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602020F / *Future AF Capabilities Applied Research* | | | | | | | |
| **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 | - | 0.000 | 79.854 | 79.901 | 0.000 | 79.901 | - | - | - | - | - | - |
| 620200: *Enterprise Transformational Appld Research* | - | 0.000 | 79.854 | 79.901 | 0.000 | 79.901 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops cross-enterprise transformational applied research efforts to accelerate the "pipeline" of technology-enabled capability candidates focused on the five strategic capabilities outlined in the Air Force 2030 Science and Technology (S&T) Strategy: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality. The Air Force Research Laboratory (AFRL) will plan and manage these funds at the enterprise level to achieve the intent of the Strategy.

These activities are managed by the Air Force Research Laboratory Chief Technologist located at Wright Patterson Air Force Base, Ohio, at the Enterprise level, and executed across the various AFRL Technology Directorate locations.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this program element would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| **B. Program Change Summary ($ in Millions)** | **FY 2020** | **FY 2021** | **FY 2022 Base** | **FY 2022 OCO** | **FY 2022 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 0.000 | 100.000 | 100.000 | 0.000 | 100.000 |
| Current President's Budget | 0.000 | 79.854 | 79.901 | 0.000 | 79.901 |
| Total Adjustments | 0.000 | -20.146 | -20.099 | 0.000 | -20.099 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | -20.146 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | 0.000 | 0.000 | | | |
| • Other Adjustments | 0.000 | 0.000 | -20.099 | 0.000 | -20.099 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602020F / *Future AF Capabilities Applied Research* |

**Change Summary Explanation**

FY2021 decrease of $20.146M Congressional Directed Reduction due to improving funds management--forward financing in the amount of 20.000M and Undistributed Reduction - Excess to Need in the amount of 0.146M.

FY2022 decrease of $20.099M adjustment to support higher AF priorities.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| ***Title:*** Transformational Capability Incubator | 0.000 | 79.854 | 79.901 | 0.000 | 79.901 |
| ***Description:*** Integrates cross-enterprise multi-directorate transformational applied research efforts to accelerate the "pipeline" of technology-enabled capability candidates pursuing the five strategic capabilities outlined in the Air Force Science and Technology Strategy. The Air Force Research Laboratory will plan and manage these research activities at the enterprise level with decentralized execution to achieve the intent of the Strategy.<br><br>***FY 2021 Plans:***<br>Conduct deliberate, structured horizon scanning and ideation activities to identify candidate technologies for consideration and pursuit. Using the results of scanning and ideation activities, will conduct modeling, simulation, and analysis to guide investment decisions, create technology roadmaps, and track technology maturation, opportunities, and gaps focused on identifying and incubating leap ahead technology solutions. Engage the Air Force and other government research organizations, industry, and academia through a series of competitive, open opportunity calls to promote solution-oriented thinking, leverage new partnerships, and incubate leap ahead technology intent to realize an Air Force that dominates time, space and complexity in future conflict.<br><br>***FY 2022 Base Plans:***<br>Continue to develop future candidate technology programs which result from the scanning and ideation activities from the previous year. The current technology programs include: Air Force Explore (now called Explore), Seedlings for Disruptive Capabilities, Wartech capability demonstrations, and novel business processes all intent on implementing the Department of the Air Force Science and Technology 2030 Strategy with applied research. Technology studies and demonstrations include integrated base defense, space integration, airships for logistics, low cost multipurpose unmanned aircraft, and predictive tracking for commercial satellites. Advance the development of disruptive seedling technologies such as integrated compact Electro-Optic/Infra-Red sensing, autonomous runway and airfield augmentation, digital arrays for airborne battle management systems, printed composites for attritable and rapidly deployable aircraft, and articulated nose technology for missiles. Continue to explore transformational research analytic technologies to enable validated positions and provide a | | | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602020F / *Future AF Capabilities Applied Research* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| solid foundation to predict future outcomes, as well as looking for more seedlings to feed the capability pipeline. Continue to advance future workforce development programs and broadening partnerships to deepen and expand the scientific and technology enterprise.<br><br>***FY 2022 OCO Plans:***<br>N/A<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Funding increased by $0.047 million from FY 2021 to FY 2022. Funding increased due Department of Defense and Department of the Air Force priorities. | | | | | |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 79.854 | 79.901 | 0.000 | 79.901 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602102F / *Materials* | | | | | | | |
| **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 | - | 212.551 | 237.847 | 113.460 | 0.000 | 113.460 | - | - | - | - | - | - |
| 624347: *Materials for Structures, Propulsion, and Subsystems* | - | 100.544 | 105.999 | 41.376 | 0.000 | 41.376 | - | - | - | - | - | - |
| 624348: *Materials for Electronics, Optics, and Survivability* | - | 56.507 | 62.240 | 30.699 | 0.000 | 30.699 | - | - | - | - | - | - |
| 624349: *Materials Technology for Sustainment* | - | 55.500 | 69.608 | 41.385 | 0.000 | 41.385 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops advanced materials, processing, and inspection technologies to reduce life cycle costs and improve performance, sustainability, availability, affordability, supportability, reliability, and survivability of current and future Department of the Air Force systems and operations. The program has three projects that develop: structural, propulsion, and sub-systems materials and processes technologies; electronic, optical, and survivability materials and processes technologies; and sustainment materials, processes technologies, and advanced non-destructive inspection methodologies. Efforts in the program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication. This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 215.851 | 140.781 | 132.522 | 0.000 | 132.522 |
| Current President's Budget | 212.551 | 237.847 | 113.460 | 0.000 | 113.460 |
| Total Adjustments | -3.300 | 97.066 | -19.062 | 0.000 | -19.062 |
| • Congressional General Reductions | 0.000 | -0.434 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 97.500 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.413 | 0.000 | | | |
| • SBIR/STTR Transfer | -3.713 | 0.000 | | | |
| • Other Adjustments | 0.000 | 0.000 | -19.062 | 0.000 | -19.062 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 624347: *Materials for Structures, Propulsion, and Subsystems* | | |
| Congressional Add: *Program increase - Certification of advanced composites* | 14.616 | 15.000 |
| Congressional Add: *Program Increase - High Performance Materials* | 7.795 | 8.000 |
| Congressional Add: *Program Increase - Additive Manufacturing* | 19.488 | 0.000 |
| Congressional Add: *Program Increase - Advanced aerospace composite structures* | 7.795 | 0.000 |
| Congressional Add: *Program Increase - Molybdenum silicon boron research* | 2.923 | 0.000 |
| Congressional Add: *Program increase - classified additive manufacturing* | 0.000 | 20.000 |
| Congressional Add: *Program increase - ceramic matrix composites* | 0.000 | 10.000 |
| Congressional Add: *Program increase - thermal protection for hypersonic vehicles* | 0.000 | 10.000 |
| Congressional Add Subtotals for Project: 624347 | 52.617 | 63.000 |
| **Project:** 624348: *Materials for Electronics, Optics, and Survivability* | | |
| Congressional Add: *Program Increase - Technology for Broadband Operation* | 0.000 | 10.000 |
| Congressional Add: *Program Increase - Minority leaders program* | 8.282 | 0.000 |
| Congressional Add: *Program Increase - Deployable passive cooling* | 4.872 | 5.000 |
| Congressional Add: *Program Increase - Human monitoring capabilities* | 9.257 | 9.500 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add Subtotals for Project: 624348 | 22.411 | 24.500 |
| **Project:** 624349: *Materials Technology for Sustainment* | | |
| Congressional Add: *Program Increase - Coating Technologies* | 9.744 | 10.000 |
| Congressional Add Subtotals for Project: 624349 | 9.744 | 10.000 |
| Congressional Add Totals for all Projects | 84.772 | 97.500 |

**Change Summary Explanation**

FY 2022 decreased by 19.062 million due to higher Department of the Air Force priorities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602102F / *Materials* | Project (Number/Name)<br>624347 / *Materials for Structures, Propulsion, and Subsystems* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624347: *Materials for Structures, Propulsion, and Subsystems* | - | 100.544 | 105.999 | 41.376 | 0.000 | 41.376 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops the materials and processing technology base for aircraft, spacecraft, launch systems, and missiles to improve affordability, maintainability, and performance of current and future Department of the Air Force systems. A family of affordable lightweight materials is being developed, including metals, polymers, ceramics, metallic and nonmetallic composites, and hybrid materials to provide upgraded capabilities for existing aircraft, missile, and propulsion systems to meet the future system requirements. The project develops high-temperature turbine engine materials that will enable engine designs to improve turbine engine thrust-to-weight ratio, specific fuel consumption and affordability. Advanced high temperature protection materials are being developed that are affordable, lightweight, dimensionally stable, thermally conductive, and/or ablation and erosion resistant to meet aerospace and missile requirements. Alternative or replacement materials are being developed to maintain the performance of fielded operational systems. The project concurrently develops advanced processing methods to enable adaptive processing of aerospace materials.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Ceramics and Composites | 28.416 | 22.789 | 23.584 |
| ***Description:*** Develop ceramic, polymer, polymer and ceramic matrix composites, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures.<br><br>***FY 2021 Plans:***<br>Continue to demonstrate and mature new advanced processing methods, coating technologies, and behavioral life prediction concepts for current and future higher capability polymer and ceramic matrix composites. Continue in-depth analyses and assessment of severe environment durability of advanced composite systems via mechanical testing. Continue validating, developing, and testing the new ceramic and polymer matrix composite materials and processes with higher temperature capability for next generation propulsion systems and aerospace structures. Continue to advance and integrate the computational material science infrastructure for composite materials in tools to model, characterize, and accelerate the development and certification of advanced composite materials. Continue to verify and validate damage progression models on increasingly complex polymer matrix composite structural applications. Continue developing newer testing and assessment methods on composite damage progression models for application in an engineering environment. Continue to develop and validate advanced materials to meet evolving requirements for structural hardening.<br><br>***FY 2022 Plans:***<br>Continue to validate, demonstrate and mature new advanced processing methods, coating technologies, and behavioral life prediction concepts for current and future higher capability polymer and ceramic matrix composites. Continue in-depth analyses | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624347 / *Materials for Structures, Propulsion, and Subsystems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| and assessment of severe environment durability of advanced composite systems via mechanical testing. Continue validating, developing, and testing the new ceramic and polymer matrix composite materials and processes with higher temperature capability for next generation propulsion systems and aerospace structures. Continue to advance and integrate the computational material science infrastructure for composite materials in tools to model, characterize, and accelerate the development and certification of advanced composite materials. Continue to verify and validate damage progression models on increasingly complex polymer matrix composite structural applications. Continue developing and validating newer testing and assessment methods on composite damage progression models for application in an engineering environment. Continue to develop and validate advanced materials to meet evolving requirements for structural hardening. Initiate development and refine modeling tools to link processing to performance of organic/polymer matrix composites and expand damage mechanics models to increasingly complex composite materials.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.795 million. Funding increased due increased emphasis on computational material science infrastructure and technologies. | | | |
| ***Title:*** Metals<br>***Description:*** Develop lightweight and high temperature metallics, life prediction technologies, and metals processing technologies for increased affordability, durability, and reliability of Department of the Air Force systems.<br>***FY 2021 Plans:***<br>Continue to demonstrate and implement advanced computation methods to support faster material development and characterization modeling. Continue to analyze relationships between microstructure, processing, properties, and performance of affordable metallic and high performance gradient metallic materials. Continue to validate integrated material/manufacturing and component analysis for life management and development of affordable structural metals and low cost processes. Continue to advance reliable affordable metallic structural components through computational methods. Continue to validate the value of integrated analytical tools in the optimization of design and certification of additively manufactured metallic components. Continue development of novel capabilities via metallic additive manufacturing to be used as an alternative process when applicable. Continue to develop and refine processing methods and affordable metals for low cost, attritable propulsion systems. Continue development of enhanced life management practices to incorporate effects of engineered residual stress. Continue research on application of advanced data science, artificial intelligence and machine learning on materials science problems. Initiate research on engine life prediction.<br>***FY 2022 Plans:***<br>Continue to validate, demonstrate and implement advanced computation methods to support faster material development and characterization modeling. Continue to analyze relationships between microstructure, processing, properties, and performance | 14.695 | 13.330 | 14.077 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624347 / *Materials for Structures, Propulsion, and Subsystems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| of affordable metallic and high performance gradient metallic materials. Continue to validate integrated material/manufacturing and component analysis for life management and development of affordable structural metals and low cost processes. Continue to advance reliable affordable metallic structural components through computational methods. Continue to validate the value of integrated analytical tools in the optimization of design and certification of additively manufactured metallic components. Continue development of novel capabilities via metallic additive manufacturing to be used as an alternative process when applicable. Continue to develop and refine processing methods and affordable metals for low cost, attritable propulsion systems. Continue development of enhanced life management practices to incorporate effects of engineered residual stress. Continue research on application of advanced data science, artificial intelligence and machine learning on materials science problems. Continue research on engine life prediction.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.747 million. Funding increased due to increase computational methods and characterization modeling. | | | |
| ***Title:*** Thermal Protection Materials | 4.816 | 4.300 | 3.715 |
| ***Description:*** Develop and evaluate lightweight, active, adaptive, multifunctional, high temperature, and durable material systems for extreme environments and hypersonic applications.<br><br>***FY 2021 Plans:***<br>Continue to mature processing methods for fabricating materials required for expendable hypersonic applications. Continue to validate, develop and refine unique experimental techniques to assess mechanical properties and time-dependent behavior. Continue to validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges, aeroshells, and apertures. Further the development of computational models to assess environmental degradation of materials in a hypersonic environment.<br>***FY 2022 Plans:***<br>Continue to validate and mature processing methods for fabricating materials required for expendable hypersonic applications. Continue to validate, develop and refine unique experimental techniques to assess mechanical properties and time-dependent behavior. Continue to validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges, aeroshells, and apertures. Further the development of computational models to assess environmental degradation of materials in a hypersonic environment.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624347 / *Materials for Structures, Propulsion, and Subsystems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $0.585 million. Funding decreased due to decreased emphasis in expendable hypersonic materials. | | | |
| ***Title:*** Pervasive and Affordable Metals Technologies<br>***Description:*** Develop and demonstrate affordable, novel high temperature powder processing materials/structures and additive metals technology concepts to enable future defense capabilities, air vehicle propulsion, and computational prediction models.<br>***FY 2021 Plans:***<br>Completed demonstration of affordable metallic turbine engine disks made via powder processing technologies through high temperature, aggressive environment testing. Completed development of low cost, complex shape metallic components made through additive manufacturing for advanced weapon system component prototypes. Completed development of computational methodologies that incorporate impact of surface residual stress on the ability to extend life and lower life cycle cost of air vehicle propulsion system components.<br>***FY 2022 Plans:***<br>Technical work in this effort completed in FY 2021.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.580 million. Funding decreased due to the completion of this effort in FY 2021. | 0.000 | 2.580 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 47.927 | 42.999 | 41.376 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - Certification of advanced composites<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 14.616 | 15.000 |
| ***Congressional Add:*** Program Increase - High Performance Materials<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 7.795 | 8.000 |
| ***Congressional Add:*** Program Increase - Additive Manufacturing | 19.488 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624347 / *Materials for Structures, Propulsion, and Subsystems* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | | |
| ***Congressional Add:*** Program Increase - Advanced aerospace composite structures<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 7.795 | 0.000 |
| ***Congressional Add:*** Program Increase - Molybdenum silicon boron research<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 2.923 | 0.000 |
| ***Congressional Add:*** Program increase - classified additive manufacturing<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 20.000 |
| ***Congressional Add:*** Program increase - ceramic matrix composites<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 10.000 |
| ***Congressional Add:*** Program increase - thermal protection for hypersonic vehicles<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 10.000 |
| **Congressional Adds Subtotals** | 52.617 | 63.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602102F / *Materials* | Project (Number/Name)<br>624348 / *Materials for Electronics, Optics, and Survivability* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624348: *Materials for Electronics, Optics, and Survivability* | - | 56.507 | 62.240 | 30.699 | 0.000 | 30.699 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops materials technologies for the Department of the Air Force's Intelligence, Surveillance, and Reconnaissance (ISR), situational awareness, and low-observable systems and subsystems for aerospace platforms and munitions. This includes sensors for microwave, short, mid, and long-wave infrared (SWIR, MWIR, LWIR) detection and countermeasures devices used for targeting, electronic warfare, and active aircraft protection. Electronic and optical materials are being developed to enable surveillance and situational awareness with faster operating speeds, greater tunability, higher power output, improved thermal management (including higher operating temperatures), greater sensitivity, and extended dynamic range. Materials for protection of aircrews, sensors, and aerospace structures from laser and high-power microwave directed energy threats are also developed. New materials are being developed to counter the most prominent laser threats and to respond to emerging and agile threat wavelengths without impairing mission effectiveness. The project develops novel materials for electromagnetic interactions with matter for electromagnetic pulse, high power microwave, and lightning strike protection. The project develops nanostructured and biological materials for aerospace structures, munitions, aerospace vehicle subsystems, and personnel.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Infrared Detector and Electromagnetic Device Materials | 11.285 | 11.354 | 9.516 |
| ***Description:*** Develop infrared (IR) detector and electro-magnetic device materials and processes technologies for performance, affordability, and operational capability of surveillance, tracking, targeting, and situational awareness systems for the Department of the Air Force. | | | |
| ***FY 2021 Plans:***<br>Continue advanced development, demonstration and validation of materials and processes for control and detection of electromagnetic radiation for Intelligence, Surveillance and Reconnaissance (ISR) technologies. Further the development, testing, and assessment of materials for use in high resolution imaging by electromagnetic radiation. Continue advanced demonstration of nanoscale materials, metamaterials, and models for use in producing detectors. Continue to utilize all aspects of computational materials science to improve performance prediction and reliability models, as well as analyzing quantum materials for aerospace applications. Continue specific development and demonstration of short wave infrared detector and hyper-spectral long wave infrared materials. Continue to verify and validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Continue development of photonics for aerospace applications, | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624348 / *Materials for Electronics, Optics, and Survivability* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| and demonstrate nanostructured materials for components to enable agile radio frequency capability. Initiate development of techniques using quantum materials and processes.<br><br>***FY 2022 Plans:***<br>Continue advanced development, demonstration and validation of materials and processes for control and detection of electromagnetic radiation for Intelligence, Surveillance and Reconnaissance (ISR) technologies. Further the development, testing, and assessment of materials for use in high resolution imaging by electromagnetic radiation. Continue advanced demonstration of nanoscale materials, metamaterials, and models for use in producing detectors. Continue to utilize all aspects of computational materials science to improve performance prediction and reliability models, as well as analyzing quantum materials for aerospace applications. Continue specific development and demonstration of short wave infrared detector and hyper-spectral long wave infrared materials. Continue to verify and validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Continue development of photonics for aerospace applications, and demonstrate nanostructured materials for components to enable agile radio frequency capability. Continue development of techniques using quantum materials and processes.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $1.838 million. Funding decreased due to reduced efforts in materials for tactical Intelligence, Surveillance, and Reconnaissance (ISR). | | | |
| ***Title:*** Directed Energy Hardened Materials<br><br>***Description:*** Develop and demonstrate technologies to enhance the safety, survivability, and mission effectiveness of personnel, sensors, viewing systems, and related Department of the Air Force assets.<br><br>***FY 2021 Plans:***<br>Continue to analyze and validate the comprehensive generated data of materials and technologies to protect against directed energy threats. Continue to develop and demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications, and continue to assess the response of new materials for high-energy laser interactions. Continue developing novel approaches for integration of multimodal hardening into structures and devices. Continue to assess data, validate repeatability and utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. Continue development of proven selected advanced materials technologies to protect against nuclear flash blindness.<br><br>***FY 2022 Plans:***<br>Continue to analyze, validate and demonstrate the comprehensive generated data of materials and technologies to protect against directed energy threats. Continue to develop and demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications, and continue to assess the response of new materials for high-energy laser | 12.894 | 13.075 | 9.210 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624348 / *Materials for Electronics, Optics, and Survivability* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| interactions. Continue developing novel approaches for integration of multimodal hardening into structures and devices. Continue to assess data, validate repeatability and utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. Continue development of proven selected advanced materials technologies to protect against nuclear flash blindness.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $3.865 million. Funding decreased due to reduced emphasis on optical coating materials and helmet mounted sensor protection. | | | |
| ***Title:*** Laser Source Materials<br>***Description:*** Develop materials to enable higher performance high power laser sources (quasi-Continuous Wave to Continuous Wave) with emphasis on laser output in the mid-InfraRed spectral region (2-5 microns).<br>***FY 2021 Plans:***<br>Continue to validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Further demonstrate and model materials processes for controlling laser beam direction and focus with optical components, and materials for frequency conversion, high power optical isolators, mid-wave infrared laser sources and high power microwave sources for directed energy sources.<br>***FY 2022 Plans:***<br>Continue to demonstrate and validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Further demonstrate and model materials processes for controlling laser beam direction and focus with optical components, and materials for frequency conversion, high power optical isolators, mid-wave infrared laser sources and high power microwave sources for directed energy sources.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.148. Funding decreased due to plans described above. | 1.368 | 1.376 | 1.228 |
| ***Title:*** Nanostructured and Biological Materials<br>***Description:*** Develop enabling and foundational biotechnologies for guidance and control, rapid tagging, tracking and identification of targets, bio-integrated electronics and sensing for the Department of the Air Force applications.<br>***FY 2021 Plans:***<br>Continue to validate and verify engineering, scientific and processing methods for nano and biological materials to address unique requirements for the Department of the Air Force human-machine integration and electronic components. Continue to explore biotechnology to assess the impact of microbes and fungi on Department of the Air Force systems. Continue to study more robust | 8.549 | 11.935 | 10.745 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624348 / *Materials for Electronics, Optics, and Survivability* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| and reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices, and validate materials and process for functional additive manufacturing of electronic components. Continue to demonstrate methods to assess reliability and field resiliency of nano and biological materials and processes. Continue to support the Flexible Hybrid Electronics Institutes for Manufacturing Innovation and the NanoBio Manufacturing Consortium for collaborative teaming. Initiate development of advanced materials for human-machine applications. Initiate Joint Service 1000 Molecules activities to support the sustainable transition of critical synthetic biology capabilities.<br>***FY 2022 Plans:***<br>Continue to validate and verify engineering, scientific and processing methods for nano and biological materials to address unique requirements for the Department of the Air Force human-machine integration and electronic components. Continue to explore biotechnology to assess the impact of microbes and fungi on Department of the Air Force systems. Continue to study more robust and reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices, and validate materials and process for functional additive manufacturing of electronic components. Continue to demonstrate methods to assess reliability and field resiliency of nano and biological materials and processes. Continue to support the Flexible Hybrid Electronics Institutes for Manufacturing Innovation and the NanoBio Manufacturing Consortium for collaborative teaming. Initiate agile materials for basing, infrastructure and expeditionary operations.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $1.190 million. Decreased funding due to decreased emphasis 1000 Molecule activities. | | | |
| **Accomplishments/Planned Programs Subtotals** | 34.096 | 37.740 | 30.699 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase - Technology for Broadband Operation<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 10.000 |
| ***Congressional Add:*** Program Increase - Minority leaders program<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 8.282 | 0.000 |
| ***Congressional Add:*** Program Increase - Deployable passive cooling | 4.872 | 5.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624348 / *Materials for Electronics, Optics, and Survivability* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| ***Congressional Add:*** Program Increase - Human monitoring capabilities<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 9.257 | 9.500 |
| **Congressional Adds Subtotals** | 22.411 | 24.500 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602102F / *Materials* | Project (Number/Name)<br>624349 / *Materials Technology for Sustainment* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624349: *Materials Technology for Sustainment* | - | 55.500 | 69.608 | 41.385 | 0.000 | 41.385 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops materials and processing technologies to support operational Department of the Air Force mission areas by providing the ability to inspect the quality of delivered systems, transition more reliable and maintainable materials, establish a capability to detect and characterize performance threatening defects, characterize materials processes and properties necessary for materials transition, and provide quick reaction support and failure analysis to the operational commands and repair centers. Repair techniques and nondestructive inspection/evaluation (NDI/E) methods are developed that are needed for metallic and non-metallic structures, coatings, corrosion control processes, and to support integration of composite structures for aerospace systems. Various NDI/E methods are essential to ensure optimum quality in the design and production of aircraft, propulsion, and missile systems. These NDI/E methods are also essential to monitor and detect the onset of any service initiated damage and/or deterioration due to aging of operational systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Material State Awareness | 16.112 | 20.863 | 14.482 |
| ***Description:*** Develop Materials State Awareness technologies to identify and characterize materials and/or damage regardless of scale for managing the health of fielded structures, propulsion systems, and low-observable materials/structures, plus enabling advanced materials qualification for Department of the Air Force systems. | | | |
| ***FY 2021 Plans:***<br>Continue to validate and demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect, characterize and quantify damage in realistic aerospace structures and engine components. Continue to analyze approaches to address the variability inherent in aerospace systems and materials to quantify the impact of that variability on nondestructive inspection capability and reliability. Continue to validate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continue to improve methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of specialty materials that enables/ensures more affordable coatings assessment. Validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation and robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization. | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624349 / *Materials Technology for Sustainment* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue to validate and demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect, characterize and quantify damage in realistic aerospace structures and engine components. Continue to analyze approaches to address the variability inherent in aerospace systems and materials to quantify the impact of that variability on nondestructive inspection capability and reliability. Continue to validate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continue to improve methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of specialty materials that enables/ensures more affordable coatings assessment. Validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation and robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $6.381 million. Decreased funding due to reduced emphasis on engine component inspection. | | | |
| ***Title:*** Production and Repair Technologies | 11.690 | 15.498 | 10.759 |
| ***Description:*** Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures for the Department of the Air Force.<br><br>***FY 2021 Plans:***<br>Develop and communicate to the field best practices to ensure repeatability of advanced materials and processes technology to repair and extend the life of Department of the Air Force systems. Further refine, through demonstration, the understanding of material durability and repair limits for emerging Department of the Air Force systems. Continue to advance the analysis and development of improved life cycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Continue to improve the service life of advanced materials, processes and designs for improved repair, maintainability and life cycle costs, of outer mold line coatings, access panel treatments, and multifunctional systems. Further advance specialty material affordability technologies and processes to reduce maintenance costs of specialty materials.<br>***FY 2022 Plans:***<br>Continue to develop and communicate to the field best practices to ensure repeatability of advanced materials and processes technology to repair and extend the life of Department of the Air Force systems. Further refine through demonstration the understanding of material durability and repair limits for emerging Department of the Air Force systems. Continue to advance the analysis and development of improved life cycle prediction test methods and techniques to understand effects of service | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624349 / *Materials Technology for Sustainment* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| environments, corrosion, residual stresses, and material processes on structural and functional materials. Continue to improve the service life of advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer mold line coatings, access panel treatments, and multifunctional systems. Continue to further advance specialty material affordability technologies and processes to reduce maintenance costs of specialty materials.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $4.739 million. Decreased funding is a result of reduced emphasis on multifunctional systems. | | | |
| ***Title:*** Failure Analysis Technologies<br>***Description:*** Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis for the Department of the Air Force.<br>***FY 2021 Plans:***<br>Continue to perform and increase efficiency of quick response failure analyses and materials investigations. Further the development and investigate improved analysis techniques to determine and prevent root cause materials failure/degradation. Continue to develop and provide advanced materials and processing solutions to ensure warfighter systems availability and safety of flight. Continue to refine development of functional materials failure analysis capabilities. Continue to analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Continue to transition advanced test and characterization methods for analyzing electrical and structural failures of emerging materials. Continue development of new, more durable materials and protection for high power wiring technologies, and advanced materials.<br>***FY 2022 Plans:***<br>Continue to perform and increase efficiency of quick response failure analyses and materials investigations. Further the development and investigate improved analysis techniques to determine and prevent root cause materials failure/degradation. Continue to develop and provide advanced materials and processing solutions to ensure warfighter systems availability and safety of flight. Continue to refine development of functional materials failure analysis capabilities. Continue to analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Continue to transition advanced test and characterization methods for analyzing electrical and structural failures of emerging materials. Continue development of new, more durable materials and protection for high power wiring technologies, and advanced materials.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $7.104 million. Decreased funding is a result of reduced emphasis on advanced materials and processing technology. | 17.954 | 23.247 | 16.144 |
| **Accomplishments/Planned Programs Subtotals** | 45.756 | 59.608 | 41.385 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602102F / *Materials* | **Project (Number/Name)**<br>624349 / *Materials Technology for Sustainment* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase - Coating Technologies | 9.744 | 10.000 |
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts. | | |
| ***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| **Congressional Adds Subtotals** | 9.744 | 10.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable.

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | | | | | | | |
| **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 | - | 148.176 | 164.426 | 163.032 | 0.000 | 163.032 | - | - | - | - | - | - |
| 622401: *Structures* | - | 37.043 | 82.400 | 51.546 | 0.000 | 51.546 | - | - | - | - | - | - |
| 622403: *Flight Controls and Pilot-Vehicle Interface* | - | 49.297 | 0.000 | 39.790 | 0.000 | 39.790 | - | - | - | - | - | - |
| 622404: *Aeromechanics and Integration* | - | 28.595 | 0.000 | 29.941 | 0.000 | 29.941 | - | - | - | - | - | - |
| 622405: *High Speed Systems Technology* | - | 33.241 | 62.578 | 38.103 | 0.000 | 38.103 | - | - | - | - | - | - |
| 622406: *Aerospace Power & Flight Control Technology* | - | 0.000 | 19.448 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 625172: *NUCLEAR SYSTEM TECHNOLOGY* | - | 0.000 | 0.000 | 3.652 | 0.000 | 3.652 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program investigates, develops, and analyzes aerospace vehicle technologies in the primary areas of high speed systems, flight control technologies, aeromechanics, structure systems and nuclear system technology. The effort has five projects, each focusing on a technology area critical to the Department of the Air Force. The High Speed Systems Technology project develops high speed/hypersonic aerospace vehicles as well as high-speed air breathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Department of the Air Force. The Flight Controls and Pilot-Vehicle Interface project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles. The Aeromechanics and Integration project designs advanced aerodynamic vehicle configurations that are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. It also develops design techniques, incorporating vehicle, inter-vehicle, and intra-vehicle control systems. The Structures project develops and exploits new materials, and fabrication processes. The Nuclear System Technology project provides science and technology to preserve nuclear deterrence for future generations.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* |

In FY 2022, the seismic technologies efforts of PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance were transferred to Appropriation 3600, Research, Development, Test & Evaluation, Air Force, PE 0602201F, Aerospace Vehicles Technologies, Project 625172, Nuclear System Technology, from Appropriation 3620, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 157.724 | 349.225 | 357.519 | 0.000 | 357.519 |
| Current President's Budget | 148.176 | 164.426 | 163.032 | 0.000 | 163.032 |
| Total Adjustments | -9.548 | -184.799 | -194.487 | 0.000 | -194.487 |
| • Congressional General Reductions | 0.000 | -0.300 | | | |
| • Congressional Directed Reductions | 0.000 | -1.200 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 10.000 | 23.000 | | | |
| • Congressional Directed Transfers | 0.000 | -206.299 | | | |
| • Reprogrammings | 0.297 | 0.000 | | | |
| • SBIR/STTR Transfer | -4.675 | 0.000 | | | |
| • Other Adjustments | -15.170 | 0.000 | -194.487 | 0.000 | -194.487 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 622404: *Aeromechanics and Integration* | | |
| Congressional Add: *Program increase - secure UAV technologies* | 0.000 | 0.000 |
| Congressional Add: *Program increase - advanced battery technology for directed energy* | 0.000 | 0.000 |
| Congressional Add Subtotals for Project: 622404 | 0.000 | 0.000 |
| **Project:** 622405: *High Speed Systems Technology* | | |
| Congressional Add: *Program increase - modeling and testing of high temperature aero vehicle* | 0.000 | 4.000 |
| Congressional Add: *Program increase - hypersonic research and education* | 0.000 | 4.000 |
| Congressional Add: *Program increase - hypersonic vehicle structures* | 10.000 | 0.000 |
| Congressional Add: *Program increase - secure UAV technologies* | 0.000 | 10.000 |
| Congressional Add: *Program increase - advanced battery technology for directed energy* | 0.000 | 5.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add Subtotals for Project: 622405 | 10.000 | 23.000 |
| Congressional Add Totals for all Projects | 10.000 | 23.000 |

**Change Summary Explanation**

Decrease in FY 2022 of 194.487 million is due to Congressional reversal of program element restructure, higher Department of the Air Force priorities, and transformational activities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>622401 / *Structures* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622401: *Structures* | - | 37.043 | 82.400 | 51.546 | 0.000 | 51.546 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops advanced structures concepts to exploit new materials and fabrication processes and investigates new concepts and design techniques. New structural concepts include low cost design and fabrication techniques, incorporating subsystem hardware items and adaptive mechanisms into the aerospace structures and/or skin of the platform.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Aircraft Service Life Technologies | 13.384 | 29.771 | 18.615 |
| ***Description:*** Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies.<br><br>***FY 2021 Plans:***<br>Complete demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. Continue lifing methods for durability and damage tolerance of aging composite structures on legacy fleet aircraft. Complete development of digital maintenance models and virtual and augment reality maintenance tools.<br><br>***FY 2022 Plans:***<br>Continue lifing methods for durability and damage tolerance of aging structures on legacy fleet aircraft. Initiate digital engineering systems analysis on a low cost attritable unmanned aircraft system.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $11.156 million. Funding decrease due to reduced emphasis on aircraft service life technologies. | | | |
| ***Title:*** Vehicle Design Technologies | 12.170 | 27.072 | 16.937 |
| ***Description:*** Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aerospace systems.<br><br>***FY 2021 Plans:***<br>Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools. Complete the development of control effector designs for supersonic tailless aircraft. Continue new design techniques to quantify and trade risk impacts against | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622401 / *Structures* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| performance in aircraft designs. Initiate the development of new design methods that link vehicle system requirements to mission operation performance.<br>***FY 2022 Plans:***<br>Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools. Continue new design techniques to quantify and trade risk impacts against performance in aircraft designs. Continue the development of new design methods that link vehicle system requirements to mission operation performance.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $10.135 million. Funding decrease due to reduced emphasis on vehicle design technologies. | | | |
| ***Title:*** Structural Concepts<br>***Description:*** Develop design methods, processes, and lightweight, adaptive, and multifunctional structural concepts to capitalize on new materials, multi-role considerations, and technology integration into aircraft systems.<br>***FY 2021 Plans:***<br>Complete development and verification of low cost attritable airframe concepts and manufacturing methods. Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft. Initiate validation of impact damage analysis and methods for advanced fail-safe composite structures applicable to Mobility aircraft.<br>***FY 2022 Plans:***<br>Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft. Continue validation of impact damage analysis and methods for advanced fail-safe composite structures applicable to Mobility aircraft. Initiate new low cost design and manufacturing structural concepts for attritable vehicles.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 9.562 million. Funding decrease due to reduced emphasis on structural concepts. | 11.489 | 25.557 | 15.994 |
| **Accomplishments/Planned Programs Subtotals** | 37.043 | 82.400 | 51.546 |

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

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622401 / *Structures* |

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

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>622403 / *Flight Controls and Pilot-Vehicle Interface* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622403: *Flight Controls and Pilot-Vehicle Interface* | - | 49.297 | 0.000 | 39.790 | 0.000 | 39.790 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops technologies that enable maximum affordable capability from manned, remotely-piloted, and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Advanced Flight Controls Technologies | 6.790 | 0.000 | 9.168 |
| ***Description:*** Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems, and software and system certification techniques for both manned/unmanned and remotely piloted aircraft.<br><br>***FY 2021 Plans:***<br>Complete the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. Initiate the development, demonstration, and assessment of autonomy capabilities under adverse and contested environments.<br><br>***FY 2022 Plans:***<br>Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. Continue the development, demonstration, and assessment of autonomy capabilities under adverse and contested environments.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased by $9.168 million compared to FY 2021. Funding increase due to increased emphasis on advanced flight controls technologies. | | | |
| ***Title:*** Manned and Unmanned Teaming Technologies | 17.644 | 0.000 | 23.569 |
| ***Description:*** Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622403 / *Flight Controls and Pilot-Vehicle Interface* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue development, demonstration, and assessment of advanced control automation techniques. Complete the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Complete the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Continue the development of autonomous behaviors for safe, effective manned-unmanned teams. Initiate the development of tactical autonomy for manned-unmanned teams in contested, dynamic mission environments.<br>***FY 2022 Plans:***<br>Continue development, demonstration, and assessment of advanced control automation techniques. Continue the development of autonomous behaviors for safe, effective manned-unmanned teams. Continue the development of tactical autonomy for manned-unmanned teams in contested, dynamic mission environments. Initiate the development of mission management autonomy for manned-unmanned teams.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased by $23.569 million compared to FY 2021. Funding increase due to increased emphasis on manned and unmanned teaming technologies. | | | |
| ***Title:*** Flight Controls Technologies Modeling and Simulation | 5.196 | 0.000 | 7.053 |
| ***Description:*** Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles.<br>***FY 2021 Plans:***<br>Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission level performance of integrated aerospace systems. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Initiate analyses of capability concepts for future advanced development programs.<br>***FY 2022 Plans:***<br>Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission level performance of integrated aerospace systems. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Continue analyses of capability concepts for future advanced development programs.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622403 / *Flight Controls and Pilot-Vehicle Interface* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased by $7.053 million compared to FY 2021. Funding increase due to increased emphasis on flight controls technologies modeling and simulation. | | | |
| ***Title:*** Future AF Capabilities Applied Research<br><br>***Description:*** Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/ unconventional weapons).<br><br>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.<br><br>***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | 19.667 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 49.297 | 0.000 | 39.790 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>622404 / *Aeromechanics and Integration* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622404: *Aeromechanics and Integration* | - | 28.595 | 0.000 | 29.941 | 0.000 | 29.941 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops aerodynamic configurations of a broad range of revolutionary, affordable aerospace vehicles. It matures and applies modeling and numerical simulation methods for fast and affordable aerodynamics prediction and integrates and demonstrates multi-disciplinary advances in airframe, propulsion, weapon, and air vehicle control integration.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Aerodynamic Systems Technologies | 6.407 | 0.000 | 6.740 |
| ***Description:*** Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles.<br><br>***FY 2021 Plans:***<br>Continue development and assessment of low cost attritable unmanned air vehicle concepts. Initiate an assessment of design options to allow runway independence for low cost attritable unmanned air vehicle concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Complete the development of a high fidelity aerodynamic analysis tool for the design of laser turrets applicable to Air Superiority 2030 requirements. Continue the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations.<br><br>***FY 2022 Plans:***<br>Complete development and assessment of low cost attritable unmanned air vehicle concepts. Complete an assessment of design options to allow runway independence for low cost attritable unmanned air vehicle concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Continue the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $6.740 million. Funding increase due to increased emphasis on aerodynamic systems technologies. | | | |
| ***Title:*** Next Generation Aerodynamic Technologies | 7.087 | 0.000 | 7.445 |
| ***Description:*** Develop and assess technologies for the next generation of multi-role large aircraft.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622404 / *Aeromechanics and Integration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Complete wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. Continue the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Continue the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design.<br>***FY 2022 Plans:***<br>Complete next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Continue the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Continue the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design. Initiate assessment of innovative next generation vehicle concepts.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $7.445 million. Funding increased due to increased emphasis on next generation aerodynamic technologies. | | | |
| ***Title:*** Aircraft Integration Technologies<br>***Description:*** Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles.<br>***FY 2021 Plans:***<br>Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility and completing the full flow path demonstration design. Complete propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements. Initiate design and analysis methods to allow rapid certification of stores separation for new small weapons on tactical aircraft.<br>***FY 2022 Plans:***<br>Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility and completing the full flow path demonstration design. Continue design and analysis methods to allow rapid certification of stores separation for new small weapons on tactical aircraft. Initiate development of hybrid electric distributed propulsion vehicle integration designs for next generation vehicle concepts.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 15.101 | 0.000 | 15.756 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622404 / *Aeromechanics and Integration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $15.756 million. Funding increased due to increased emphasis on aircraft integration technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 28.595 | 0.000 | 29.941 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - secure UAV technologies<br>***FY 2020 Accomplishments:*** Not Applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 0.000 |
| ***Congressional Add:*** Program increase - advanced battery technology for directed energy<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 0.000 |
| **Congressional Adds Subtotals** | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>622405 / *High Speed Systems Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622405: *High Speed Systems Technology* | - | 33.241 | 62.578 | 38.103 | 0.000 | 38.103 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This effort investigates, analyzes, and develops high speed/hypersonic aerospace vehicle technologies. Advanced high temperature structures concepts are explored and developed to exploit new materials, fabrication processes, and design techniques. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. Advanced flight control technologies are developed and simulated for hypersonic vehicles. These technologies will enable future high speed weapons; intelligence, surveillance, and reconnaissance systems; and space access vehicles.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Speed Systems Technology | 13.511 | 23.008 | 22.123 |
| ***Description:*** Develop design analysis methods and technologies for high speed systems at extreme flight conditions.<br><br>***FY 2021 Plans:***<br>Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue maturation of innovative structural concepts, analytical methods, service life predictions, and thermal management techniques for structures. Continue development of design/analysis techniques/tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign-levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities.<br><br>***FY 2022 Plans:***<br>Continue to mature critical technologies for high speed/ hypersonic flight with primary emphasis on longer range flight and heavier payloads. Continue maturation of innovative structural concepts, analytical methods, service life predictions, airframe/engine integration, and thermal management techniques for structures. Complete development of design and analysis techniques and tools as well as experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities including affordable expendable systems and robust reusable systems. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622405 / *High Speed Systems Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| component technologies through ground and flight testing. Complete assessment of engagement, mission, and campaign-levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 0.795 million. Funding decreased described in plans above. | | | |
| ***Title:*** High Speed Vehicle Aeromechanics and Integration<br><br>***Description:*** Develop new and improved components, concepts, and designs for sustained flight of high-speed/hypersonic expendable and re-useable vehicles. Conduct analyses of high speed/hypersonic vehicles to enable revolutionary capabilities.<br><br>***FY 2021 Plans:***<br>Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities. Continue assessment of campaign level benefits of preferred high speed weapon alternatives.<br><br>***FY 2022 Plans:***<br>Continue to mature critical technologies for high speed/hypersonic flight with primary emphasis on longer range flight, heavier payloads, and high speed deployment. Continue development of design and analysis techniques and tools as well as experimental approaches to enhance high-speed engine inlet performance over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduce drag, evaluate uncertainty, improve instrumentation accuracy, enable payload deployment, and achieve robust stability & control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through ground and flight testing. Continue assessment of engagement, mission, and campaign level effectiveness for promising high speed system concepts and refine concept designs to incorporate needed capabilities. Complete assessment of campaign level benefits of preferred high speed weapon alternatives.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 0.590 million. Funding decreased described in plans above. | 9.730 | 16.570 | 15.980 |
| **Accomplishments/Planned Programs Subtotals** | 23.241 | 39.578 | 38.103 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622405 / *High Speed Systems Technology* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - modeling and testing of high temperature aero vehicle<br>***FY 2020 Accomplishments:*** Not Applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 4.000 |
| ***Congressional Add:*** Program increase - hypersonic research and education<br>***FY 2020 Accomplishments:*** Not Applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 4.000 |
| ***Congressional Add:*** Program increase - hypersonic vehicle structures<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable. | 10.000 | 0.000 |
| ***Congressional Add:*** Program increase - secure UAV technologies<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. This effort will be executed in PE 0602201F Aerospace Vehicle Technologies, Project 622404 Aeromechanics and Integration. | 0.000 | 10.000 |
| ***Congressional Add:*** Program increase - advanced battery technology for directed energy<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. This effort will be executed in PE 0603216F, Aerospace Propulsion and Power Technology, Project 633035 Aerospace Power Technology. | 0.000 | 5.000 |
| **Congressional Adds Subtotals** | 10.000 | 23.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>622406 / *Aerospace Power & Flight Control Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622406: *Aerospace Power & Flight Control Technology* | - | 0.000 | 19.448 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops integrated electrical and thermal management components, controls and systems for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable future military megawatt level power and thermal management needs. Controls and system integration technologies ensure the interoperability of aircraft, power, thermal, engine and other systems and subsystems. This project supports development of electrical power and thermal management components, controls and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed. This project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Power System Technologies | 0.000 | 8.000 | 0.000 |
| ***Description:*** Develop integrated system architecture, controls, and component technologies to provide for the large amounts of electrical power needed, and concurrent thermal mitigation required, by current and future manned and unmanned systems.<br><br>***FY 2021 Plans:***<br>Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continue development of hybrid approaches to power generation, storage, and application as well as thermal management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Continue power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Continue analysis and development of adaptive power and thermal control systems for high-power aircraft. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures. Initiate medium-scale propulsion, power and thermal system studies and development.<br><br>***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622406 / *Aerospace Power & Flight Control Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $8 million. In FY 2022, this work will be performed in PE 0602203F Aerospace Propulsion, Project 623145 Aerospace Power Technology. | | | |
| ***Title:*** Advanced Flight Control Technologies<br><br>***Description:*** Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems and software and system certification techniques for both manned/unmanned and remotely piloted aircraft.<br><br>***FY 2021 Plans:***<br>Complete the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. Initiate the development, demonstration, and assessment of autonomy capabilities under adverse and contested environments.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.624 million. In FY 2022, this work will be performed in PE 0602201F, Project 622402 Flight Controls and Pilot-Vehicle Interface. | 0.000 | 2.624 | 0.000 |
| ***Title:*** Manned and Unmanned Teaming Technologies<br><br>***Description:*** Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.<br><br>***FY 2021 Plans:***<br>Continue development, demonstration, and assessment of advanced control automation techniques. Complete the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Complete the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Continue the development of autonomous behaviors for safe, effective manned-unmanned teams. Initiate the development of tactical autonomy for manned-unmanned teams in contested, dynamic mission environments.<br><br>***FY 2022 Plans:*** | 0.000 | 6.817 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>622406 / *Aerospace Power & Flight Control Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $6.817 million. In FY 2022, this work will be performed in PE 0602201F, Project 622402 Flight Controls and Pilot-Vehicle Interface. | | | |
| ***Title:*** Flight Controls Technologies Modeling and Simulation<br>***Description:*** Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles.<br>***FY 2021 Plans:***<br>Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission level performance of integrated aerospace systems. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Initiate analyses of capability concepts for future advanced development programs.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.007 million. In FY 2022, this work will be performed in PE 0602201F, Project 622402 Flight Controls and Pilot-Vehicle Interface. | 0.000 | 2.007 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 19.448 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602201F / *Aerospace Vehicle Technologies* | Project (Number/Name)<br>625172 / *NUCLEAR SYSTEM TECHNOLOGY* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625172: *NUCLEAR SYSTEM TECHNOLOGY* | - | 0.000 | 0.000 | 3.652 | 0.000 | 3.652 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project provides sustaining S&T to preserve nuclear deterrence for future generations, develops complimentary projects to inform future systems, establishing inter-agency partnerships for Modeling & Simulation (M&S) and test platforms, and coordinates with existing programs for next generation strategic systems development and test platforms.

In FY 2022, the seismic technologies efforts of PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance were transferred to Appropriation 3600, Research, Development, Test & Evaluation, Air Force, PE 0602201F, Aerospace Vehicles Technologies, Project 625172, Nuclear System Technology, from Appropriation 3620, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Seismic Technologies | 0.000 | 0.000 | 3.652 |
| ***Description:*** Develop seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors. | | | |
| ***FY 2021 Plans:***<br>Not applicable | | | |
| ***FY 2022 Plans:***<br>Continue to test new algorithms on high performance computing capabilities with special focus on automation of seismic event discrimination and characterization, improving earth structure models, and developing analysis methods for emerging detection technologies. Continue to exercise earth models in use in high-performance computing modeling and simulation codes for operational expert analysis of difficult-to-discriminate earthquakes and explosions. Continue to test specific algorithms for application of big data heuristics to more quickly characterize seismic events. Continue to further develop new statistical approaches to the behavior of discriminants for local and regional seismic events. Initiate refinement of distributed acoustic sensing methodology to provide a new detection solution for seismic explosion monitoring. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.652 million. Funding increased due to the transfer and realignment of the work in the Seismic Technologies effort in PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance, | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602201F / *Aerospace Vehicle Technologies* | **Project (Number/Name)**<br>625172 / *NUCLEAR SYSTEM TECHNOLOGY* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| to Appropriation 3600, Research, Development, Test & Evaluation, Air Force, PE 0602201F, Aerospace Vehicle Technologies, Project 625172, Nuclear System Technology due to the creation of a new Appropriation for Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 0.000 | 3.652 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602202F / *Human Effectiveness Applied Research* | | | | | | | |
| **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 | 0.000 | 128.434 | 133.877 | 136.273 | 0.000 | 136.273 | - | - | - | - | - | - |
| 621123: *Learning and Operational Readiness* | 0.000 | 19.315 | 22.361 | 18.591 | 0.000 | 18.591 | - | - | - | - | - | - |
| 625328: *Human Dynamics Evaluation* | 0.000 | 51.449 | 46.841 | 63.815 | 0.000 | 63.815 | - | - | - | - | - | - |
| 625329: *Sensory Evaluation and Decision Science* | 0.000 | 30.545 | 37.547 | 35.783 | 0.000 | 35.783 | - | - | - | - | - | - |
| 627757: *Bioeffects* | 0.000 | 27.125 | 27.128 | 18.084 | 0.000 | 18.084 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program conducts applied research in the area of airmen training, airmen performance sustainment, bioeffects, and understanding and shaping adversarial behavior. The Learning and Operational Readiness project conducts research to increase the agility of training for readiness while advancing learning and performance assessment science and practice. The Human Dynamics Evaluation project conducts research to discover, demonstrate, and transition capabilities which optimize and safe-guard Airman physical and cognitive performance allowing for the maximum potential of the multi-domain Airman. The Sensory Evaluation and Decision Science project conducts research to discover, develop, and transition advanced interface technology, decision aiding tools, and situationally-adaptive augmentation methods to seamlessly integrate Airmen and intelligent machines into maximally collaborative warfighting teams. The Bioeffects project conducts novel and operational exposure bioeffects research, exposure effects analysis and national/international exposure standards for the Air Force to enable, sustain, and enhance Airman performance and protection during deployment and application of advanced chemicals/materiel in air superiority platforms and warfighting directed energy systems.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 134.795 | 115.222 | 119.441 | 0.000 | 119.441 |
| Current President's Budget | 128.434 | 133.877 | 136.273 | 0.000 | 136.273 |
| Total Adjustments | -6.361 | 18.655 | 16.832 | 0.000 | 16.832 |
| • Congressional General Reductions | 0.000 | -0.245 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 18.900 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.373 | 0.000 | | | |
| • SBIR/STTR Transfer | -2.121 | 0.000 | | | |
| • Other Adjustments | -4.613 | 0.000 | 16.832 | 0.000 | 16.832 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 625328: *Human Dynamics Evaluation* | | |
| Congressional Add: *Warfighter Physiology Program* | 0.000 | 5.000 |
| Congressional Add: *Human Motion Assessment* | 0.000 | 4.000 |
| Congressional Add: *Pilot Hypoxia Detection and Notification* | 0.000 | 9.900 |
| Congressional Add Subtotals for Project: 625328 | 0.000 | 18.900 |
| **Project:** 625329: *Sensory Evaluation and Decision Science* | | |
| Congressional Add: *Program increase - Advanced technology development* | 2.923 | 0.000 |
| Congressional Add Subtotals for Project: 625329 | 2.923 | 0.000 |
| Congressional Add Totals for all Projects | 2.923 | 18.900 |

**Change Summary Explanation**

FY 2022 increased by $16.832 million due to increased emphasis on human effectiveness.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602202F / *Human Effectiveness Applied Research* | Project (Number/Name)<br>621123 / *Learning and Operational Readiness* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 621123: *Learning and Operational Readiness* | 0.000 | 19.315 | 22.361 | 18.591 | 0.000 | 18.591 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project advances research to measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. The emphasis is on developing technology to enable a more lethal force by delivering revolutionary training and readiness capabilities at the speed of operations. Research is conducted in two focus areas: personalized learning and cognitive modeling. Personalized learning focuses on exploratory application of adaptive proficiency technologies and interactive task learning capabilities to provide more effective, efficient learning that improves mission readiness. Cognitive modeling advances computational and mathematical methods to represent human information processing to facilitate the development of models capable of operating as intelligent teammates, adversaries, or coaches, and cognitive performance prediction systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Personalized Learning | 11.589 | 13.416 | 11.155 |
| ***Description:*** Research enhances distributed mission operations (DMO) and live-virtual-constructive (LVC) environments through the creation and exploratory application of adaptive proficiency technologies and interactive task learning capabilities, to provide more effective, efficient learning that improves mission readiness.<br><br>In FY 2021, this effort is renamed from Continuous Learning to Personalized Learning.<br><br>***FY 2021 Plans:***<br>Continue to mature emerging technologies for the Readiness Product Line by advancing proficiency-based training through persistent, high resolution human and system measurement and secure multi-classification-level training integration. Balance the applied research portfolio with exploratory research in novel methods for adaptive, multi-objective instruction and interactive task learning, as well as the development of quantitative measures to estimate uncertainty in proficiency measurement and prediction.<br><br>***FY 2022 Plans:***<br>Initiate research to evaluate new integrated human and machine personalized learning capabilities in mission-relevant laboratory, testbed, and field environments. Continue development of novel methods for adaptive, multi-objective optimization of instruction, as well as the development of quantitative measures to estimate uncertainty in proficiency measurement and prediction. In collaboration with Cognitive Modeling effort within this project and Multisensory Perception and Communication effort within the Sensory Evaluation and Decision Science Project, initiate research on the integration of multi-modal data to support improved inference, understanding, and decision-making in team-based performance environments.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>621123 / *Learning and Operational Readiness* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $2.262 million. Funding decrease due to reduced emphasis in personalized learning, and multi-objective instruction and interactive task learning. | | | |
| ***Title:*** Cognitive Modeling<br><br>***Description:*** Research explores application of mathematical and computational modeling to understand the human mind and factors that will enhance or degrade cognitive performance. Simulations of training in mission-relevant environments (e.g., flight simulators, multi-domain operations) will optimize learning strategies during training to increase/accelerate mission readiness.<br><br>***FY 2021 Plans:***<br>Continue research and development toward the maturation of emerging technologies addressing training and airman cognitive state sensing and assessment needs. Initiating maturation of models of physiology with computational cognitive models to predict cognitive performance under low-oxygen and chemical exposure conditions. Continue maturation of framework for rapidly developing high-fidelity representations of human cognitive behavior and performance. Continue research and development of high-cognitive-fidelity models capable of broader social interactions within Air Force relevant environments.<br><br>***FY 2022 Plans:***<br>Initiate research to track performance by profiling cognitive performance during task execution. Identify mechanisms to predict performance impacts of fatigue countermeasures. Demonstrate technology to track and predict individual fatigue. Continue integration of physiological and cognitive models to predict performance under chemical exposure. Evaluate models that identify and resolve knowledge gaps resulting from learning from text-based instructions. Initiate research on language adaptation in team-based communication in collaboration with Personalized Learning effort within this project and Multisensory Perception and Communication effort within the Sensory Evaluation and Decision Science Project.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $1.508 million. Funding decrease due to reduced emphasis in high-cognitive-fidelity models for predictive cognitive performance. | 7.726 | 8.945 | 7.436 |
| **Accomplishments/Planned Programs Subtotals** | 19.315 | 22.361 | 18.591 |

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

N/A

**Remarks**

None

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602202F / *Human Effectiveness Applied Research* | Project (Number/Name)<br>625328 / *Human Dynamics Evaluation* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625328: *Human Dynamics Evaluation* | 0.000 | 51.449 | 46.841 | 63.815 | 0.000 | 63.815 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops technologies to sense, assess, and augment Airman physical and cognitive performance by conducting biological/bioengineering research focused in the areas of 1) cognitive science, 2) systems biology and performance, and 3) molecular sensing and physiology. Cognitive sciences develops and validates assessments of current and predicted cognitive states combined with personalized cognitive performance enhancement techniques and incorporation of technologies to augment these states. Systems biology for performance integrates the full spectrum of biosciences to discover the underlying mechanisms of airman performance. Molecular sensing and physiology will utilize real-time non-invasive physiological and environmental monitoring to assess the biological state of the airman for the purposes of maintaining and enhancing airman performance. Project also conducts research to predict physiological impacts of extreme, dynamic aerospace environments on aircrew safety, and performance.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Future AF Capabilities Applied Research | 18.933 | 0.000 | 0.000 |
| ***Description:*** Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/ unconventional weapons).<br><br>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.<br><br>***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Human Analyst Augmentation | 10.289 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625328 / *Human Dynamics Evaluation* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Conduct research to enhance human components of intelligence, surveillance and reconnaissance (ISR). Develop ability to improve human analytic efficiency and effectiveness with fewer personnel and in increasingly complex mission space. Develop the ability to improve human cognitive performance of the ISR weapon system through improved data exploitation and intelligence content synthesis. Conduct research to optimize multi-domain ISR airman performance.<br><br>***FY 2021 Plans:***<br>In FY 2021, Human Analyst Augmentation work will be performed under the System Analytics effort and the Collaborative Interfaces and Teaming effort in Project 625329, Sensory Evaluation and Decision Science.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Human Trust and Interaction<br><br>***Description:*** Conduct research in cross-cultural communication and automated speech translation tools for Air Force missions. Conduct research to address important aspects of trust in airman-machine teams including investigating how an airman knows an autonomous or semiautonomous system is safe to use and whether the system, data, conclusions, and decision recommendations can be trusted.<br><br>***FY 2021 Plans:***<br>In FY 2021, Human Trust and Interaction work will be transferred to the System Analytics effort in Project 625329, Sensory Evaluation and Decision Science.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 8.826 | 0.000 | 0.000 |
| ***Title:*** Molecular Sensing and Physiology<br><br>***Description:*** Provides advanced science and technology solutions for the characterization and exploitation of novel molecular biosignatures attributed to physiological stress and utilizing these biosignatures to sense and assess the physiological state of airmen within their associated operational environments. Goal of this research is to sustain and/or augment airmen performance and alert the airmen and their commanders when they are trending toward sub-optial performance so that intervention strategies | 6.136 | 6.985 | 15.953 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625328 / *Human Dynamics Evaluation* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| can be implemented to restore mission effectiveness. Research performance of On-board Oxygen Generation System (OBOGS) and implications on human physiology for current and next-generation aircraft.<br><br>***FY 2021 Plans:***<br>Research biological recognition elements (BRE) for biosignature detection. Investigate new biosignatures in non-invasive biofluids. Develop reliable, wearable sensors for near real-time detection in non-invasive physiological fluids and sensors for hydration monitoring in Air Force environments. Evaluate and down select sensors for an aircrew fatigue management system.<br><br>***FY 2022 Plans:***<br>Mature BRE (Biological Recognition Elements) development pipeline and optimize for BRE transition to sensor platforms. Develop and test different sensor options (electrochemical, field effect transistors, etc.) for biomarker and VOCs (Volatile Organic Compounds) detection in different operational environments. Incorporate sensor modalities into wearable and injectable sensors. Integration of biological system and their components in sensing platforms. Design, test and evaluate solutions for air quality assessment (sampling, analysis and models). Finalize investigation into OBOGS oxygen and flow performance decrements during highly dynamic operating conditions. Conduct OBOGS chemical containment research to assess quality of OBOGS breathing gas under realistic operating conditions. Develop OBOGS performance monitor for predicting failure. In FY 2021 and prior years, the OBOGS research is performed under Project 625328/Human Dynamics Evaluation, Aircrew Biodynamics and Protection sub-project.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $8.968 million. Funding increase due to an added emphasis in molecular sensing and the design, test and evaluate solutions for air quality assessment. | | | |
| ***Title:*** Systems Biology for Performance<br><br>***Description:*** Investigates the underlying molecular-biological mechanisms contributing to airman physiological and cognitive performance optimization. Provide airman protection from performance degradation and/or enhance performance capability under demanding training and mission activities through molecular bioscience research.<br><br>***FY 2021 Plans:***<br>Apply biotechnology to investigate methods for engineering the microbiome for enhancing airman performance. Explore synthetic biology techniques to enable performance modification and resiliency. Develop mathematical models to predict system biology system biology performance. Develop advanced organ and tissue human models for mechanistic assessments.<br><br>***FY 2022 Plans:*** | 7.265 | 6.985 | 15.954 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625328 / *Human Dynamics Evaluation* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Explore mechanistically inspired synthetic biology and other performance enhancing technologies to include engineering the microbiome. Generate mechanistic understanding of the effects of stress factors from which to generate biomarkers. Develop advanced physical and in silico models and simulations to predict individualized performance.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $8.968 million. Funding increase due to an added emphasis in systems biology performance efforts, and the development of advanced physical and in silico models and simulations to predict individualized performance. | | | |
| ***Title:*** Cognitive Neuroscience<br><br>***Description:*** Conduct research to develop and validate assessments of current and predicted cognitive states, enabling the development of personalized cognitive performance enhancements (e.g., neuromodulation, nutrition, physiological training, recovery approaches), supported by a foundational understanding of neurological mechanisms.<br><br>***FY 2021 Plans:***<br>Refine neuromodulation animal models for use in predicting human cognitive performance to include molecular predictors. Integrate inclusion of stress models on cognitive performance. Validate transcranial Direct Current Stimulation (tDCS) in operational environments and contexts. Expand Signature Tracking for Optimized Nutrition and Training (STRONG) Laboratory research to outside units for assessing program effectiveness. Complete a flexible domain package of cognitive workload assessment. Continue to develop algorithms for faster, predictable decision making capabilities. Initiate exploration of brainmachine interface research to enhance human state assessment, decision making, and trust. Explore use of bioinformatics to predict changes in cognitive neuroscience. Deliver enhanced lumbar spinal injury criteria and advance spinal injury prediction. Continue development of Multi-Axis Neck Injury Criteria (MANIC) model neck injury criteria transfer functions. Continue development of 5th and 95th percentile computational human ejection models to include expanded aircrew populations. Conduct current trainer aircraft on-board oxygen generation system (OBOGS) test & evaluations. Begin other fighter and new trainer aircraft OBOGS test & evaluation. Finalize and integrate innovative single/dual-breathing machine simulator development.<br><br>***FY 2022 Plans:***<br>Continue research to elucidate the neural mechanisms of neuromodulation and stress on cognitive performance in animal models. Conduct studies of peripheral nerve stimulation effects on various aspects of cognition including learning, attention, and multitasking. Explore methods of addressing physiologic variability between days, people, tasks, and time to improve the accuracy of cognitive state assessments. Perform research to develop methods of assessing fatigue state via physiology and compare the effects of cognitive interventions on performance during sleep deprivation. Continue development of a novel Brain Machine Interface technology to accelerate training for Air Force personnel such as pilots.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 0.000 | 6.985 | 15.954 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625328 / *Human Dynamics Evaluation* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $8.968 million. Funding increase due to and added emphasis in cognitive neuroscience and performance efforts, and novel Brain Machine Interface technology to accelerate training for Air Force personnel. | | | |
| ***Title:*** Aircrew Biodynamics and Protection<br><br>***Description:*** Conduct research to predict physiological impacts of extreme, dynamic aerospace environments (e.g., aircrew ejection, high altitude, high-G flight) on aircrew safety and performance. Research and develop novel innovative protective and safety devices related to aircraft ejection systems and flight safety equipment. Assess existing Air Force and Department of Defense safety standards and criteria for neck/spinal injury.<br><br>***FY 2021 Plans:***<br>Deliver enhanced lumbar spinal injury criteria and advance spinal injury prediction. Continue development of Multi-Axis Neck Injury Criteria model neck injury criteria transfer functions. Continue development of 5th and 95th percentile computational human ejection models to include expanded aircrew populations. Conduct current trainer aircraft OBOGS test & evaluations. Begin other fighter and new trainer aircraft OBOGS test & evaluation. Finalize and integrate innovative single/dual-breathing machine simulator development.<br><br>***FY 2022 Plans:***<br>Conduct research to develop and validate lumbar and neck injury criteria. Continue development of computational modeling to predict and assess acute and chronic injury to full aircrew. Conduct research to ascertain injury mechanisms of chronic neck and back pain to aircraft mission durations and vibration effects. Continue research on evaluation of structural integrity of medical transport devices.<br><br>In FY 2022, the OBOGS research will be performed under Project 625328/Human Dynamics Evaluation sub-project.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $8.968 million. Funding increase due to an added emphasis in aircrew biodynamics and aircrew protection efforts, and efforts such as computational modeling to predict and assess acute and chronic injury to full aircrew. | 0.000 | 6.986 | 15.954 |
| **Accomplishments/Planned Programs Subtotals** | 51.449 | 27.941 | 63.815 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Warfighter Physiology Program | 0.000 | 5.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625328 / *Human Dynamics Evaluation* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not Applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts | | |
| ***Congressional Add:*** Human Motion Assessment<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts | 0.000 | 4.000 |
| ***Congressional Add:*** Pilot Hypoxia Detection and Notification<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts | 0.000 | 9.900 |
| **Congressional Adds Subtotals** | 0.000 | 18.900 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602202F / *Human Effectiveness Applied Research* | Project (Number/Name)<br>625329 / *Sensory Evaluation and Decision Science* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625329: *Sensory Evaluation and Decision Science* | 0.000 | 30.545 | 37.547 | 35.783 | 0.000 | 35.783 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project conducts research to discover, develop, and transition advanced interface technology, decision aiding tools, and situationally-adaptive augmentation methods to seamlessly integrate Airmen and intelligent machines into maximally collaborative warfighting teams. Advanced technologies will enhance how Airmen fight, via improved team interactions and adaptive information throughput. Airman-Machine interaction design is critical for achieving mission success and maintaining meaningful human control in highly complex, uncertain, and rapidly evolving environments.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Applied Neuroscience | 13.195 | 0.000 | 0.000 |
| ***Description:*** Develop technologies to enhance Airman performance and Airman-machine collaboration in high-stress decision-making environments. Conduct research to predict physiological impacts of extreme, dynamic environments.<br><br>***FY 2021 Plans:***<br>In FY 2021, Applied Neuroscience work will performed under the Cognitive Neuroscience effort and the Aircrew Biodynamics and Protection effort in Project 625328, Human Dynamics Evaluation.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Collaborative Interfaces and Teaming | 5.616 | 10.138 | 9.661 |
| ***Description:*** Research new Human-Machine Teaming (HMT) technologies and concepts (e.g., information portrayal, control devices, decision aiding algorithms and adaptive agents) for effective human-machine interaction and teamwork.<br><br>***FY 2021 Plans:***<br>Execute the following: research on swift trust development and effective teaming methods between human operators in an MDC2 context; research on trust in software code; experiments to test visualizations and displays using HMT simulations, research and experimentation focused on HMT and collaborative interface design among mixed human-human and human-machine teams; | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625329 / *Sensory Evaluation and Decision Science* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| research on intelligent agent development and testing; conduct research focused on development of software architectures and platforms to enable HMT for pilot-vehicle interfaces, Unmanned Aerial System (UAS) teaming, and Air Battle Management.<br>***FY 2022 Plans:***<br>Develop and test multiple interface designs for teaming solutions based on research on swift trust development and effective teaming methods between human operators in a Joint All Domain Command and Control (JADC2) context; develop a multi-domain playbook for JADC2 operators; conduct research and experimentation focused on human-machine-teaming (HMT) and collaborative interface design among mixed human-human and human-machine teams; conduct research on trust development within mixed human-synthetic agent teams; conduct research on human implications of machine learning and run-time assurance technologies; conduct research focused on development of software architectures and platforms to enable HMT for pilot-vehicle interfaces, Unmanned Aerial System teaming, base defense, and air battle management.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.476 million. Funding decrease due to reduced emphasis described in plans above. | | | |
| ***Title:*** Battlespace Visualization<br>***Description:*** Research the visualization, interaction and understanding of complex information to enhance warfighter decision making.<br>***FY 2021 Plans:***<br>In FY 2021, Battlespace Visualization work will be performed under the Multisensory Perceptions and Communication effort within this Project.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 5.824 | 0.000 | 0.000 |
| ***Title:*** Battlespace Acoustics<br>***Description:*** Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments.<br>***FY 2021 Plans:*** | 2.987 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625329 / *Sensory Evaluation and Decision Science* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY 2021, Battlespace Acoustics work will be performed under the the Multisensory Perceptions and Communication effort within this Project.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Multisensory Perceptions and Communication<br>***Description:*** Multisensory Perception and Communication focuses on identifying and exploiting the underlying sensory and cognitive mechanisms mediating human perception and communication in order to inform the development of multimodal interfaces and speech/language technologies. Research will examine sensory processing, multisensory integration, and human communication processes in simple and complex environments to identify the barriers to effective information transmission and inform the development of technologies to overcome, or exploit, those barriers in order to enhance Airmen performance.<br>***FY 2021 Plans:***<br>Initiate research examining impact of communication interruption on task performance and develop a prototype real-time system; Plan study examining relative contribution of vocabulary and language rhythms and sounds on human interruption strategies; Initiate new behavioral/neurophysiological studies of multisensory perception and multimodal display research; Initiate program on multimodal contribution to automatic speech recognition and machine translation; Initiate lab experiments on perceptual jamming; Continue experiments on speech perception in complex environments; Plan new research in spatial attention monitoring; Measure and model acoustic signatures for aircraft and operational environments.<br>***FY 2022 Plans:***<br>Conduct research examining impact of communication interruption on task performance and refine a prototype real-time interruption system for human-machine communication; evaluate impact of communication management technologies used in real-world operations; develop laboratory and web-based toolkit and tablet-based applications for studying communication and perception for use in remote and in-house experimentation; generate and test model of perception of real-world sounds in complex environments for developing tools supporting perceptual disruption; establish new testbed for neurophysiological studies of multisensory perception and multimodal display research; conduct research on multimodal contribution to automatic speech recognition and machine translation; develop new algorithms for real-time speech synthesis for speech displays; conduct experiments on speech perception in complex environments to improve operational communication; develop program for research in visual and auditory attention monitoring to inform advanced multimodal interfaces; measure, model, and simulate operational | 0.000 | 14.268 | 13.597 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625329 / *Sensory Evaluation and Decision Science* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| acoustic environments for use in training and interface research and development; address requests for direct support from operational community.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.670 million. Funding decrease due to reduced emphasis described in plans above. | | | |
| ***Title:*** System Analytics<br><br>***Description:*** System Analytics studies the macro-cognition of the Airman using computational tools to accomplish mission objectives, encompassing interactions between operators, analytics, and environment. The goal of this research area is to describe, assess, and design for effective integration of analytics into mission systems.<br><br>***FY 2021 Plans:***<br>Leverage ongoing research investments to: develop analytics that bring structure, meaning, and context to mission data in order to build representations to support warfighter mission systems; assess the benefits and costs of integrated data analytics by quantifying how analytics alter thinking and reasoning in order to promote effective decision making. Key research lines include assessment of analytics for full motion video, data visualization for dynamic wide area monitoring, and development of analytics to improve analytic insight and reasoning during exploitation of multiple data sources.<br><br>***FY 2022 Plans:***<br>Advance development of theory-driven, evidence-based approaches to integrate new "analytics" (including decision aids, algorithms, automation, autonomy, and artificial intelligence/machine learning technologies) into human-machine systems in complex operational environments. Lines of effort will emphasize maturation and transition of research in systems analytics assessment, dynamic wide area discovery and exploitation, "meaning making" in the information environment, applied operational analytics, joint integrated ISR, and human language technology. Efforts will include increased investment in evaluation of conversational artificial intelligence, exploitation of publically available information, and explain-ability and ISR applications of topological data analytics.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.617 million. Funding decrease due to an added emphasis described in plans above. | 0.000 | 13.141 | 12.525 |
| **Accomplishments/Planned Programs Subtotals** | 27.622 | 37.547 | 35.783 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - Advanced technology development | 2.923 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>625329 / *Sensory Evaluation and Decision Science* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable | | |
| **Congressional Adds Subtotals** | 2.923 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602202F / *Human Effectiveness Applied Research* | Project (Number/Name)<br>627757 / *Bioeffects* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 627757: *Bioeffects* | 0.000 | 27.125 | 27.128 | 18.084 | 0.000 | 18.084 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project conducts applied research on the effects of human exposure to electromagnetic (EM) energy (direct current (DC) to radio frequency (RF) to optical, scalable directed energy weapons, and non-lethal weapons. This research addresses fundamental physical principles, as well as the biophysical interaction between directed energy and the individual or groups of individuals. Research is divided into two core focus areas: novel directed energy bioeffects and mechanisms and directed energy modeling, simulation, and analysis. The research enhances combat survivability and systems effectiveness through technologies that enable deployed forces to counter optical threats and exploit optical systems for offensive applications. In addition, basic biological investigations into the mechanisms associated with high peak power and high average power RF exposure allow for the exploitation of directed energy systems for offensive capabilities while protecting the warfighter from adversarial use of RF technologies. The novel directed energy bioeffects mechanisms research examines the physical, physiological, and neural interactions of EM with tissues to understand dose-response effects as well as reveal the means to cause or prevent a specific effect. The directed energy modeling, simulation, and analysis research is focused on new software components that represent and optimize concepts of directed energy system employment from the Airman standpoint. These components are matured for future transition and application for engagement-to-mission level simulations in which directed energy weapons are employed.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Optical Radiation Bioeffects | 15.317 | 0.000 | 0.000 |
| ***Description:*** Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats. | | | |
| ***FY 2021 Plans:***<br>Not applicable | | | |
| ***FY 2022 Plans:***<br>Not applicable | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Radio Frequency Bioeffects | 11.808 | 0.000 | 0.000 |
| ***Description:*** Conduct laboratory experiments and field research to enable safe exploitation of directed energy technologies for communication, target identification, and weapons development. | | | |
| ***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>627757 / *Bioeffects* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Novel Directed Energy Bioeffects and Mechanisms | 0.000 | 9.495 | 6.329 |
| ***Description:*** Conduct laboratory experiments to provide fundamental knowledge of mechanisms of interaction of directed energy (DE) with molecules, cells, tissues, organs, and whole organisms in support of military DE systems. Conduct laboratory experiments to understand the mechanistic and behavioral effects of novel weapon incidents to the Airman and to understand the effects of protection strategies on Airman performance.<br><br>***FY 2021 Plans:***<br>Complete bioeffects studies of potential future use laser wavelengths for use in high-energy lasers and the assessment of relative hazards. Develop metrics for the influence of optical distortion in evaluating developing eye protection technology. Conduct studies to understand use of laser eye protection on Airman performance. Conduct in vivo measurement of high average power exposures and high peak power microwave exposures to identify and baseline novel bioeffects. Build thermo-acoustic dosimetry techniques for in vivo assessment of high power sources including radio frequency (RF) thermal elastic expansion. Determine acute and chronic bioeffects from emerging sources. Expand in vivo molecular signature of RF exposure to assess acute and chronic bioeffects of RF to inform exposure scenarios.<br><br>***FY 2022 Plans:***<br>Continue multiple parameterization, validation and verification experimental studies which examine high peak power microwave, high energy laser, and other emerging directed energy weapon concepts in order to assure valid modeling of real-world concerns. Initiate studies to further understanding of superthreshold effects on critical tissues including dynamic tissue characteristics under superthreshold insult. Develop methodologies to validate representation of DE vision effects within the Modeling and Simulation environment. Collect data that leads to more refined exposure limits for militarily relevant environments. Examine postulated second-order effects for their impact on military missions. Examine mechanisms emerging from subcellular and cellular level response to RF and optical radiation. Participate in activities that further development of directed energy bioeffects policy and standards to maximize safe use of the technology.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602202F / *Human Effectiveness Applied Research* | **Project (Number/Name)**<br>627757 / *Bioeffects* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $3.165 million. Funding decrease due to reduced emphasis in novel and experimental directed energy efforts to better understand dynamic tissue characteristics. | | | |
| ***Title:*** Directed Energy Bioeffects Modeling, Simulation and Analysis<br><br>***Description:*** Conduct physics-level modeling and simulations to represent and optimize directed energy bioeffects to include direct, scalable, and collateral effects.<br><br>***FY 2021 Plans:***<br>Initiate validation and verification experiments for 3-dimensional tissue models of laser exposures. Transition model for probabilistic evaluation of risks from laser exposures on Air Force and Department of Defense laser ranges. Advance dose-response models to include severe retinal and skin optical radiation and radio frequency exposures. Mature models for combining separate images of same retinal or skin area into one image with higher fidelity of injury.<br><br>***FY 2022 Plans:***<br>Expand content of component level models to support future transitions of digital human representations to tactical wargaming and models. Translate new data from relevant biological experiments to establish engineering to mission-level models supporting severity of outcome in system risk assessments. Initiate new approaches for utilizing high performance computing for better characterizing uncertainty in quantitative models for bioeffects analysis. Extend advanced multi physics models to contain accurate representations of newly-discovered or postulated mechanisms of directed energy biological activity.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $5.879 million. Funding decrease due to reduced emphasis in directed energy bioeffects modeling, simulation and analysis efforts, and efforts such as supporting severity of outcome in system risk assessments. | 0.000 | 17.633 | 11.755 |
| **Accomplishments/Planned Programs Subtotals** | 27.125 | 27.128 | 18.084 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | | | | | | | |
| **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 | - | 214.814 | 201.048 | 174.683 | 0.000 | 174.683 | - | - | - | - | - | - |
| 623012: *Advanced Propulsion Technology* | - | 29.802 | 0.000 | 17.679 | 0.000 | 17.679 | - | - | - | - | - | - |
| 623048: *Combustion and Mechanical Systems* | - | 11.134 | 0.000 | 11.345 | 0.000 | 11.345 | - | - | - | - | - | - |
| 623066: *Turbine Engine Technology* | - | 50.601 | 73.887 | 62.350 | 0.000 | 62.350 | - | - | - | - | - | - |
| 623145: *Aerospace Power Technology* | - | 44.213 | 57.121 | 37.557 | 0.000 | 37.557 | - | - | - | - | - | - |
| 624847: *Rocket Propulsion Technology* | - | 74.322 | 62.488 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 625171: *Missile Rocket Propulsion* | - | 0.000 | 0.000 | 37.114 | 0.000 | 37.114 | - | - | - | - | - | - |
| 625330: *Aerospace Fuel Technology* | - | 4.742 | 7.552 | 8.638 | 0.000 | 8.638 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This effort develops propulsion and power technologies to achieve enabling and revolutionary aerospace technology capabilities. The effort has six projects, each focusing on a technology area critical to the Department of the Air Force. The Advanced Propulsion Technology project develops high-speed air breathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Department of the Air Force. The Combustion and Mechanical Systems project develops engine mechanical system technologies: bearings, seals, drives, and lubricants as well as combustion components, concepts, and technologies for legacy and advanced turbine engines. The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems and develops component technologies for ultra high pressure ratio, substantially improved durability, and adaptive cycle engine architecture to provide optimized performance, fuel efficiency, and life for widely varying mission needs. The Aerospace Power Technology project develops electrical power and thermal control technologies for military applications that remove operational limitations and enable advanced vehicle designs and high-power mission systems. The Rocket Propulsion Technology project develops advances in rocket propulsion technologies for space access, space maneuver, missiles, the sustainment of strategic systems, and tactical rockets. The Aerospace Fuel Technology project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pulse detonation, and combined-cycle engines. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* |

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

All transfers detailed below are administrative realignments due to the stand up of the United States Space Force, and not new starts. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, OH, Edwards Air Force Base, CA, or Arnold Air Force Base, TN.

In FY 2022, the work and funding associated with space technology research in PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force.

In FY 2022, the work and funding associated with missile rocket propulsion technologies in PE 0602203F, Aerospace Propulsion are transferred from Project 624847, Rocket Propulsion Technology to Project 625171, Missile Rocket Propulsion Technology due to the creation of a new Appropriation for Space Force.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 226.775 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 214.814 | 201.048 | 174.683 | 0.000 | 174.683 |
| Total Adjustments | -11.961 | 201.048 | 174.683 | 0.000 | 174.683 |
| • Congressional General Reductions | 0.000 | -0.367 | | | |
| • Congressional Directed Reductions | 0.000 | -2.450 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 28.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 203.865 | | | |
| • Reprogrammings | 0.467 | 0.000 | | | |
| • SBIR/STTR Transfer | -5.478 | 0.000 | | | |
| • Other Adjustments | -34.950 | 0.000 | 174.683 | 0.000 | 174.683 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 623066: *Turbine Engine Technology* | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add: *Program increase - advanced turbine technologies* | 2.000 | 0.000 |
| Congressional Add Subtotals for Project: 623066 | 2.000 | 0.000 |
| **Project:** 623145: *Aerospace Power Technology* | | |
| Congressional Add: *Program increase - thermal management technologies* | 7.000 | 0.000 |
| Congressional Add Subtotals for Project: 623145 | 7.000 | 0.000 |
| **Project:** 624847: *Rocket Propulsion Technology* | | |
| Congressional Add: *Program increase - next generation hall thrusters* | 14.000 | 0.000 |
| Congressional Add: *Program increase - next generation liquid propulsion* | 5.000 | 0.000 |
| Congressional Add Subtotals for Project: 624847 | 19.000 | 0.000 |
| Congressional Add Totals for all Projects | 28.000 | 0.000 |

**Change Summary Explanation**

Increase in FY 2022 of 174.683 million is due to Congressional reversal of program element restructure, higher Department of the Air Force priorities, and transformational activities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>623012 / *Advanced Propulsion Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623012: *Advanced Propulsion Technology* | - | 29.802 | 0.000 | 17.679 | 0.000 | 17.679 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops combined/advanced cycle air breathing high-speed (up to Mach 5) and hypersonic (Mach 5 to 7) propulsion technologies to provide revolutionary propulsion options for the Air Force. These new engine technologies will enable future high-speed/hypersonic weapons and aircraft concepts. The primary focus is on hydrocarbon-fueled engines capable of operating over a broad range of flight Mach numbers. Efforts include modeling, simulations, and proof of concept demonstrations of critical components; advanced component development; and ground-based demonstrations.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Hypersonic Scramjet Technologies | 29.802 | 0.000 | 17.679 |
| ***Description:*** Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.<br><br>***FY 2021 Plans:***<br>Continue to develop and demonstrate advanced engine components to improve scramjet operating margin, operating time, and to refine scramjet scaling laws for expendable and reusable applications. Continue to develop low internal drag flame stabilization devices and flight test engine components. Continue propulsion studies and design efforts required for the development and demonstration of an engine flight test that expands the flight environment of current high speed propulsion systems.<br><br>***FY 2022 Plans:***<br>Continue development and demonstration of advanced engine components to improve scramjet operating margin, operating time, and to refine scramjet scaling laws for expendable and reusable applications. Continue development of low internal drag flame stabilization devices, instrumentation, endothermic fuels, and flight test engine components. Continue propulsion studies and design efforts required for the development and demonstration of an engine flight test that expands the flight environment of current high speed propulsion systems.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $17.679 million. Funding increase due to increased emphasis on hypersonic scramjet technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 29.802 | 0.000 | 17.679 |

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

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623012 / *Advanced Propulsion Technology* |

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

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>623048 / *Combustion and Mechanical 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623048: *Combustion and Mechanical Systems* | - | 11.134 | 0.000 | 11.345 | 0.000 | 11.345 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project evaluates lubricants, mechanical systems, and combustion concepts for advanced turbine engines, pulse detonation engines, and combined cycle engines. This project also develops technologies to increase turbine engine operational reliability, durability, mission flexibility, maintainability, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include: missiles, aircraft, and re-usable high-speed vehicles. Analytical and experimental areas of emphasis include: lubricants, bearings, mechanical systems diagnostics, mechanical systems prognostics, rotor dynamics, oil-less engine technology, optical diagnostics, fundamental combustion, detonations, combustors, and afterburners. Lubricants for these engines must be thermally stable, cost-effective, and operate over a broad range of conditions. Advanced combustion concepts must be cost-effective, durable, and reduce pollutant emissions. A portion of this project supports adaptive cycle technologies. Adaptive cycle technologies develops component technology for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Combustion Technologies | 4.600 | 0.000 | 4.687 |
| ***Description:*** Develop, test, and evaluate revolutionary combustion and propulsion concepts for gas turbine, pulse detonation, and combined cycle engines for missiles, manned and unmanned systems. | | | |
| ***FY 2021 Plans:***<br>Continue exploring interactions and effects of compressor and turbine components on the combustor and combustor materials to reduce engine weight and increase efficiency. Continue using advanced diagnostics tools to develop high-quality datasets for use by academia and industry for model development and verification. Continue the determination of necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue to support development of advanced computational fluid dynamics (CFD) models to reduce combustor and augmentor design costs. Continue development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components and system level architectures. Continue to explore advanced combustion and flameholding concepts working towards improved understanding at relevant operating conditions such as sub-atmospheric (less than 1 atmosphere) and high pressure (greater than 10 atmospheres); this includes initiating fundamental combustion modeling and fluid-dynamic phenomena on high speed systems and rocket propulsion and advanced turbine engine applications, identifying modeling and simulation concepts/approaches to address combustion chemistry and physics and light/matter interactions, for high speed systems exploring turbulent combustion modeling in advanced configurations, exploring advanced combustion including pressure gain propulsion as it relates to new applications and architectures. Initiate the development and demonstration of new tools and use of new designs and materials to improve | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623048 / *Combustion and Mechanical Systems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| efficiency, power under quiet operations. Initiate investigation to identify and assess disruptive propulsion/power concepts and evaluate concepts. Initiate development of new technologies for unmanned aircraft system propulsion/power systems for improved understanding at relevant operating conditions.<br><br>***FY 2022 Plans:***<br>Continue exploring interactions and effects of compressor and turbine components on the combustor and combustor materials to reduce engine weight and increase efficiency. Continue using advanced diagnostics tools to develop high-quality datasets for use by academia and industry for model development and verification. Continue the determination of necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue to support development of advanced computational fluid dynamics (CFD) models to reduce combustor and augmentor design costs. Continue development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components and system level architectures. Continue to explore advanced combustion and flameholding concepts working towards improved understanding at relevant operating conditions such as sub-atmospheric (less than 1 atmosphere) and high pressure (greater than 10 atmospheres); this includes fundamental combustion modeling and fluid-dynamic phenomena on high speed systems and rocket propulsion and advanced turbine engine applications, identifying modeling and simulation concepts/approaches to address combustion chemistry and physics and light/matter interactions, for high speed systems exploring turbulent combustion modeling in advanced configurations, exploring advanced combustion including pressure gain propulsion as it relates to new applications and architectures. Continue the development and demonstration of new tools and use of new designs and materials to improve efficiency, power under quiet operations. Continue investigation to identify and assess disruptive propulsion/power concepts and evaluate concepts. Continue development of new technologies for unmanned aircraft system propulsion/power systems for improved understanding at relevant operating conditions<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.687 million. Funding increase is due to increased emphasis on combustion technologies. | | | |
| ***Title:*** Diagnostic Technologies<br><br>***Description:*** Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies.<br><br>***FY 2021 Plans:***<br>Complete the development and demonstration of diagnostic systems for high-bandwidth kilohertz to megahertz measurement of combustion chemistry and physics. Complete the development of diagnostic techniques to include 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. | 0.790 | 0.000 | 0.805 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623048 / *Combustion and Mechanical Systems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Complete the application of the insights gained to engine test cells and fielded systems including development and deployment of fiber-coupled sensor systems based on hyperspectral absorption spectroscopy. Continue supporting computational fluid dynamics combustion modeling by providing, insights for interpreting experimental results using existing Modeling & Simulation methodologies and applying recently developed high-speed, spatially resolved laser diagnostics to our representative, single element combustion experiments in order to demonstrate and deliver measurements of key combustion species and flow properties under high pressure conditions. Continue development of diagnostic tools/methods for robust measurement capability in engine test cells and full annular ground test environments including; reacting and non-reacting spray experiments for liquid fuel spray model development, employing Nonintrusive optical diagnostics will be used to obtain accurate, spatially/temporally resolved data. This provides the local flow field data required for comparisons to results of numerical simulations. Complete the development of portable measurement capability for engine testing. Complete the advancement of algorithms for tomographic reconstruction and spatiotemporal nonlinear data analysis to assess the rich data sets generated in the fundamental experiments and system testing described above. Initiate the development of improved numerical methods and turbulent combustion models to guide design and development of experimental components and systems utilizing existing Modeling & Simulation methodologies.<br>***FY 2022 Plans:***<br>Continue supporting computational fluid dynamics combustion modeling by providing, insights for interpreting experimental results using existing Modeling & Simulation methodologies and applying recently developed high-speed, spatially resolved laser diagnostics to our representative, single- element combustion experiments in order to demonstrate and deliver measurements of key combustion species and flow properties under high pressure conditions. Continue development of diagnostic tools/ methods for robust measurement capability in engine test cells and full annular ground test environments including reacting and nonreacting spray experiments for liquid fuel spray model development and employment of Nonintrusive optical diagnostics that will be used to obtain accurate, spatially/temporally resolved data. This provides the local flow field data required for comparisons to results of numerical simulations. Continue the development of improved numerical methods and turbulent combustion models to guide design and development of experimental components and systems utilizing existing Modeling & Simulation methodologies.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.805 million. Funding increased due to increased emphasis on diagnostic technologies. | | | |
| ***Title:*** Lubricant Technologies | 2.734 | 0.000 | 2.786 |
| ***Description:*** Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. | | | |
| ***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623048 / *Combustion and Mechanical Systems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue developing innovative fluids by; defining target requirements for new polyol ester oils, conducts Research & Development for new/enhanced turbine engine oils for legacy & emerging engines, qualifies new & updated engine oil products for legacy & emerging engines. Complete identification and development on in-line mechanical system health monitoring sensor technology. Continue the development of lubricant modeling through characterization of heat generation, lubrication system cooling effectiveness, failure progression of bearing materials under relevant engine conditions, and overall system performance of advanced bearing concepts for model validation. Continue supporting the warfighter on field-related mechanical system issues. Initiate performance validation study of advanced bearing designs/materials, lubricant & lubrication system components via fullscale high-fidelity laboratory parametric testing at representative engine operating conditions. Initiate the generation of the fatigue life database & assess fatigue growth characteristics of state of the art baseline, emerging, & advanced engine rolling element bearing materials thru sub-scale experimental investigations.<br>***FY 2022 Plans:***<br>Continue developing innovative fluids by; defining target requirements for new polyol ester oils, conducts Research & Development for new/enhanced turbine engine oils for legacy & emerging engines, qualifies new & updated engine oil products for legacy & emerging engines. Continue the development of lubricant modeling through characterization of heat generation, lubrication system cooling effectiveness, failure progression of bearing materials under relevant engine conditions, and overall system performance of advanced bearing concepts for model validation. Continue supporting the warfighter on field-related mechanical system issues. Continue performance validation study of advanced bearing designs/materials, lubricant & lubrication system components via full-scale high-fidelity laboratory parametric testing at representative engine operating conditions. Continue the generation of the fatigue life database & assess fatigue growth characteristics of state of the art baseline, emerging, & advanced engine rolling element bearing materials thru sub-scale experimental investigations<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $2.786 million. Funding increased due to increased emphasis on lubricant technologies. | | | |
| ***Title:*** Bearing Technologies<br>***Description:*** Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications.<br>***FY 2021 Plans:***<br>Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Continue incorporating fatigue life, fault evolution, and parametric heat generation of advanced material systems into the models. Continue development of oil-free bearing technology for Unmanned Air Systems. Complete development of active thrust-balance/prognostic health management system for large man-rated and | 3.010 | 0.000 | 3.067 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623048 / *Combustion and Mechanical Systems* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| medium-scale propulsion. Initiate the development and demonstration of propulsion technologies for subsonic expendable and attritable air platforms, small and medium scale propulsion technologies, and evaluate lubricants, mechanical systems, bearing technology and combustion concepts for advanced turbine engines. Initiate the development of fundamental knowledge of bearing material rolling contact fatigue failure mechanisms and lubricant interactions through microstructural investigations and failure analysis.<br>***FY 2022 Plans:***<br>Continue developing physics-based bearing life model based on bearing alloy fatigue and microstructural investigations, including bearing life factors for advanced bearing materials. Continue incorporating fatigue life, fault evolution, and parametric heat generation of advanced material systems into the models. Continue development of oil-free bearing technology for Unmanned Air Systems. Continue the development and demonstration of propulsion technologies for subsonic expendable and attritable air platforms, small and medium scale propulsion technologies, and evaluate lubricants, mechanical systems, bearing technology and combustion concepts for advanced turbine engines. Continue the development of fundamental knowledge of bearing material rolling contact fatigue failure mechanisms and lubricant interactions through microstructural investigations and failure analysis.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.067 million. Funding increased due to increased emphasis on bearing technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 11.134 | 0.000 | 11.345 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>623066 / *Turbine Engine Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623066: *Turbine Engine Technology* | - | 50.601 | 73.887 | 62.350 | 0.000 | 62.350 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, integrated power and thermal management systems, engine inlet integration, mechanical systems, adaptive cycle technologies, and structural design. This project develops component technology for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs. This project supports joint Department of Defense, agency, and industry efforts to focus turbine propulsion technology on national needs. The project plan is relevant across capability areas for global responsive strike, tactical and global mobility, responsive space lift, and persistent intelligence, surveillance, and reconnaissance (ISR).

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Turbofan/Turbojet Engine Core Technologies | 20.277 | 32.602 | 27.461 |
| ***Description:*** Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.<br><br>***FY 2021 Plans:***<br>Complete development and validation of modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for advanced engines including: planning for a conceptual design, fabrication, and testing of component technology rigs, including bearing testing; exploring new approaches for advanced engine technologies, including use of high-temperature materials, integrated propulsion, power and thermal technologies and responsive controls; finalizing the concepts for achieving the product goals for increased fuel efficiency, power and thermal management and propulsive capability. Continue development of improved aerodynamic design tools and analysis methods to extend engine operability and efficiency.<br><br>***FY 2022 Plans:***<br>Continue development of improved aerodynamic design tools and analysis methods to extend engine operability and efficiency.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $5.141 million. Funding decrease due to reduced emphasis on turbofan and turbojet engine core technologies. | | | |
| ***Title:*** Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies | 20.423 | 0.000 | 0.000 |
| ***Description:*** Develop turbofan/turbojet engine components (i.e., fans, nozzles, etc.) used in engines for fighters, bombers, sustained supersonic strike and hypersonic cruise vehicles, and transports. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623066 / *Turbine Engine Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed in PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Revolutionary Propulsion Technology effort and Missile and Unmanned Aerial System (UAS) Engine Technology effort.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | | | |
| ***Title:*** Missile and Remotely Piloted Aircraft Engine Technologies<br>***Description:*** Develop limited life engine components for missile and remotely piloted aircraft (RPA) applications, including long-range supersonic and hypersonic vehicles.<br>***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed in PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | 4.923 | 0.000 | 0.000 |
| ***Title:*** Turboshaft/Turboprop and Small Turbofan Engine Technologies<br>***Description:*** Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports.<br>***FY 2021 Plans:***<br>Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Continue development and validation of modeling and simulation tools for the design and analysis of turbine components with mission-tailored aero-performance and highly efficient cooling geometries. Complete the development and validation of parameter, process, and performance modeling for components manufactured through additive technologies. Complete the development and validation of rules and tools to enable flexible design for targeted life applications. Continue the new innovative architectures, critical technologies, exploration of targeted life applications for small missile and remotely piloted aircraft applications; evaluate critical technologies that will increase range, performance, durability, electrical power and thermal capacity of these systems. Continue the exploration of new small engine technologies that can operate in | 2.978 | 5.653 | 4.793 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623066 / *Turbine Engine Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| high speed applications; Evaluate risk reduction technologies to increase usage time of systems. Complete development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components. Continue demonstrating advanced component designs and modeling tools in rig and engine testing. Continue to utilize validation data to develop improved test protocol for small engine designs. Continue development and validation of modeling and simulation tools for the design and analysis of engine components with new manufacturing processes. Continue the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. Continue exploration of new small and medium size engine technologies for increased fuel efficiency, propulsive capability, power and thermal management, and reduced life cycle cost. Continue identification of new architectures and critical technologies for integrated power and thermal systems. Continue identification of requirements and develop models for simulation of highly integrated systems.<br>***FY 2022 Plans:***<br>Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Continue development and validation of modeling and simulation tools for the design and analysis of turbine components with mission-tailored aero-performance and highly efficient cooling geometries. Continue the new innovative architectures, critical technologies, exploration of targeted life applications for small missile and remotely piloted aircraft applications; evaluate critical technologies that will increase range, performance, durability, electrical power and thermal capacity of these systems. Continue the exploration of new small engine technologies that can operate in high speed applications; evaluate risk reduction technologies to increase usage time of systems. Continue demonstrating advanced component designs and modeling tools in rig and engine testing. Continue to utilize validation data to develop improved test protocol for small engine designs. Continue development and validation of modeling and simulation tools for the design and analysis of engine components with new manufacturing processes. Continue the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. Continue exploration of new small and medium size engine technologies for increased fuel efficiency, propulsive capability, power and thermal management, and reduced life cycle cost. Continue identification of new architectures and critical technologies for integrated power and thermal systems. Continue identification of requirements and develop models for simulation of highly integrated systems.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.86 million. Funding decrease due to reduced emphasis on turboshaft and turboprop and small turbofan engine technologies. | | | |
| ***Title:*** Revolutionary Propulsion Technology<br>***Description:*** Develop, test, and evaluate revolutionary propulsion concepts for gas turbine, pressure gain propulsion, and combined cycle engines for missiles, manned and unmanned systems.<br>***FY 2021 Plans:*** | 0.000 | 19.972 | 16.861 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623066 / *Turbine Engine Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Complete development of modeling and simulation tools, for advanced turbine engine concepts. Complete advanced modeling and simulation tools for the design and analysis of advanced propulsion technologies to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Complete analysis of advanced propulsion engines, such as rotating detonation engines and advanced high-speed concepts. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Initiate studies for exploration of advanced propulsion technologies. Explore and evaluate innovative architectures for affordable & efficient airlaunched propulsion capability from Mach 3 to Mach 5+, and turbine based combined cycle propulsion capability to Mach 5+.<br>***FY 2022 Plans:***<br>Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Continue the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike and Intelligence, Surveillance, and Reconnaissance (ISR) systems. Continue studies for exploration of advanced propulsion technologies. Continue exploration and evaluation of innovative architectures for affordable & efficient airlaunched propulsion capability from Mach 3 to Mach 5+, and turbine based combined cycle propulsion capability to Mach 5+.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $3.111 million. Funding decrease due to reduced emphasis on revolutionary propulsion technology. | | | |
| ***Title:*** Missile and Unmanned Aerial Systems (UAS) Engine Technologies | 0.000 | 15.660 | 13.235 |
| ***Description:*** Develop limited life engine components for missile and Unmanned Aerial System (UAS) applications, including longrange subsonic, supersonic and hypersonic vehicles.<br>***FY 2021 Plans:***<br>Complete development of modeling and simulation tools for advanced missile and unmanned aerial system concepts. Complete advanced modeling and simulation tools for the design and analysis of new systems to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623066 / *Turbine Engine Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Explore new engine concepts for missile and unmanned systems.<br>***FY 2022 Plans:***<br>Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Continue the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike and Intelligence, Surveillance, and Reconnaissance (ISR) systems. Continue exploration of new engine concepts for missile and unmanned systems.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.425 million. Funding decreased due to decreased emphasis on missile and Unmanned Aerial System (UAS) engine technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 48.601 | 73.887 | 62.350 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - advanced turbine technologies | 2.000 | 0.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts | | |
| ***FY 2021 Plans:*** Not applicable. | | |
| **Congressional Adds Subtotals** | 2.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>623145 / *Aerospace Power Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623145: *Aerospace Power Technology* | - | 44.213 | 57.121 | 37.557 | 0.000 | 37.557 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops integrated electrical and thermal management components, controls and systems for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable future military megawatt level power and thermal management needs. Controls and system integration technologies ensure the interoperability of aircraft, power, thermal, engine and other systems and subsystems. This project supports development of electrical power and thermal management components, controls and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Power System Technologies | 37.213 | 57.121 | 37.557 |
| ***Description:*** Develop integrated system architecture, controls, and component technologies to provide for the large amounts of electrical power needed, and concurrent thermal mitigation required, by current and future manned and unmanned systems.<br><br>***FY 2021 Plans:***<br>Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continue development of hybrid approaches to power generation, storage, and application as well as thermal management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Continue power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Continue analysis and development of adaptive power and thermal control systems for high-power aircraft. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures. Initiate medium-scale propulsion, power and thermal system studies and development.<br><br>***FY 2022 Plans:***<br>Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Complete development of hybrid approaches to power generation, storage, and application as well as thermal management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation for energy optimization. Continue development of advanced, safe energy storage, power distribution, and management | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>623145 / *Aerospace Power Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| systems to include Silicon Carbide applications and batteries and fan tip generator development. Complete power and thermal development toward demonstration of tactical aircraft high-power payload capability to include +/-270 Volts Direct Current (VDC) power generation and storage. Continue analysis and development of adaptive power and thermal control systems for highpower aircraft to include open system integration and test. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures. Continue medium-scale propulsion, power and thermal system studies and development to include innovative, integrated hybrid architectures.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $19.564 million. Funding decrease due to reduced emphasis on high power system technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 37.213 | 57.121 | 37.557 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - thermal management technologies | 7.000 | 0.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts | | |
| ***FY 2021 Plans:*** Not applicable. | | |
| **Congressional Adds Subtotals** | 7.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>624847 / *Rocket Propulsion Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624847: *Rocket Propulsion Technology* | - | 74.322 | 62.488 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops rocket propulsion technologies for space access, space maneuver, the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts), and tactical missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, technology for sustainment of strategic systems, and innovative space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Develop technologies to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). Technologies under this project enable capabilities of interest to both DoD and National Aeronautics and Space Administration (NASA). Tasks include: modeling and simulation; proof of concept tests of critical components; advanced component development; and ground-based tests. Aging and surveillance tasks could reduce lifetime prediction uncertainties for individual motors by 50%, enabling motor replacement for cause. All thrusts are part of the Rocket Propulsion 21 (RP21) collaboration and are reviewed by a DoD level steering committee yearly for relevance to DoD missions and progress towards RP21 Goals.

In FY 2022, the work and funding associated with space technology research in PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force.

In FY 2022, the work and funding associated with missile rocket propulsion technologies in PE 0602203F, Aerospace Propulsion are transferred from Project 624847, Rocket Propulsion Technology to Project 625171, Missile Rocket Propulsion Technology due to the creation of a new Appropriation for Space Force.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Fuel Technologies | 9.404 | 12.595 | 0.000 |
| ***Description:*** Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods. | | | |
| ***FY 2021 Plans:***<br>Continue to develop solid rocket propellant binder systems for use across operationally relevant conditions. Continue to devise, synthesize, scale-up, and characterize novel energetic ingredients for monopropellants, fuels, and oxidizers, for use across the span of space and missile applications including tactical, strategic, and in-space thrust and attitude control. Continue knowledge transfer for making green monopropellants to United States industrial base. Continue to formulate, scale-up, and evaluate formulations of solid and liquid rocket propellants. Continue to identify, evaluate, and adapt 21st century material processing | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>624847 / *Rocket Propulsion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| techniques and equipment to enable more rapid and agile development for more precise products. Continue research in high temperature resins, insulators, and composite case fabrication techniques to enable high performance rocket motor cases.<br><br>***FY 2022 Plans:***<br>Complete development of solid rocket propellant binder systems for use across operationally relevant conditions. Continue to devise, synthesize, scale-up, and characterize novel energetic ingredients for monopropellants, fuels, and oxidizers, for use across the span of space and missile applications including tactical, strategic, and in-space thrust and attitude control. Continue to formulate, scale-up, and evaluate formulations of solid and liquid rocket propellants, including green monopropellants. Continue to identify, evaluate, and adapt 21st century automated formulation and production techniques to enable more rapid and agile munitions production arrangements. Continue research in high- temperature resins, insulators, and composite case fabrication techniques to enable high performance rocket motor cases.<br><br>In FY2022, work and funding associated with fuel technologies in Project 624847, Rocket Propulsion Technology, are transferred to Project 625171, Missile Rocket Technology, due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $12.596 million. Funding decreased due to work and funding associated with fuel technologies in Project 624847, Rocket Propulsion Technology, being transferred to Project 625171, Missile Rocket Technology, due to the creation of a new Appropriation for Space Force. | | | |
| ***Title:*** Liquid Engine Combustion Technologies | 7.708 | 11.216 | 0.000 |
| ***Description:*** Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.<br><br>***FY 2021 Plans:***<br>Continue evaluation of methane multi-injector designs in hot-fire conditions. Continue hot fire tests in combustion stability rig. Continue combustion stability modeling critical for future hydrocarbon fueled liquid rocket engines. Complete the delivery of combustion stability codes with nearly complete set of validation data to rocket community, enabling more robust and stable engine designs. Continue developing understanding of hydrocarbon fuel production, expanding testing into methane fuels and other cryogenic cooling. Continue the employment of new fuel and material operating limitations, manufacturing processes, and launch goals in cycle analysis to identify trade space for future engines. Continue to develop and evaluate advanced material solutions for high temperature components in rocket propulsion. Continue installation of new test facility that will fill the current capability gap and allow for fast, low-cost testing of multi-injector designs and stability strategies at conditions relevant to the demands of both Department of Defense and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). Continue development and payoff determination of rotating detonation rocket engine technologies.<br><br>***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>624847 / *Rocket Propulsion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY2022, the work and funding associated with liquid engine combustion technologies in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $11.216 million. Due to in FY2022, the work and funding associated with liquid engine combustion technologies in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force. | | | |
| ***Title:*** Advanced Liquid Engine Technologies<br><br>***Description:*** Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles.<br><br>***FY 2021 Plans:***<br>Complete exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Continue sub-scale risk mitigation and technology maturation activities to incorporate into next generation engine concepts. Continue modular component integration and interaction research activities supporting next generation engine concepts.<br><br>***FY 2022 Plans:***<br>In FY2022, the work and funding associated with advanced liquid engine technology in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $4.965 million. Due to in FY2022, the work and funding associated with advanced liquid engine technology in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force. | 10.459 | 4.965 | 0.000 |
| ***Title:*** On-Orbit Propulsion Technologies<br><br>***Description:*** Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations.<br><br>***FY 2021 Plans:***<br>Continue advanced chemical propellants scale-up research focusing on transition of numerical tools and experimental methodologies for advanced monopropellants to spacecraft industry. Continue to support the maturation of advanced diagnostics | 14.938 | 7.651 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>624847 / *Rocket Propulsion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| for both chemical and electric propulsion thruster plumes with potential for integrated state-of-health application. Continue to expand the validation and verification programs (both experimental and flight) to quantify accuracy of modeling and simulation tools developed to support thruster-spacecraft integration. Continue transition and support of thruster/ plume modeling framework to spacecraft industry, with addition of advanced Electric Propulsion thruster models, to industry partners. Expanding exploration of advanced integrated electric propulsion and chemical thruster concepts and assess new spacecraft propulsion requirements.<br>***FY 2022 Plans:***<br>In FY2022, the work and funding associated with on-orbit propulsion technologies in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by D7.651 million. Due to in FY2022, the work and funding associated with on-orbit propulsion technologies in Project 624847, Rocket Propulsion Technology, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Project 624847, Rocket Propulsion Technology, due to the creation of a new Appropriation for Space Force. | | | |
| ***Title:*** Space Access and Strike Applications<br>***Description:*** Develop missile propulsion and boost technologies for space access and strike applications.<br>***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed under the Ballistic and Tactical Propulsion Technologies major thrust.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | 5.066 | 0.000 | 0.000 |
| ***Title:*** Ballistic and Tactical Propulsion Technologies<br>***Description:*** Develop missile propulsion technologies and aging & surveillance technologies for ballistic and tactical missiles.<br>***FY 2021 Plans:***<br>Continue to apply next generation of chemical and mechanical aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user needs and unique challenges. Continue development of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena further improve data acquisition and reduce uncertainty in tactical, hypersonic, and ballistic missile solid rocket motor service life predictions. Continue long-term validation of tools through long-term aging and testing of sub-scale motors. Continue to develop advanced tactical | 7.747 | 26.061 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>624847 / *Rocket Propulsion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| propulsion and concepts. Continue propellant development efforts including long-life and other novel propellant systems. Continue development, evaluation, verification, and validation of next generation of updated, physics-based modeling, simulation, and analysis tools for rapid and agile missile propulsion design, analysis, and production to include designs for 21st century material processing techniques and equipment. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment.<br>***FY 2022 Plans:***<br>In FY2022 the work and funding associated with ballistic and tactical propulsion technologies in Project 624847, Rocket Propulsion Technology, are transferred to Project 625171, Missile Rocket Technology, due to the creation of a new Appropriation for Space Force.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $26.061 million. Funding decreased due to the work and funding associated with ballistic and tactical propulsion technologies in PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, are transferred to Project 625171, Missile Rocket Technology, due to the creation of a new Appropriation for Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 55.322 | 62.488 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - next generation hall thrusters<br>***FY 2020 Accomplishments:*** Not Applicable<br>***FY 2021 Plans:*** Not applicable. | 14.000 | 0.000 |
| ***Congressional Add:*** Program increase - next generation liquid propulsion<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed effort<br>***FY 2021 Plans:*** Not applicable. | 5.000 | 0.000 |
| **Congressional Adds Subtotals** | 19.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>625171 / *Missile Rocket Propulsion* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625171: *Missile Rocket Propulsion* | - | 0.000 | 0.000 | 37.114 | 0.000 | 37.114 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops rocket propulsion technologies for the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts), and tactical missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, and technology for sustainment of strategic systems. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Develop technologies to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). Tasks include: modeling and simulation; proof of concept tests of critical components; advanced component development; and ground-based tests. Aging and surveillance tasks could reduce lifetime prediction uncertainties for individual motors by 50%, enabling motor replacement for cause. All thrusts are part of the Rocket Propulsion 21 (RP21) collaboration and are reviewed by a DoD level steering committee yearly for relevance to DoD missions and progress towards RP21 Goals.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Fuel Technologies | - | 0.000 | 12.146 |
| ***Description:*** Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods. | | | |
| ***FY 2021 Plans:***<br>Before FY2022, this work is performed in PE 0602203F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort. | | | |
| ***FY 2022 Plans:***<br>Complete development of solid rocket propellant binder systems for use across operationally relevant conditions. Continue to devise, synthesize, scale-up, and characterize novel energetic ingredients for monopropellants, fuels, and oxidizers, for use across the span of space and missile applications including tactical, strategic, and in-space thrust and attitude control. Continue to formulate, scale-up, and evaluate formulations of solid and liquid rocket propellants, including green monopropellants. Continue to identify, evaluate, and adapt 21st century automated formulation and production techniques to enable more rapid and agile munitions production arrangements. Continue research in high- temperature resins, insulators, and composite case fabrication techniques to enable high performance rocket motor cases. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>625171 / *Missile Rocket Propulsion* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $12.146 million. Funding increase is due to work shifting from project, 624847 / Rocket Propulsion Technology. | | | |
| ***Title:*** Ballistic and Tactical Propulsion Technologies | - | 0.000 | 24.968 |
| ***Description:*** Develop missile propulsion technologies and aging & surveillance technologies for ballistic and tactical missiles.<br><br>***FY 2021 Plans:***<br>Before FY2022, this work is performed in PE 0602203F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Ballistic and Tactical Propulsion Technologies effort at $26.214 million.<br><br>***FY 2022 Plans:***<br>Continue to apply next generation of chemical and mechanical aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user needs and unique challenges. Complete development of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena further improve data acquisition and reduce uncertainty in tactical, hypersonic, and ballistic missile solid rocket motor service life predictions. Complete long-term validation of tools through long-term aging and testing of sub-scale motors. Continue to develop advanced tactical propulsion and concepts. Complete propellant development efforts including long-life and other novel propellant systems. Continue development, evaluation, verification, and validation of next generation of updated, physics-based modeling, simulation, and analysis tools for rapid and agile missile propulsion design, analysis, and production to include designs for 21st century material processing techniques and hardware. Continue to support advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment. Initiate automated solid rocket motor production techniques and equipment to enable more rapid and agile munitions production and logistic support.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $24.968 million. Funding increase is due to work shifting from project, 624847 / Rocket Propulsion Technology. | | | |
| **Accomplishments/Planned Programs Subtotals** | - | 0.000 | 37.114 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602203F / *Aerospace Propulsion* | Project (Number/Name)<br>625330 / *Aerospace Fuel Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625330: *Aerospace Fuel Technology* | - | 4.742 | 7.552 | 8.638 | 0.000 | 8.638 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, detonation, and combined cycle engines. This project also considers fuel related concepts that can increase turbine engine operational reliability, durability, mission flexibility, energy efficiency, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include missiles, aircraft, sustained high-speed vehicles, hypersonic, and responsive space launch. Analytical and experimental areas of emphasis include evaluations of fuel properties and characteristics of traditional fuels and alternative fuels developed from unconventional sources (such as coal, natural gas, biomass, and combinations thereof), specialty fuels and components development used in integrated thermal and energy management systems including high heat sink fuel capability, fuels logistics and associated vulnerabilities, and combustion diagnostics and engine emissions measurements.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Alternative Fuels | 0.093 | 0.718 | 0.636 |
| ***Description:*** Investigate novel sustainable aviation fuels for engines, missiles, aircraft, sustained high-speed vehicles, hypersonic, and responsive space launch applications. Conduct evaluations and perform technical assessments of alternative fuels developed from unconventional sources for use in legacy and advanced aerospace systems. Support development of alternative fuel specification for commercial jet fuels with Federal Aviation Agency. | | | |
| ***FY 2021 Plans:***<br>Complete development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force. | | | |
| ***FY 2022 Plans:***<br>Initiate investigation and development of novel sustainable aviation fuels and technologies for potential propulsion performance enhancement. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.082 million. Funding decrease due to reduced emphasis on alternative fuels. | | | |
| ***Title:*** Integrated Thermal and Energy Management | 1.496 | 2.293 | 2.728 |
| ***Description:*** Develop advanced and specialty fuels, components, associated technologies, and conduct performance assessments of advanced integrated thermal and energy management systems for engines, missiles, aircraft, sustained high-speed vehicles, hypersonic, and responsive space launch. Evaluate stability and performance of advanced and specialty fuels. | | | |
| ***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>625330 / *Aerospace Fuel Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking for hypersonic applications. Continue model development for integrated thermal and energy management to include designs and evaluation of vehicle fuel systems, and prototype sensors to monitor the fuel chemistry that produces coke deposits and characterization of system-level impacts from thermally-stressed fuel. Continue evaluation of fuel reaction models that enable high temperature systems for evaluating endothermic fuels. Continue investigation of fuel heat sink approaches for thermal management of advanced engines and other systems that evaluate integrated power and thermal management approaches. Initiate the development of fuel models for system design and evaluation. Continue development of online sensors for monitoring chemistry that causes deposits. Continue characterization system-level impacts of emerging aviation technologies. Initiate new, continue, and complete studies using fuel as a thermal management fluid to meet AF requirements to include impact on combustor performance and emissions. Continue investigation of heat exchangers including additive manufactured units and their reaction to fuels. Continue developing integrated test rigs to tests these approaches and assess efficiency of these approaches.<br>***FY 2022 Plans:***<br>Continue the development and evaluation of novel additives, catalysts, and fuel composition and fuel system approaches enable new hypersonic applications. Continue model development for integrated thermal and energy management that include designs and evaluation of vehicle fuel systems, and prototype sensors to monitor the fuel chemistry that produces coke deposits and characterization of system-level impacts from thermally-stressed fuel. Continue evaluation of fuel reaction models that enable high temperature systems for evaluating endothermic fuels. Continue investigation of fuel heat sink approaches for thermal management of advanced engines and other systems that evaluate integrated power and thermal management approaches. Continued the development of fuel models for system design and evaluation of fuel system. Continue development of sensors and analysis techniques for monitoring fuel chemistry that causes deposits. Continue characterization system-level impacts of emerging aviation technologies. Continue studies using fuel as a thermal management fluid to meet Air Force requirements. Continue investigation of fuel heat exchangers including additive manufactured units and their reaction to fuels. Continue developing integrated test rigs to tests these approaches and assess efficiency of these approaches.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.435 million. Funding increase due to increased emphasis on integrated thermal and energy management. | | | |
| ***Title:*** Fuel Logistics and Sustainment | 1.496 | 2.295 | 2.728 |
| ***Description:*** Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies. Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Department of the Air Force.<br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>625330 / *Aerospace Fuel Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue supporting fuel sustainment issues as needed, to understand problems and work to find solutions. Continue determining fuel temperature limits and other fuel technology approaches (additives, deoxygenation) for full-life fuel systems for advanced applications. Identify new approaches to be able to: capture fuel stability limiters to minimize logistics vulnerabilities, work on bio-detection and mitigations to support logistics readiness, and coordinate and collaborate with Army and Navy in identification and development of fuel sensing technologies. Continue the development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Continue the development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. Continue development of compositional analysis that can be verified across services and leverages a database of specification and extended compositional information to advance data visualization and analytics. Continue to analyze to develop fuels, fuel blends and catalyst formulations that provide endothermic cooling capacity for hypersonic applications. Continue study of fuels and models for next generation vehicles. Continue study of fuel temperature limitations and use data to validate models, including the development and utilization of the analytical methods and knowledge discovery tools necessary to understand fundamental fuel composition and its impact across the operational domain to ensure readiness across the operational domain for the AF.<br>***FY 2022 Plans:***<br>Continue supporting fuel sustainment issues as needed, to understand problems and work to find solutions. Continue development of compositional analysis that can be verified across services and leverages a database of specification and extended compositional information to advance data visualization and analytics. Continue approaches to be able to: capture fuel stability limiters to minimize logistics vulnerabilities; develop detection and mitigations for fuel biocontamination to support logistics readiness; and develop fuel sensing technologies with coordination and collaboration across the government. Continue thermal stability studies, models (such as chemistry, fuel system, and hybrid) developments, and technologies (such as additives, deoxygenation, and platform thermal stability sensors) developments for traditional, specialty, and sustainable aviation fuels under simulated operational domain conditions to ensure readiness across the Air Force's operational domains. Continue to analyze and develop fuels, fuel blends, and catalyst formulations that provide endothermic cooling capacity for hypersonic applications. Continue study of fuels and models for next generation vehicles.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.433 million. Funding increase due to increased emphasis on fuel logistics and sustainment. | | | |
| ***Title:*** Combustion Emissions and Performance<br>***Description:*** Develop and test applied emissions diagnostic techniques for air breathing propulsion systems. Evaluate aviation fuel for combustion and emissions characteristics and fuel composition performance impacts. Identify and develop approaches to improve system performance and emissions across different fuels and types.<br>***FY 2021 Plans:*** | 1.657 | 2.246 | 2.546 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602203F / *Aerospace Propulsion* | **Project (Number/Name)**<br>625330 / *Aerospace Fuel Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions.<br>***FY 2022 Plans:***<br>Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. Initiate studies of impact on combustor performance and emissions based on fuel chemistry (traditional, specialty, and sustainable aviation fuels), and fuel entrance temperature well above historic use levels, and other operational impacts, such as high altitude. Initiate development of low temperature catalyst augmented combustion technologies.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.300 million. Funding increase due to increased emphasis on combustion emissions and performance. | | | |
| **Accomplishments/Planned Programs Subtotals** | 4.742 | 7.552 | 8.638 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | | | | | | | |
| **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 | - | 210.940 | 232.876 | 193.514 | 0.000 | 193.514 | - | - | - | - | - | - |
| 622002: *Electronic Component Technology* | - | 52.667 | 55.327 | 35.772 | 0.000 | 35.772 | - | - | - | - | - | - |
| 622003: *EO Sensors & Countermeasures Tech* | - | 30.934 | 45.638 | 24.725 | 0.000 | 24.725 | - | - | - | - | - | - |
| 622005: *Cyber Technology* | - | 9.387 | 16.625 | 6.934 | 0.000 | 6.934 | - | - | - | - | - | - |
| 624920: *Electronic Warfare Technology* | - | 34.795 | 44.749 | 45.347 | 0.000 | 45.347 | - | - | - | - | - | - |
| 626095: *Sensor Fusion Technology* | - | 27.577 | 35.716 | 28.984 | 0.000 | 28.984 | - | - | - | - | - | - |
| 627622: *RF Sensors and Countermeasures Tech* | - | 55.580 | 34.821 | 51.752 | 0.000 | 51.752 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops the technology base for Air Force aerospace sensors and electronic combat. Advances in aerospace sensors are required to increase combat effectiveness by providing anytime, anywhere surveillance, reconnaissance, precision targeting, and electronic warfare (EW) capabilities. To achieve this progress, this program pursues simultaneous advances in: 1) generating, controlling, receiving, and processing electronic and photonic signals for radio frequency (RF) sensor aerospace applications; 2) electro-optical (EO) and infrared (IR) aerospace sensor technologies for a variety of offensive and defensive uses; 3) radio frequency antennas and associated electronics for airborne and space surveillance, together with active and passive electro-optical/infrared sensors; 4) technologies to manage and fuse on-board sensor information for timely, comprehensive situational awareness; 5) technology for affordable, trusted, and reliable, all-weather surveillance, reconnaissance, and precision strike radio frequency sensors and electronic combat systems; and 6) technologies that aid in the development of agile and resilient mission systems. This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601S.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* |

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 219.912 | 211.301 | 205.495 | 0.000 | 205.495 |
| Current President's Budget | 210.940 | 232.876 | 193.514 | 0.000 | 193.514 |
| Total Adjustments | -8.972 | 21.575 | -11.981 | 0.000 | -11.981 |
| • Congressional General Reductions | 0.000 | -0.425 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 22.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.625 | 0.000 | | | |
| • SBIR/STTR Transfer | -2.495 | 0.000 | | | |
| • Other Adjustments | -7.102 | 0.000 | -11.981 | 0.000 | -11.981 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 622002: *Electronic Component Technology* | | |
| Congressional Add: *Program increase - exploitation detection* | 8.898 | 5.000 |
| Congressional Add Subtotals for Project: 622002 | 8.898 | 5.000 |
| **Project:** 622003: *EO Sensors & Countermeasures Tech* | | |
| Congressional Add: *Low cost sensors for small unmanned vehicles* | 0.000 | 5.000 |
| Congressional Add: *Additive manufacturing for electronics* | 0.000 | 6.000 |
| Congressional Add Subtotals for Project: 622003 | 0.000 | 11.000 |
| **Project:** 622005: *Cyber Technology* | | |
| Congressional Add: *Cyber assurance and assessment of electronic hardware systems* | 0.000 | 6.000 |
| Congressional Add Subtotals for Project: 622005 | 0.000 | 6.000 |
| **Project:** 627622: *RF Sensors and Countermeasures Tech* | | |
| Congressional Add: *Program increase - RF spectrum situational awareness* | 7.909 | 0.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add Subtotals for Project: 627622 | 7.909 | 0.000 |
| Congressional Add Totals for all Projects | 16.807 | 22.000 |

**Change Summary Explanation**

FY 2020 Other Adjustments: Decrease of 7.102 million due to Air Force reprogramming.

FY 2022: Decrease of $11.981 million due to DAF higher priorities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>622002 / *Electronic Component Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622002: *Electronic Component Technology* | - | 52.667 | 55.327 | 35.772 | 0.000 | 35.772 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project focuses on electronics and optoelectronics technologies that generate, control, receive, and process electromagnetic spectrum for aerospace sensor and electronic warfare (EW) applications. The enabling technologies developed under this project will be used for intelligence, surveillance, reconnaissance, electronic warfare, battlespace access, and precision engagement capabilities. The technologies developed include exploratory electronic and optoelectronic devices, components, microsystems and subsystems.

This project also assesses designs, develops, fabricates, and demonstrates the associated technologies for integrating combinations of these component technologies. The project demonstrates significantly smaller size, lower weight, lower cost, lower power dissipation, higher reliability, trustworthiness and improved performance. The device and subsystem technology developments under this project are military unique; they are based on Air Force and other Department of Defense weapon systems requirements in the areas of radar, communications, electronic warfare, positioning, navigation, timing, and smart weapons.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Sensor Subsystems | 8.108 | 9.060 | 7.012 |
| ***Description:*** Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function subsystems for aerospace sensors.<br><br>***FY 2021 Plans:***<br>Complete development of direction finding subsystem prototypes for attritable systems. Complete research for highly miniaturized and power-efficient on-board sensor processing. Continue low cost electro-optical/infrared sensor subsystem development. Initiate research into autonomous low size, weight and power sensor processing. Initiate research into digital at every element technology for multifunction microwave and millimeter wave arrays.<br><br>***FY 2022 Plans:***<br>Complete low cost electro-optical/infrared sensor subsystem development. Continue research into autonomous low size, weight and power sensor processing. Continue research into digital at every element technology for multifunction microwave and millimeter wave arrays. Initiate development of low size weight and power wideband multifunction RF sensor subsystem suitable for Group 4 unmanned aircraft system operation.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.048 million. Decrease is due to decreased emphasis in sensor subsystems. | | | |
| ***Title:*** Electronic Devices | 7.185 | 8.769 | 5.893 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622002 / *Electronic Component Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Assess, research, develop, demonstrate and transition revolutionary and evolutionary electronic devices and their associate technologies.<br><br>***FY 2021 Plans:***<br>Complete wide-bandgap device technology proof of concept for power generation and management. Continue advanced wide band-gap model development for multi-use applications. Continue novel wide-band gap switch integration with millimeter-wave transistor development. Initiate development of integrated chip-level radio frequency devices and power conversion modeling and wide bandgap device and power conversion integration technologies.<br><br>***FY 2022 Plans:***<br>Complete advanced wide band-gap model development for multi-use applications. Complete initial demonstration of novel wide-band gap switch integration with millimeter-wave transistor development. Continue development of integrated chip-level radio frequency device and power conversion modeling. Continue development of wide bandgap device and power conversion integration technologies. Initiate prototype demonstration of high efficiency microwave power modules with integrated high speed power conversion switching.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 2.876 million. Decrease is due to decreased emphasis in electronic devices. | | | |
| ***Title:*** Electro-Optical/Infrared (EO/IR) Components | 8.395 | 8.930 | 6.069 |
| ***Description:*** Research, develop, demonstrate and transition electro-optical/infrared (EO/IR) components for next generation intelligence, surveillance, reconnaissance (ISR) and countermeasures.<br><br>***FY 2021 Plans:***<br>Complete initial evaluation of innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Complete compact, tunable, laser source prototype. Continue advanced avalanche photo-diode based focal plane array development. Initiate photonic and quantum substructure technology development. Initiate research into non-linear devices for tunablity and power scaling.<br><br>***FY 2022 Plans:***<br>Complete advanced avalanche photo-diode based focal plane array development. Continue photonic and quantum substructure technology development. Continue research into non-linear devices for tunablity and power scaling. Initiate development of high power, narrow line width lasers sources for advanced sensing and countermeasure applications.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622002 / *Electronic Component Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $2.861 million. Decrease is due to realignment of funding to Project 622002, Electronic Component Technology, Microelectronics & Embedded System Assurance effort. | | | |
| ***Title:*** Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Mission Systems<br><br>***Description:*** Investigate and develop designs of trusted electronic and optoelectronic systems when integrating commercially available solutions with emerging government-off-the-shelf advanced technologies. Areas of development include: multi-function radio frequency and electro-optical subsystems, advanced electronic and optoelectronic materials, on-board sensor processing, high-frequency power modules, electro-optical/infrared sources, electro-optical/infrared detectors, beam control and waveguides, and trusted and reliable electronics.<br><br>***FY 2021 Plans:***<br>Complete initial investigations of trust in design and trust in fabrication. Continue studies of modeling and simulation capability to improve predictive capability of mission assurance for highly integrated microsystems, devices, and materials. Continue development of prototype trustworthiness assessment capability. Continue reliability assessments of advanced heterogeneously integrated microsystems. Continue investigations of trust technologies and techniques in sensors and sensor systems to deter reverse engineering and exploitation of critical hardware and software technology and impede unwanted technology transfer, alteration of system capability, and prevent the development of countermeasures to our systems. Initiate the development of processes and techniques for trust through design. Initiate investigations of security verification techniques and methodologies for integrated circuit designs.<br><br>***FY 2022 Plans:***<br>Mature trust in design and trust in fabrication. Continue studies of modeling and simulation capability to improve predictive capability of mission assurance for highly integrated microsystems, devices, and materials. Advance development of prototype trustworthiness assessment capability. Continue reliability assessments of advanced heterogeneously integrated microsystems. Continue the development of processes and techniques for trust through design. Continue verification and validation of security techniques and methodologies for integrated circuit designs.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $8.529 million. Decrease is due to realignment of funding to Project 622002, Electronic Component Technology, Microelectronics & Embedded System Assurance effort. | 13.449 | 15.575 | 7.046 |
| ***Title:*** Advanced Highly Integrated Microsystems for Intelligence, Surveillance, Reconnaissance and Electronic Warfare<br><br>***Description:*** Perform research and development of electronic and photonic circuit and microsystem technologies focused on miniaturization, power reduction, reconfigurability and reduced cost.<br><br>***FY 2021 Plans:*** | 6.632 | 7.993 | 5.592 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622002 / *Electronic Component Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Complete assessment of military relevant heterogeneous integration technologies. Complete development of additive techniques for advanced electronic subsystems. Initiate development of next generation reconfigurable transceiver prototype. Continue development of photonically enabled electronic intelligence subsystem. Continue development of photonic antenna remoting concept. Continue development of integrated and adaptable transceiver microsystems. Initiate development of microsystem integration solutions that integrate advanced components and thermal management technologies for cost, size, weight and power constrained microwave and millimeter wave applications.<br>***FY 2022 Plans:***<br>Complete development of photonically enabled electronic intelligence subsystem. Complete development of photonic antenna remoting concept. Complete development of integrated and adaptable transceiver microsystems. Continue development of next generation reconfigurable transceiver prototype. Continue development of microsystem integration solutions that integrate advanced components and thermal management technologies for cost, size, weight and power constrained microwave and millimeter wave applications. Initiate development of chip-scale photonic/electronic wideband transceiver components.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 2.401 million. Decrease is due to decreased emphasis in microsystems. | | | |
| ***Title:*** Microelectronics & Embedded System Assurance<br>***Description:*** Investigate and develop microelectronics security technologies to impede unwanted technology transfer and enable timely adoption of commercial and government-off-the-shelf microelectronic technologies that enable revolutionary capabilities for the Air Force.<br>***FY 2021 Plans:***<br>Not applicable<br>***FY 2022 Plans:***<br>Investigate trust technologies and techniques in sensors and sensor systems to deter reverse engineering and exploitation of critical hardware and software technology and impede unwanted technology transfer, alteration of system capability, and prevent the development of countermeasures to our systems.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.160 million. Increase is a result of realignment of funding from Project 622002, Electronic Component Technology, Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Mission Systems effort. | 0.000 | 0.000 | 4.160 |
| **Accomplishments/Planned Programs Subtotals** | 43.769 | 50.327 | 35.772 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622002 / *Electronic Component Technology* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - exploitation detection | 8.898 | 5.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressional directed efforts | | |
| ***FY 2021 Plans:*** Conduct Congressional directed efforts | | |
| **Congressional Adds Subtotals** | 8.898 | 5.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>622003 / *EO Sensors & Countermeasures Tech* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622003: *EO Sensors & Countermeasures Tech* | - | 30.934 | 45.638 | 24.725 | 0.000 | 24.725 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project determines the technical feasibility of advanced electro-optical aerospace sensor technologies for a variety of offensive and defensive uses. The sensor technologies under development range from the ultraviolet through the infrared portion of the spectrum. Related efforts include improvements in avionics integration, digital processing, analysis tools, and sensor architectures. One of the project's goals is to improve electro-optical and related technologies for the detection, tracking, and identification of non-cooperative and difficult targets, such as those obscured by camouflage or acquired at great range. This project also develops the passive and active imaging sensors and algorithms needed to enable precision targeting in severe weather. These technologies are critical to future aerospace surveillance and targeting. Other project goals include advanced electro-optical threat warning and countermeasures.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Passive Electro-Optical/Infrared Sensing in Contested Environments | 15.529 | 18.396 | 12.411 |
| ***Description:*** Develop innovative passive optical sensing technology to support surveillance and reconnaissance in contested environments. Develop high performance focal planes, aperture technologies, sensing architectures, and imaging techniques capable of long range target detection and characterization for intelligence, surveillance, reconnaissance and air-to-air sensing. | | | |
| ***FY 2021 Plans:***<br>Conduct a flight test evaluation of the staring infrared search and track system against military relevant targets. Start development of a low-cost, low volume, real-time hyperspectral sensor and processor for attritable platforms including advanced machine learning algorithms to improve performance, speed and computational efficiency of hyperspectral detection. Complete analysis of active hyperspectral imaging demonstrations in preparation for transition. Initiate development of low-earth orbit sensing systems for critical Air Force needs. | | | |
| ***FY 2022 Plans:***<br>Conduct flight test evaluation of the staring infrared search and track system against military relevant targets. Complete flight testing of compact, low-cost, low volume, real-time hyperspectral sensor for attritable platforms in preparation for operational demonstration. Continue development of low-earth orbit sensing systems for critical Air Force needs, including event-based sensors and passive interferometry. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 5.985 million. Decrease is due to decreased emphasis in infrared sensing. | | | |
| ***Title:*** Laser Radar Sensing in Contested Environments | 15.405 | 16.242 | 12.314 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622003 / *EO Sensors & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop innovative laser sensing technology for non-cooperative identification of airborne and ground-based targets in contested environments. Develop optical spectrum transmitters, detectors and agile aperture technologies capable of sensing multiple target characteristics for robust non-cooperative target identification.<br><br>***FY 2021 Plans:***<br>Continue development of data processing algorithms for 3-dimension sensing and synthetic aperture lidar (laser radar). Continue to advance the state of the art in coherent lidar (digital holography) and non-mechanical beam steering for low-cost sensing applications. Continue development of Aided Target Recognition algorithms for 3-dimension laser radar. Investigate use of data from flight collection of the vibration sensor to advance aided target recognition algorithms using artificial intelligence and machine learning. Continue to make improvements on lidar modeling to include engagement level models for evaluating mission effectiveness of various laser radar systems.<br><br>***FY 2022 Plans:***<br>Continue refinement/improvement of laser radar model to improve performance predictions of ability to meet operational demands. Collect additional data from an airborne laser vibrometry system to feed artificial intelligence algorithms for positive target identification. Build small-scale demonstration to show feasibility of new small size, weight and power digital holography system. Complete evaluation of new detector technology for coherent laser radar. Conduct feasibility analysis for space base laser radar concept.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 3.928 million. Decrease is due to decreased emphasis in laser radar sensing. | | | |
| **Accomplishments/Planned Programs Subtotals** | 30.934 | 34.638 | 24.725 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Low cost sensors for small unmanned vehicles<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct congressional directed efforts | 0.000 | 5.000 |
| ***Congressional Add:*** Additive manufacturing for electronics<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressional directed efforts | 0.000 | 6.000 |
| **Congressional Adds Subtotals** | 0.000 | 11.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622003 / *EO Sensors & Countermeasures Tech* |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>622005 / *Cyber Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622005: *Cyber Technology* | - | 9.387 | 16.625 | 6.934 | 0.000 | 6.934 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project focuses on technologies for enabling agile and resilient Air Force mission systems. This project improves our understanding of cyber vulnerabilities of mission systems by investigating the fundamental nature of those vulnerabilities including: how they come about, how they can be discovered, how they can be quantified and categorized, how they can be exploited, and how they can be removed or mitigated to secure the system. This project develops adaptable and resilient hardware/software for real-time avionics cyber-attack pattern recognition and develop a protection system with the capability for autonomous learning, adaptation, and self-protection. This project investigates open architecture concepts and technologies to deliver capability flexibility to Air Force mission systems. These technologies are matured via integrated capability demonstrations.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Vulnerability Mitigation | 4.324 | 5.185 | 0.000 |
| ***Description:*** Apply knowledge from computer vulnerability discovery and computer security to investigate capabilities for identifying and mitigating vulnerabilities in United States mission systems resulting from software and/or hardware deficiencies. Develop automated and cost effective processes, techniques and technologies to assist in the identification of potential vulnerabilities.<br><br>***FY 2021 Plans:***<br>Complete assessing Test, Maintenance, and Acquisition community capability gaps of transitioned automated test tools. Start last round of new tools and technique refinements as required. Continue to work with other Services to demonstrate cyber resiliency capabilities on air, ground and sea platforms. Continue development of next generation mission systems architecture to design in agile and resilient capabilities. Perform initial flight demonstration of integrated Open Mission Systems architecture with next generation mission systems architecture.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 622005, Cyber Technology, Flexible and Secure Avionics effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $5.185 million. The decrease is due to the realignment of funding to Project 622005, Cyber Technology, Flexible and Secure Avionics effort. | | | |
| ***Title:*** Flexible and Secure Avionics | 5.063 | 5.440 | 6.934 |
| ***Description:*** Develop avionics protection tools and capabilities to enable manned and unmanned aircraft, avionics, and related support equipment to automatically adapt to and withstand cyber attacks. Research and develop tools, methodologies and architecture guidelines that enable the design of avionics systems with sense, learn and adapt capabilities. Support test, | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622005 / *Cyber Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| maintenance, and acquisition communities with cyber subject matter expertise and techniques through consultation and technical interchange. Support other Services with cyber resiliency capabilities for air, ground and sea platforms and develop Open Mission Systems architectures incorporating cyber protections and resilience technologies.<br><br>***FY 2021 Plans:***<br>Demonstrate initial capabilities for malware detection, diagnostics, and attack inferencing for mission systems. Continue research and develop real-time response mechanisms for cyber-attacks and software, firmware, and hardware diversity techniques to enable resilient cyber defense systems. Demonstrate automated test generation tools that expose malware embedded within mission critical software and firmware. Continue to investigate protection methodologies and open system architecture standards and approaches to improve agility and resiliency of legacy and next-generation mission systems architectures.<br>***FY 2022 Plans:***<br>Perform flight test and demonstrations in operationally relevant capabilities for malware detection, diagnostics, and attack inferencing for mission systems. Continue research and develop real-time response mechanisms for cyber-attacks and software, firmware, and hardware diversity techniques to enable resilient cyber defense systems. Mature laboratory demonstrations of automated test generation tools to expose malware embedded within mission critical software and firmware. Continue to investigate protection methodologies and open system architecture standards and approaches to improve agility and resiliency of legacy and next-generation mission systems architectures. Perform laboratory and flight demonstrations on flight worthy hardware. Share expertise with other Services and Test, Maintenance, and Acquisition communities.<br><br>In FY 2022 this effort was renamed from Agile Mission Systems Protections to Flexible and Secure Avionics.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.494 million. The increase is due to realignment of funding from Project 622005, Cyber Technology, Vulnerability Mitigation effort. | | | |
| **Accomplishments/Planned Programs Subtotals** | 9.387 | 10.625 | 6.934 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Cyber assurance and assessment of electronic hardware systems | 0.000 | 6.000 |
| ***FY 2020 Accomplishments:*** Not applicable | | |
| ***FY 2021 Plans:*** Conduct Congressional directed efforts | | |
| **Congressional Adds Subtotals** | 0.000 | 6.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>622005 / *Cyber Technology* |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>624920 / *Electronic Warfare Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624920: *Electronic Warfare Technology* | - | 34.795 | 44.749 | 45.347 | 0.000 | 45.347 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops and assesses affordable, reliable, all weather radio frequency countermeasure concepts for aerospace applications covering the range of radio frequency sensors including communications, navigation, intelligence, surveillance and reconnaissance (ISR), and radar, both active and passive, across the air, land, sea, space and cyber domains. It develops and evaluates technology for electronic warfare, integrated radar and electronic warfare systems, and electro-optical/ infrared seeker defeat. This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. The project also explores technologies to maintain a military advantage in positioning, navigation and timing integrity, accuracy, and resiliency as well as on aircraft mission assurance - the protection of airborne platforms, manned and unmanned, in contested environments. The ultimate goal of the project is to ensure unrestricted access to the airspace and the electromagnetic spectrum in contested and congested environments.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Positioning, Navigation and Timing in Contested/Denied Environments | 9.663 | 12.446 | 14.415 |
| ***Description:*** Develop resilient position, navigation and timing sensors. Explore position, navigation and timing solutions to enable novel distributed radio frequency sensing and countermeasure techniques. Develop technology base to provide solutions addressing navigation and timing threats. | | | |
| ***FY 2021 Plans:***<br>Continue research on navigation sensor integration, modeling, and simulation to incorporate open architecture attributes. Continue alternative navigation, bandwidth efficient communications for navigation, and timing technologies research. Continue exploring technologies to support precise time and time transfer with airborne platforms to enable coherent sensing (intelligence, surveillance, reconnaissance) and effects (electromagnetic warfare). Begin to develop the requirements for a prototype communications receiver to provide a connected solution for time, frequency, velocity and position data transfer. Continue development of trust techniques to enable military use of global navigational satellite systems. Continue modeling and simulation studies to address the multi-spectrum threats to satellite navigation systems. | | | |
| ***FY 2022 Plans:***<br>Continue the exploration of position, navigation and timing alternatives to satellite navigation, such as RF signals of opportunity, magnetic, and vision aiding of inertial navigation systems. Prototype technologies to support airborne precise time, frequency, velocity and position as well as transfer between platforms to enable coherent sensing (intelligence, surveillance, reconnaissance) and effects (electromagnetic warfare). Demonstrate prototype trust techniques to enable military use of foreign satellite navigation signals. Develop software defined antenna electronics to complement software defined navigation receiver efforts, and explore | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>624920 / *Electronic Warfare Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| advanced algorithms for software defined navigation. Begin to develop the requirements for a prototype communications receiver to provide a connected solution for time, frequency, velocity and position data transfer.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 1.969 million. Funding increased due to realignment from PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, Resilient Positioning, Navigation and Timing effort. | | | |
| ***Title:*** Radio Frequency Electronic Warfare Technologies<br><br>***Description:*** This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. This project develops techniques and technologies to detect and counter the communications links and sensors of threat integrated air defense systems and hostile command and control networks.<br><br>***FY 2021 Plans:***<br>Continue research to demonstrate electronic warfare technologies that can reason about threat capabilities and intentions and the electromagnetic environment to synthesize an optimized response in a time frame to support aircraft survivability against adaptive and agile threats. Conduct technology maturation demonstrations to showcase improved performance. Continue the demonstration of robust modeling, simulation, and assessment capability to study the efficiency versus effectiveness of electronic support and electronic attack capabilities, including distributed electronic warfare assets and cognitive/autonomous technologies, against complex threat emitters in integrated air defense systems and in complex electromagnetic spectrum background environments. Start experimentation with low cost and miniaturized electronic attack assets. Conduct demonstration of distributed and robust techniques that are delivered through digital at the aperture jammers. Continue incorporation of electro-optical and radio frequency integrated engagement model development to meet multispectrum threats.<br><br>***FY 2022 Plans:***<br>Continue research to develop electronic warfare technologies that can reason about threat capabilities and intentions and the electromagnetic environment to synthesize an optimized response in a time frame to support aircraft survivability against adaptive and agile threats. Continue the demonstration of robust modeling, simulation, and assessment capability to determine the efficiency versus effectiveness of emerging electronic support and electronic attack technologies, in complex electromagnetic spectrum background environments with hardware in the loop. Continue to develop and demonstrate distributed electronic warfare techniques to defeat integrated air defense systems. Continue integration of electro-optical and radio frequency engagement model development and experimentation to develop strategies to counter multispectrum threats to airborne platforms.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 17.631 | 22.759 | 20.741 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>624920 / *Electronic Warfare Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $2.018 million. Decrease is due to realignment of funding to Project 624920, Electronic Warfare Technology, Positioning, Navigation and Timing in Contested/Denied Environments effort and Electro-Optical/ Infrared Threat Warning and Countermeasures Technologies effort. | | | |
| ***Title:*** Electro-Optical/Infrared Threat Warning and Countermeasures Technologies<br><br>***Description:*** Develop electro-optical/infrared sensor countermeasure technologies. Explore novel concepts to enable electro-optical/infrared threat seeker exploitation and surrogate modeling. Conduct fundamental research in countermeasures to defeat electro-optical/infrared threat seekers. Conduct fundamental research on integrated electro-optical/infrared threat warning systems.<br><br>***FY 2021 Plans:***<br>Continue threat characterization and countermeasures techniques development against new infrared guided threats. Evaluate advanced threat surrogates during infrared countermeasure testing at several test ranges. Begin laboratory and field testing of new low-cost missile warning sensor and evaluate upgrades to Large Aircraft Infrared Counter-Measure program missile warning and countermeasures sensors. Continue to investigate long-range missile and laser warning technology concepts. Continue development of electro-optical and radio frequency integrated engagement models into the Advanced Framework for Simulation, Integration and Modeling environment to meet multispectrum threats. Start test of novel countermeasure techniques against advanced threats.<br><br>***FY 2022 Plans:***<br>Continue threat characterization and development of countermeasures techniques to defeat emerging advanced electro-optical/ infrared guided threats to airborne platforms. Continue the development of advanced threat surrogates and conduct infrared countermeasure testing at test ranges. Continue to investigate long-range missile warning and laser warning technology concepts. Continue development of an advanced framework for modeling and simulation and hardware in the loop assessment with scene generation of engagements and techniques to defeat electro-optical and infrared guided threats to airborne platforms. Validate results using data collected in live fire tests.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 0.647 million. Justification for this increase is described in plans above. | 7.501 | 9.544 | 10.191 |
| **Accomplishments/Planned Programs Subtotals** | 34.795 | 44.749 | 45.347 |

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

N/A

**Remarks**

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>624920 / *Electronic Warfare Technology* |

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>626095 / *Sensor Fusion Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 626095: *Sensor Fusion Technology* | - | 27.577 | 35.716 | 28.984 | 0.000 | 28.984 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops foundational technologies required for closed-loop autonomous sensing employing multiple information domains, diverse sensor phenomena, and multiple platform types to provide intelligence, surveillance, and reconnaissance; target recognition; situational awareness and battlespace visualization; fire control; and battle damage assessment capabilities against a wide variety of targets engaged in multitudes of behaviors in a broad range of operational environments. This project conducts exploratory investigations to determine technology feasibility and estimate operational capability constraints associated with missions in future contested and highly contested operating environments, using cooperative and non-cooperative sensing sources. This project develops techniques to automate multi-sensor exploitation and information processing that leverage the data fusion, adaptive signal processing, and artificial intelligence / machine learning research communities. This project develops concepts and algorithms for efficient processing at the edge, parallel processing, distributed processing, and high-performance computing in sensor data processing and synthetic data generation.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Battlespace Awareness Sensing Fusion | 11.260 | 14.450 | 11.738 |
| ***Description:*** Continue to develop novel techniques for behavioral and physical knowledge generation from multiple sensors, intelligence sources, domains (Air, Space, Cyber) and sources to include algorithm development, assessment, and experiments across multiple distributed, homogeneous and heterogeneous sensors. This effort will focus on technology areas of data association, entity detect/track/identification, information fusion, training with limited data, and data/performance modeling. The application of machine learning techniques to address technical challenges in contested environments is a particular emphasis. | | | |
| ***FY 2021 Plans:***<br>Continue to develop capabilities for space-time alignment of multiple domain information sources. Continue to apply deep and machine learning techniques to the detection/tracking/identification of stationary and moving objects and systems, and for pattern of life understanding in a broader set of operating conditions. Start advance development in decision/feature-level fusion capabilities that will be applied to new multi-sensor exploitation for autonomy efforts. Continue to investigate fusion of hard and soft information sources for military relevant applications. Continue to design and evaluate neural network training techniques, to include blended measured-synthetic training, for deep and machine learning classifiers. | | | |
| ***FY 2022 Plans:***<br>Continue to generate knowledge through fusion of multiple spatial and temporal sensors to provide solutions for contested environments wherein data is extremely limited. Continue to apply deep and machine learning techniques to the detection/ tracking/targeting and recognition of stationary and moving objects and systems, and for pattern of life understanding in a broad set of sensing operating conditions. Advance the development in decision/feature and/or signal-level fusion capabilities | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>626095 / *Sensor Fusion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| that will be applied to new multi-sensor exploitation for autonomy efforts to include demonstration of four-dimensional change detection for intelligence, surveillance and reconnaissance applications. Continue to investigate fusion of hard and soft information sources for military relevant applications. Design and evaluate neural network training techniques, to include blended measured-synthetic training, for deep and machine learning classifiers to produce timely and autonomous intelligence, surveillance and reconnaissance, enhanced situational awareness and improved battlespace awareness with decision timelines inside the adversary's observe, orient, decide, act loop.<br><br>In FY 2022 this effort was renamed from Synthesis for Understanding to Battlespace Awareness Sensing Fusion.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 2.712 million. Decrease is due to decreased emphasis in sensing fusion. | | | |
| ***Title:*** Multi-Domain Sensing Effects and Analysis | 5.308 | 7.763 | 6.046 |
| ***Description:*** This effort will focus on two primary areas: (1) Multi domain sensing and effects mission analysis and (2) performance understanding and assessments. It will develop methodologies and modeling, simulation, and analysis tools to enable multi domain analysis and technology development, informing other efforts and projects across the directorate. Investments in modeling, simulation and analysis will represent current and next generation sensing platforms to include air, space, and cyber as well as the fusion of information amongst these three domains.<br><br>***FY 2021 Plans:***<br>Continue to leverage academic partnerships with respect to specific Air Force applications in modeling, simulation and analysis. Continue to design and build next generation correct fidelity performance models. Continue to develop operational vignettes to support Air Force technology investment understanding. Continue to support in-the-field data collections to verify and validate performance using measured sensor data. Start research efforts for effectively collecting, tagging, curating, and retrieving data for advanced sensing development. Start the development of representative scenarios for autonomy development.<br>***FY 2022 Plans:***<br>Develop new autonomy performance evaluation techniques adapted to specific artificial intelligence and machine learning challenges. Continue to perform empirical performance estimation for intelligence, surveillance, and reconnaissance automated sensing exploitation of military-critical targets with limited training data. Continue to mature sensor data as-a-service research environment by extending into classified networks and pursuing integration with other data science and research cloud environments further enabling sensing autonomy developers and warfighting analysts. Develop defense applications for new data tagging and automated availability architecture; assist transitions of this capability service-wide and to intelligence community partners. Transition test and evaluation harness software to department-wide performance analysis community; continue to standardize test metrics and performance understanding.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>626095 / *Sensor Fusion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by 1.717 million. Decrease is due to decreased emphasis in sensing effects. | | | |
| ***Title:*** Knowledge and Execution Management<br><br>***Description:*** Develop, evaluate, and demonstrate models for sensing and for adversary behavior that support anticipatory asset tasking, characterization of latencies and related uncertainties, and joint inference and control. Develop multisource sensing techniques providing environment characterization consistent with the needs of automated and autonomous systems.<br><br>***FY 2021 Plans:***<br>Continue development of mission resource management techniques for distributed sensing capabilities. Start the development of improving representational and computational efficiency of ground base and on-board reasoning and re-planning methods. Continue development of foundational management algorithms for situation awareness incorporating environment analysis, target detection, tracking and recognition, and operationally representative contingencies.<br><br>***FY 2022 Plans:***<br>Improve and integrate onboard mission resource management techniques for distributed sensing/effects capabilities via open autonomy architectures and continue experimentation via simulation, live, and blended sim/live testing (multiple aircraft & sensors). Continue improving representational and computational efficiency of on-board reasoning about ground targets and target groupings, and target behaviors. Continue development of foundational knowledge management algorithms for situation awareness incorporating interacting ground targets, environments, and operationally representative contingencies. Embrace new forms of reasoning and continue to evolve forms of representations and combined representations and reasoning approaches like self-querying synergistic knowledge graph / machine learning world models, more diverse state representations in reinforcement learning, and spiking neural network reinforcement learning.<br><br>In FY 2022 this effort was renamed from Multisource Knowledge Representation and Management to Knowledge and Execution Management.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $6.603 million. Decrease is due to realignment of funding to Project 626095, Sensor Fusion Technology, Cyber Physical Sensing effort. | 11.009 | 13.503 | 6.900 |
| ***Title:*** Cyber Physical Sensing<br><br>***Description:*** Cyber Physical Sensing is a new sensing opportunity area. This technology investment looks at the sensing opportunities which exist at the point where physics meets the cyber domain. This effort focuses on the proliferated sensing devices, extracting information from multi-INT sensors and translating that information into detection, tracking and identification by use of multi-INT fusion. This effort leverages processing at-the-edge and distributed processing to enable machine learning, artificial intelligence and deep learning techniques. | 0.000 | 0.000 | 4.300 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>626095 / *Sensor Fusion Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Not applicable<br>***FY 2022 Plans:***<br>Master real-world sensing physics between the adversary and devices uniquely available via the cyber domain. Develop and instrument empirical, multi domain research facilities to collect, demonstrate, and access cyber physical sensing in mission-relevant context. Research, develop, and transition processing and exploitation techniques with edge and core flexibilities on proliferated and distributed cyber physical platforms. Advance deployed warfighters tactics, techniques, and procedures through the use of exploited cyber physical modalities. Create unsolvable dilemmas for our adversaries by persistent, omniscient sensing of their physical state through cyber means.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.300 million. Increase is due to realignment of funding from Project 626095, Sensor Fusion Technology, Knowledge and Execution Management effort. | | | |
| **Accomplishments/Planned Programs Subtotals** | 27.577 | 35.716 | 28.984 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602204F / *Aerospace Sensors* | Project (Number/Name)<br>627622 / *RF Sensors and Countermeasures Tech* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 627622: *RF Sensors and Countermeasures Tech* | - | 55.580 | 34.821 | 51.752 | 0.000 | 51.752 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops and assesses affordable, reliable all weather radio frequency sensing and countermeasure concepts for aerospace applications covering the range of radio frequency sensors including communications, navigation, intelligence, surveillance and reconnaissance (ISR), and radar, both active and passive, across the air, land, sea, space and cyber domains. This project also develops and evaluates technology for intelligence, surveillance and reconnaissance sensors, fire control radars, electronic warfare, integrated radar and electronic warfare systems, and offensive information operations systems. It emphasizes the detection and tracking of surface and airborne targets with radio frequency signatures that are difficult to detect due to reduced radar cross sections, concealment and camouflage measures, severe clutter, or heavy jamming. Techniques exploited include the use of multiple radio frequency phenomenologies, multi-dimensional adaptive processing, advanced waveforms and knowledge-aided processing techniques. This project also develops concepts to counter threats to our aerospace systems. It develops and evaluates technology for electronic warfare, integrated radar and electronic warfare systems, and electro-optical/infrared seeker defeat. This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. The project also explores technologies to maintain a military advantage in positioning, navigation and timing integrity, accuracy, and resiliency.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Radio Frequency Sensor Technologies | 14.262 | 9.946 | 0.000 |
| ***Description:*** Conduct applied research and development for the advancement of passive and active radio frequency sensors; including phenomenology, modeling and simulation, algorithm development, and experimentation. Plan, execute, and maintain state-of-the-art radio frequency sensor research and development facilities. Conduct research on sensing, learning, and adapting to enable the countering of emerging adaptive, agile radio frequency threats. | | | |
| ***FY 2021 Plans:***<br>Complete analysis of ground-based data from passive illumination selection manager and initiate algorithm improvements. Start analysis of bistatic high resolution radar data in conjunction with advanced automated target recognition algorithms to demonstrate improved timeliness for combat identification of complex targets from bistatic radar systems. Initiate system integration and ground testing of low cost bistatic radar system for attritable/expendable platforms. Initiate integration of low cost data collection and signal processing backend to provide real-time processing for future airborne demonstration. | | | |
| ***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 627622, RF Sensors and Countermeasure Tech, Passive Radio Frequency Sensing effort and Distributed Radio Frequency Sensing effort. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>627622 / *RF Sensors and Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $9.946 million. Funding decreased due to realignment to Project 627622, RF Sensors and Countermeasures Tech, Passive Radio Frequency Sensing effort and Distributed Radio Frequency Sensing effort. | | | |
| ***Title:*** Multiband Multifunction Radio Frequency Sensing<br><br>***Description:*** Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks.<br><br>***FY 2021 Plans:***<br>Continue to employ adaptive, additively manufactured phased array demonstration by laboratory testing and performance validation of single subarray panel. Start fabricating and integrating multiple subarray panels designed for a Low Cost Attritable Aircraft Technology experimental platform. Start advanced mode development for multi-beam digital arrays, implementing more complex modes and advanced waveforms. Start integration of advanced digital signal processing techniques to demonstrate mode-switching and multi-function capability.<br><br>***FY 2022 Plans:***<br>Complete demonstration of electronic support measure/airborne moving target indicator/ground moving target indicator modes in ultra high frequency to S-band ground demonstrator. Continue advanced mode development for multi-beam digital arrays, implementing more complex modes and advanced waveforms. Continue investigation of advanced digital signal processing techniques to demonstrate mode-switching and multi-function capability. Initiate mode development for 2-18 GHz airborne digital array. Perform laboratory demonstration of millimeter wave digital beamforming array for command and control functionality. Continue demonstration of additive manufacturing techniques and use of COTS components to fabricate low-cost, wide bandwidth, scalable, and conformal phased array antennas for integration on unmanned sensing platforms such as the Low Cost Attritable Aircraft Technology XQ-58A experimental platform. Complete study of alternative digital backend technologies. Complete performance assessment of wideband digital arrays embedded on platforms. Initiate full wave analysis of sensor performance on large platforms.<br><br>In FY 2022 this effort was renamed from Multi-Band/Multi-Beam Technologies to Multiband Multifunction Radio Frequency Sensing.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $6.774 million. Increase is a result Department of the Air Force reprogramming. | 17.707 | 13.498 | 20.272 |
| ***Title:*** Sensor Resource Management<br><br>***Description:*** Develop technology to enable optimization of sensor resources in contested environments on own-ship and multi-ship in manned, unmanned and manned/unmanned teaming concepts. | 15.702 | 11.377 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>627622 / *RF Sensors and Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue development of sensor resource management within Defense Advanced Research Projects Agency Arrays at Commercial Timescales architecture, extending beyond basic array control to real-time implementation including latency effects on mission execution. Initiate implementation of sensor resource management concepts for passive multi-mode radar, providing coordination of system resources between electronic support, illumination selection manager and passive radar subsystems. Continue development of multi-ship sensor resource management techniques for optimizing distributed and multi-spectral sensing resources.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 627622, RF Sensors and Countermeasure Tech, Passive Radio Frequency Sensing effort and Distributed Radio Frequency Sensing effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $11.377 million. Funding decreased due to realignment of funding to Project 627622, RF Sensors and Countermeasures Tech, Passive Radio Frequency Sensing effort and Distributed Radio Frequency Sensing effort. | | | |
| ***Title:*** Passive Radio Frequency Sensing<br>***Description:*** Develop a system that performs traditional radar sensing modes through passive means. The research plan is designed to continue the development of the subsystems which make up the passive radar and to follow a spiral development path that involves the integration and testing of various technology instantiations to produce alternate versions of a full passive multi-mode system. Includes the development of low size-weight-and-power radio frequency signal detection and geolocation payloads for small unmanned air systems and the integration of advanced receiver subsystems to meet a particular need of the Air Force. Explore combat identification technologies, modeling and simulation enhancements, and technologies supporting passive radar, electronic support, and signals intelligence.<br>***FY 2021 Plans:***<br>For FY 2021 and prior, this work is performed under Project 627622, RF Sensors and Countermeasures Tech, Radio Frequency Sensor Technologies effort, Sensor Resource Management effort, and Multiband Multifunction Radio Frequency Sensing effort.<br>***FY 2022 Plans:***<br>Continue development of low cost, size, weight and power direction finding payloads and geolocation techniques. Continue integration onto attritable unmanned air systems to improve radio frequency situational awareness for advanced battle management system applications. Initiate development of advanced processing techniques for onboard signal characterization, geolocation/track, and signals pattern-of-life analysis. Continue integration of bi- and multi-static radar clutter models into high | 0.000 | 0.000 | 11.554 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>627622 / *RF Sensors and Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| fidelity radar system models for evaluation of advanced passive radar performance in complex environments. Continue analysis of bi-static target/ground scattering phenomenology to improve combat identification of ground targets from bi-static/multi-static radar systems. Continue analysis of bi-static high resolution radar data in conjunction with advanced automated target recognition algorithms to demonstrate improved timeliness for combat identification of complex targets from bi-static radar systems.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $11.554 million. Funding increased due to realignment of funding from Project 627622, RF Sensors and Countermeasures Tech, Radio Frequency Sensor Technologies effort and Sensor Resource Management effort. | | | |
| ***Title:*** Distributed Radio Frequency Sensing<br>***Description:*** Develop innovative, timely, and affordable target detection, tracking, and characterization (namely imaging/ identification) capabilities that leverage two or more spatially-distributed receivers and transmitters that use cooperative radio frequency transmitters (illuminators), namely those radio frequency sources that have a common objective to the receiver systems being used.<br>***FY 2021 Plans:***<br>For FY 2021 and prior, this work is performed under Project 627622, RF Sensors and Countermeasures Tech, Radio Frequency Sensor Technologies effort, Sensor Resource Management effort, and Multiband Multifunction Radio Frequency Sensing effort.<br>***FY 2022 Plans:***<br>Continue development of robust multi-static transmit waveforms and receive processing chains for operationally relevant multi-static ground moving target indicator systems. Continue development of clutter mitigation techniques for multi-channel distributed sensor systems to detect slow-moving targets in denied environments. Continue advancement of multi-static synthetic aperture radar algorithms to improve operation in complex environments. Complete study of imaging alternatives for low signal-to-noise environments. Initiate assessments of multi-static synthetic aperture radar algorithms to support combat identification and automatic target recognition requirements on tactical timelines. Initiate implementation and demonstration of multi-static synthetic aperture radar algorithms on low cost, size, weight and power platforms. Continue data collection and analysis to assess performance of distributed radar systems for ground moving target indicator and synthetic aperture radar modes.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $19.926 million. Funding increased due to realignment from Project 627622, RF Sensors and Countermeasures Tech, Radio Frequency Sensor Technologies effort and Sensor Resource Management effort. | 0.000 | 0.000 | 19.926 |
| **Accomplishments/Planned Programs Subtotals** | 47.671 | 34.821 | 51.752 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602204F / *Aerospace Sensors* | **Project (Number/Name)**<br>627622 / *RF Sensors and Countermeasures Tech* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - RF spectrum situational awareness | 7.909 | 0.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressional directed efforts | | |
| ***FY 2021 Plans:*** Not applicable | | |
| **Congressional Adds Subtotals** | 7.909 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602212F / *Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)* | | | | | | | |
| **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 | - | 100.519 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 622030: *Defense Lab R&D Projects* | - | 100.519 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

Implementation of 10 U.S.C. Section 2363, amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B), to fund: innovative basic and applied research conducted at the defense laboratory and supports military missions; development programs supporting the transition of technologies developed by the defense laboratory into operational use; workforce development activities improving the capacity of the defense laboratory to recruit and retain personnel with necessary scientific and engineering expertise that support military missions; and the repair or minor military construction of the laboratory infrastructure and equipment.

The Air Force is dependent on technological advances in response to emerging threats and to maintain a competitive advantage. Air Force has a comprehensive and deliberative planning process to identify and fund research that is expected to have the greatest benefit to the Air Force and the warfighter. 10 U.S.C. Section 2363 provides the Commander of the Air Force Research Laboratory (AFRL), in consultation with the Air Force Science and Technology (S&T) Executive, a degree of flexibility to rapidly exploit scientific breakthroughs or respond to emerging threats, to include developing a skilled workforce and necessary infrastructure. This flexibility increases the rate of innovation and accelerates the development and fielding of needed military capabilities to address current and future problems.

The Air Force has established PE 0602212F, where the 10 U.S.C. Section 2363 funds are internally reprogrammed to this program element in the year of execution after receipt of the appropriation. This allows increased transparency to Congress on 10 U.S.C. Section 2363 funding and additional execution flexibility for 10 U.S.C. Section 2363 activities to cross all technology areas.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602212F / *Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 100.519 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | 100.519 | 0.000 | 0.000 | 0.000 | 0.000 |
| • Congressional General Reductions | 0.000 | 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 | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | 0.000 | 0.000 | | | |
| • Other Adjustments | 100.519 | 0.000 | 0.000 | 0.000 | 0.000 |

**Change Summary Explanation**

Increase in FY 2020 in Other Adjustments is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2358, as amended by 10 U.S.C. 2805(d)(1)(B) and 10 U.S.C. Section 2363.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Defense Laboratories R&D Projects - Air Force Research Laboratory | 100.519 | 0.000 | 0.000 |
| ***Description:*** Implementation of 10 U.S.C. Section 2363, amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B), to fund: innovative basic and applied research conducted at the Air Force Research Laboratory (AFRL) and supports military missions; development programs supporting the transition of technologies developed by AFRL into operational use; workforce development activities improving the capacity of AFRL to recruit and retain personnel with necessary scientific and engineering expertise that support military missions; and the repair or minor military construction of the laboratory infrastructure and equipment.<br><br>***FY 2021 Plans:***<br>None<br><br>***FY 2022 Plans:***<br>N/A | | | |
| **Accomplishments/Planned Programs Subtotals** | 100.519 | 0.000 | 0.000 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602212F / *Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)* |

**D. Other Program Funding Summary ($ in Millions)**

**Remarks**

**E. Acquisition Strategy**

Not Applicable

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602298F / *Science and Technology Management - Major Headquarters Activities* |

| 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 | - | 8.346 | 8.910 | 8.891 | 0.000 | 8.891 | - | - | - | - | - | - |
| 622520: *Science and Technology Management - Major HQ* | - | 8.346 | 8.910 | 8.891 | 0.000 | 8.891 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The Air Force Research Laboratory (AFRL) is a global technical enterprise, boasting some of the best and brightest leaders in the world. It provides revolutionary, relevant, and responsive science and technology (S&T) to the Warfighter. AFRL's mission is to lead the discovery, development, and integration of affordable warfighting technologies for the global air, space, and cyberspace force.

This program element includes necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, and 1206601SF.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 7.968 | 8.926 | 8.526 | 0.000 | 8.526 |
| Current President's Budget | 8.346 | 8.910 | 8.891 | 0.000 | 8.891 |
| Total Adjustments | 0.378 | -0.016 | 0.365 | 0.000 | 0.365 |
| • Congressional General Reductions | 0.000 | 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 | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | 0.000 | 0.000 | | | |
| • Other Adjustments | 0.378 | -0.016 | 0.365 | 0.000 | 0.365 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602298F / *Science and Technology Management - Major Headquarters Activities* | Project (Number/Name)<br>622520 / *Science and Technology Management - Major HQ* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622520: *Science and Technology Management - Major HQ* | - | 8.346 | 8.910 | 8.891 | 0.000 | 8.891 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The Air Force Research Laboratory (AFRL) is a global technical enterprise, boasting some of the best and brightest leaders in the world. It provides revolutionary, relevant, and responsive science and technology (S&T) to the Warfighter. AFRL's mission is to lead the discovery, development, and integration of affordable warfighting technologies for the global air, space, and cyberspace force.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** AFRL - Major Headquarters Activities | 8.346 | 8.910 | 8.891 |
| ***Description:*** Provide professional government civilian workforce in support of all AFRL programs and activities.<br><br>***FY 2021 Plans:***<br>Continue to provide professional government civilian workforce in support of all AFRL programs and activities.<br><br>***FY 2022 Plans:***<br>Continue to provide professional government civilian workforce in support of all AFRL programs and activities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding decreased compared to FY 2021 by $0.019. Funding decrease due to civilian pay reprice adjustments. | | | |
| **Accomplishments/Planned Programs Subtotals** | 8.346 | 8.910 | 8.891 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602602F / *Conventional Munitions* | | | | | | | |
| **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 | - | 132.090 | 127.193 | 151.757 | 0.000 | 151.757 | - | - | - | - | - | - |
| 622068: *Advanced Guidance Technology* | - | 75.300 | 73.016 | 101.070 | 0.000 | 101.070 | - | - | - | - | - | - |
| 622502: *Ordnance Technology* | - | 56.790 | 54.177 | 50.687 | 0.000 | 50.687 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program investigates, develops, and establishes the technical feasibility and military utility of guidance and ordnance technologies for conventional air-launched munitions. The effort supports core technical competencies of fuze technology; energetic materials; damage mechanisms; munitions aerodynamics, guidance, navigation, and control; terminal seeker sciences; and munition systems effects. Technologies to be developed include blast, fragmentation, penetrating and low-collateral-damage warheads, hard-target fuzing, precise terminal guidance, and high-performance and insensitive explosives.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602605F, 0602788F, 1206601SF, and 0602298F.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| **B. Program Change Summary ($ in Millions)** | **FY 2020** | **FY 2021** | **FY 2022 Base** | **FY 2022 OCO** | **FY 2022 Total** |
|---|---|---|---|---|---|
| Previous President's Budget | 142.772 | 132.425 | 147.652 | 0.000 | 147.652 |
| Current President's Budget | 132.090 | 127.193 | 151.757 | 0.000 | 151.757 |
| Total Adjustments | -10.682 | -5.232 | 4.105 | 0.000 | 4.105 |
| • Congressional General Reductions | 0.000 | -0.232 | | | |
| • Congressional Directed Reductions | 0.000 | -5.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.324 | 0.000 | | | |
| • SBIR/STTR Transfer | -3.762 | 0.000 | | | |
| • Other Adjustments | -7.244 | 0.000 | 4.105 | 0.000 | 4.105 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602602F / *Conventional Munitions* | Project (Number/Name)<br>622068 / *Advanced Guidance Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622068: *Advanced Guidance Technology* | - | 75.300 | 73.016 | 101.070 | 0.000 | 101.070 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project investigates, develops, and evaluates conventional munitions guidance technologies to establish technical feasibility and military utility of innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation. Project payoffs include adverse-weather, Global Positioning System (GPS)-degraded and Global Positioning System-denied, networked, and autonomous precision munition guidance capability; increased number of kills per sortie; increased aerospace vehicle survivability; improved weapon reliability and affordability; and improved weapon survivability and effectiveness.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Seeker Technologies | 8.216 | 13.790 | 23.921 |

***Description:*** Develops seeker technologies for air-delivered munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.

***FY 2021 Plans:***

Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons into the kill chain to enable distributive, flexible seeker targeting with or without an operator in the loop. Continue development and testing of innovative engagements for fifth generation aircraft and beyond. Continue materials research efforts on radomes and apertures, to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to explore specific techniques for seeker cost reduction with performance improvement such as sparse sensing and compressive sensing. Continue research on integrated processing techniques to enable networked systems. Continue multi-function radio frequency technique development to enable coherent multi-weapon operation. Further development of Open Seeker Architecture with extended view to integrate into weapon mission computer to enable cooperative weapon operation. Continue integration of the Open Seeker architecture into the Weapon Open System Architecture and evaluate the impact with respect to cyber vulnerability. Continue to develop and demonstrate coherent collaborative radio frequency seeker operation.

***FY 2022 Plans:***

Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622068 / *Advanced Guidance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| into the kill chain to enable distributive, flexible seeker targeting with or without an operator in the loop. Continue development and testing of innovative engagements for fifth generation aircraft and beyond. Continue materials research efforts on radomes and apertures to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker sub-systems. Continue to explore specific techniques for seeker cost reduction with performance improvement such as sparse sensing and compressive sensing. Continue research on integrated processing techniques to enable networked systems. Continue multi-function radio frequency technique development to enable coherent multi-weapon operation. Continue to develop Open Seeker Architecture with extended view and continue integration into weapon mission computer to enable cooperative weapon operation. Continue open seeker architecture integration into the weapon open system architecture and evaluate the impact with respect to cyber vulnerability. Continue to develop and demonstrate coherent collaborative radio frequency seeker operation.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $10.131 million. Funding increased due to additional emphasis on seeker development for contested engagement settings with cluttered backgrounds to support convergence effects for precision weapon delivery. | | | |
| ***Title:*** Aerodynamics, Navigation, and Control Technologies | 27.076 | 34.941 | 41.770 |
| ***Description:*** Develops weapon aerodynamic control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.<br><br>***FY 2021 Plans:***<br>Continue execution of Global Positioning System denied navigation demonstration programs. Initiate cooperative weapon swarming playbooks, demonstrating autonomous and collaborative behaviors, with various legacy weapon systems. Continue experiments demonstrating precision navigation, emphasizing cruise missile, form-factored optics and tracker for celestial aided navigation at supersonic cruise missile speeds and trajectory. Continue flight testing of articulating head missile at supersonic speeds at full scale. Continue flight demonstration on heterogeneous capability integrating kinetic swarm plays with electronic attack swarm plays. Continue flight demonstration of network aided navigation autonomy playbook. Continue flight demonstration of high-speed, high-performance weaponized quadrotor in a complex environment. Continue to use machine learning of a visual servo; learn servo commands from drone pilots using front looking camera.<br>***FY 2022 Plans:***<br>Continue novel position, navigation and timing technology development for global positioning system denied environments with intent to insert into demonstration programs. Continue to investigate cooperative, autonomous, and collaborative weapon behaviors to develop robust algorithms and swarming playbooks. Continue experiments demonstrating precision navigation, emphasizing cruise missile, form-factored optics and tracker for celestial aided navigation at supersonic cruise missile speeds and | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622068 / *Advanced Guidance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| trajectory. Continue flight testing of articulating head missile at supersonic speeds at full scale. Completed flight demonstration of heterogeneous collaborative capability which integrated kinetic swarm plays with electronic attack swarm plays. Initiate new phase of kinetic and electronic attack swarm plays incorporating cyber domain, electric warfare, and kinetic effects. Continue flight demonstration of network aided navigation autonomy playbook. Continue flight demonstration of high-speed, high-performance weaponized quadrotor in a complex environment in support of autonomy tactics development and maturation. Complete machine learning of visual servos. Initiate machine learning to develop tactics for multi-weapon engagements.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $6.829 million. Funding increased due to increased emphasis on alternate navigation technologies. | | | |
| ***Title:*** Guidance Technologies | 20.342 | 24.285 | 35.379 |
| ***Description:*** Develops guidance subsystem integration and evaluation technologies to provide open and closed-loop ground testing, flight test risk reduction, and digital simulation of novel concepts.<br><br>***FY 2021 Plans:***<br>Continue low-cost cruise missile demonstration of critical behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Further improve constructive and virtual analysis tools for design, development, and analysis of advanced low cost cruise missile concepts in representative environments. Continue engagement level analysis on hypersonic and air-to-air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to improve simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to add additional targets and improved terrain resolution to radar/millimeter wave/infrared/ ultraviolet signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue development of hypersonic hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Initiate simulator upgrades to accommodate resolution requirements for navigation quality synthetic aperture radar target and background modeling. Continue development of infrared light emitting diode infrared target simulator technology to create higher framerate and higher resolution target simulator technology. Continue providing multi-security level, cross-domain distributed modeling and simulation support for munition research and development using distributed connectivity between multiple Eglin Air Force Base facilities. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force Simulator. Initiate hardware-in-the-loop activities in support of international cooperative research efforts. Complete hardware-in-the-loop facility expansion by adding optics lab for infrared target simulator development.<br>***FY 2022 Plans:***<br>Continue low-cost cruise missile demonstration of critical behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Continue to improve constructive and virtual analysis tools for design, development, and | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622068 / *Advanced Guidance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| analysis of advanced low-cost cruise missile concepts in representative environments. Continue engagement level analysis on hypersonic and air-to-air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to improve simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to add additional targets and improved terrain resolution to radar, millimeter wave, infrared, and ultraviolet signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue development of hypersonic hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Complete simulator upgrades to accommodate resolution requirements for navigation quality synthetic aperture radar target and background modeling. Continue development of infrared light emitting diode target simulator technology to create higher frame rate and higher resolution target simulator technology. Continue providing weapon oriented multi-security level, cross-domain distributed modeling and simulation support using distributed connectivity between Eglin Air Force Base facilities and other geographic locations. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force Simulator. Continue hardware-in-the-loop activities in support of international cooperative research efforts.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $11.094 million. Funding increased due to additional emphasis on guidance and seeker modeling activities. | | | |
| ***Title:*** Future AF Capabilities Applied Research | 19.666 | 0.000 | 0.000 |
| ***Description:*** Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/ unconventional weapons).<br><br>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.<br>***FY 2021 Plans:***<br>Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622068 / *Advanced Guidance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable. | | | |
| **Accomplishments/Planned Programs Subtotals** | 75.300 | 73.016 | 101.070 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602602F / *Conventional Munitions* | Project (Number/Name)<br>622502 / *Ordnance Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 622502: *Ordnance Technology* | - | 56.790 | 54.177 | 50.687 | 0.000 | 50.687 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project investigates, develops, and evaluates conventional ordnance technologies to establish technical feasibility and military utility for advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage, and dispensing. The project also assesses the lethality and effectiveness of current and planned conventional weapons technology programs and assesses target vulnerability. The payoffs include improved storage capability and transportation safety of fully assembled weapons, improved warhead and fuze effectiveness, improved sub-munitions dispensing, low-cost airframe/subsystem components and structures, and reduced aerospace vehicle and weapon drag.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Energetic Materials Technology | 4.772 | 4.833 | 4.721 |
| ***Description:*** Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for air-delivered munitions. | | | |
| ***FY 2021 Plans:***<br>Continue to advance and develop selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop tools and analysis techniques to further understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue to formulate and test liner technologies to improve Insensitive Munitions performance. Continue to mature additive manufacturing techniques to increase the design space for kinetic weapon lethality. Continue formulation of novel explosive fill to satisfy severe environmental constraints. Continue development of large scale nano-energetic material fabrication. | | | |
| ***FY 2022 Plans:***<br>Continue to advance and develop selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop tools and analysis techniques to further the understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Complete liner technologies formulation and test to improve Insensitive Munitions performance. Continue to mature additive manufacturing techniques to increase the design space for kinetic weapon lethality. Continue formulation of novel explosive fill to satisfy severe environmental constraints. Continue development of large scale nano-energetic material fabrication. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622502 / *Ordnance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by 0.112 million. Funding decreased due to higher Air Force priorities. | | | |
| ***Title:*** Fuze Technologies<br><br>***Description:*** Investigate and develop fuzing technology for air-delivered weapons to ensure reliable and optimal function to maximize weapon lethality for all engagement scenarios.<br><br>***FY 2021 Plans:***<br>Continue to develop testing capabilities for munitions penetration scenarios and increase modeling and simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during munition penetration at high-impact speeds. Continue research to facilitate tailored lethal effects and enable optimum fuzing solutions across the spectrum of weapon and target interactions. Continue research for distributed and multi-point fuzing concepts. Continue implementing additive manufacturing techniques to increase fuze reliability. Continue fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Continue fuze endgame, active imaging for target detection and aim point selection.<br><br>***FY 2022 Plans:***<br>Continue to develop testing capabilities for munitions penetration scenarios and increase modeling and simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during munition penetration at high-impact speeds. Continue research to facilitate tailored lethal effects and enable optimum fuzing solutions across the spectrum of weapon and target interactions. Continue research for distributed and multi-point fuzing concepts. Continue implementing additive manufacturing techniques to increase fuze reliability. Continue fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Continue fuze endgame, active imaging for target detection and aim point selection.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 0.198 million. Funding decreased due to higher Air Force priorities. | 6.103 | 5.977 | 5.779 |
| ***Title:*** Warhead Technologies<br><br>***Description:*** Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios.<br><br>***FY 2021 Plans:***<br>Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve test capabilities to enhance quantification of the mechanical response under high-rate, high-pressure loading conditions for use in high-fidelity Modeling and Simulation tools, to include materials used in additive | 9.980 | 8.691 | 8.225 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622502 / *Ordnance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| manufacturing processes. Continue to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration into hard targets. Continue to develop warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms taking advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability. Continue the development of topological optimization in support of additive manufacturing. Continue studies of composite based warheads for penetrator/perforator applications.<br>***FY 2022 Plans:***<br>Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve test capabilities to enhance quantification of the mechanical response under high-rate, high-pressure loading conditions for use in high-fidelity modeling and simulation tools, to include materials used in additive manufacturing processes. Continue to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration into hard targets. Continue to develop warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms taking advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue integration of warhead research with related activities planned for the advanced/integrated ordnance sub-systems research capability. Continue the development of topological optimization in support of additive manufacturing. Continue studies of composite-based warheads for penetrator/perforator applications.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.466 million. Funding decreased due to higher Air Force priorities. | | | |
| ***Title:*** Ordnance Technologies | 35.935 | 34.676 | 31.962 |
| ***Description:*** Investigate and develop ordnance sub-system (energetics, fuzes and war-heads) and integrated system concepts using both high-fidelity and fast-running engineering level Modeling and Simulation tools.<br>***FY 2021 Plans:***<br>Continue to develop validated mesoscale Modeling and Simulation tools for computational physics sciences. Continue to develop engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue to implement cost-effective and rapid transition war-head technologies for inventory penetrators. Continue to Modeling and Simulation efforts exploring the ordnance technology trade space for low-cost, long-range munition concepts. Continue to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue to develop test capability and data collection for Modeling and Simulation tools to | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602602F / *Conventional Munitions* | **Project (Number/Name)**<br>622502 / *Ordnance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Continue the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight.<br>***FY 2022 Plans:***<br>Continue to develop validated mesoscale modeling and simulation tools for computational physics sciences. Continue to develop engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue to implement cost-effective and rapid transition warhead technologies for inventory penetrators. Continue modeling and simulation efforts exploring the ordnance technology trade space for low-cost, long-range munition concepts. Continue to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue to develop test capability and data collection for modeling and simulation tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Continue the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.714 million. Funding decreased due to higher Air Force priorities. | | | |
| **Accomplishments/Planned Programs Subtotals** | 56.790 | 54.177 | 50.687 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602605F / *Directed Energy Technology* | | | | | | | |
| **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 | - | 114.297 | 130.375 | 121.869 | 0.000 | 121.869 | - | - | - | - | - | - |
| 624866: *Lasers & Imaging Technology* | - | 82.277 | 96.588 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 624867: *Advanced Weapons & Survivability Technology* | - | 32.020 | 33.787 | 51.185 | 0.000 | 51.185 | - | - | - | - | - | - |
| 625173: *Laser Technology* | - | 0.000 | 0.000 | 70.684 | 0.000 | 70.684 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program covers research in Directed Energy (DE) technologies, primarily High Energy Lasers (HEL); including devices, subcomponents, and novel materials; optical beam control; laser system integration; target laser lethality/vulnerability assessments; ground-based optical Space Domain Awareness (SDA); and high power microwaves (HPM). Laser research includes moderate to high power laser devices that are applicable to a wide range of applications, optical technologies to propagate laser beams through the atmosphere, and integration of these technologies into demonstration packages. Space Domain Awareness research uses the Starfire Optical Range (SOR) and the Maui Space Surveillance System (MSSS) to develop and implement technologies that identify visual characteristics such as status and health of orbiting space objects. High power microwaves research examines technologies for applications such as counter-electronics and non-lethal weapons. This program conducts research into other novel Directed Energy applications; conducts Directed Energy vulnerability/lethality assessments; develops protection technologies versus Directed Energy; conducts research into other advanced non-conventional/innovative weapons; develops and uses tools to compare solutions to determine the most effective and efficient Directed Energy technologies to meet Air Force needs; coordinates efforts through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2022, a portion of PE 0602605F, the optical space domain awareness and satellite vulnerability efforts of PE 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, was transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624866, Lasers & Imaging Technology from Appropriation 3600, Budget Activity 2 due to the creation of a new Appropriation for Space Force. In addition, the funds associated with High Energy Laser Technologies and Directed Energy Assessments were moved from PE 0602605F, Project 624866, to PE 0602605F, Project 625173.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602788F, 1206601SF, and 0602298F.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* |

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 124.379 | 128.113 | 129.514 | 0.000 | 129.514 |
| Current President's Budget | 114.297 | 130.375 | 121.869 | 0.000 | 121.869 |
| Total Adjustments | -10.082 | 2.262 | -7.645 | 0.000 | -7.645 |
| • Congressional General Reductions | 0.000 | -0.238 | | | |
| • 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 | 0.243 | 0.000 | | | |
| • SBIR/STTR Transfer | -2.322 | 0.000 | | | |
| • Other Adjustments | -8.003 | 0.000 | -7.645 | 0.000 | -7.645 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 624866: *Lasers & Imaging Technology* | | |
| Congressional Add: *DE Center of Excellence* | 0.000 | 2.500 |
| Congressional Add Subtotals for Project: 624866 | 0.000 | 2.500 |
| Congressional Add Totals for all Projects | 0.000 | 2.500 |

**Change Summary Explanation**

Air Force activities supporting Directed Energy Science and Technology FY 2022 decreased compared to FY 2021 by 8.506 Million. The overall decrease is due to: 1) increased emphasis in Laser and Imaging Technology and 2) planned activities transferred to the United States Space Force Program Element 1206601SF.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602605F / *Directed Energy Technology* | Project (Number/Name)<br>624866 / *Lasers & Imaging Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624866: *Lasers & Imaging Technology* | - | 82.277 | 96.588 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project explores the technical feasibility of moderate to high power lasers, including beam control, for applications such as aircraft protection, force protection, and precision engagement from the Department of the Air Force platforms. This project investigates the effects of laser weapons on a wide range of systems and components as well as producing, modifying, validating and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. Additionally, this project conducts research supporting ground-based optical space situational awareness.

In FY 2022, A portion of PE 0602605F, the optical space domain awareness and satellite vulnerability efforts of PE 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, was transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624866, Lasers & Imaging Technology from Appropriation 3600, Budget Activity 2 due to the creation of a new Appropriation for Space Force. In addition the funds associated with High Energy Laser Technologies and Directed Energy Assessments were moved to PE 0602605F, Project 625173.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Energy Laser Technologies and Directed Energy Assessments | 56.624 | 67.447 | 0.000 |
| ***Description:*** This effort explores the technical feasibility of moderate to high power lasers, including beam control, for applications such as aircraft protection, force protection, and precision engagement from the Department of the Air Force platforms. This project investigates the effects of laser weapons on a wide range of systems and components as well as producing, modifying, validating and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue.<br><br>***FY 2021 Plans:***<br>Continue to develop beam control technologies including aero-effects mitigation techniques based on transonic and supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with laser effects testing to establish system requirements and validate models. Complete System Requirements Review/Concept Design Review (SRR/CoDR) for 150 kW compact laser system. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users. Transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support the Department of the Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>624866 / *Lasers & Imaging Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.<br><br>***FY 2022 Plans:***<br>For FY 2022, this effort moved to BA2, Program 060205F, Directed Energy Technology, Project 625173, Laser Technology. Funds moved as a result of the creation of the Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2021 decreased from $67.447M to zero in FY 2022. Funding decreased due to moving funds to BA2, Program 060205F, Directed Energy Technology, Project 625173, Laser Technology. Funds moved as a result of the creation of the Space Force. | | | |
| ***Title:*** Optical Space Situational Awareness and Satellite Vulnerability<br><br>***Description:*** Develop advanced, long-range, electro-optical technologies that enable ground-based optical Space Domain Awareness (SDA) and quantum-based optical communications. Develop and use technologies to understand the vulnerability of blue satellite systems and components to lasers. Operate the Starfire Optical Range (SOR) to conduct research meeting internal and customer requirements.<br><br>***FY 2021 Plans:***<br>Continue fielding the dynamic telescope subsystem that searches the geosynchronous satellite belt visible from the mid-Pacific multiple-times per night, enabling a periodic comprehensive census of dim objects in the geobelt. Continue to mature daylight detection of geosynchronous satellites thus allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically rapid course-of-action decision-making enabling protection methods. Continue development of laser-enabled space situational awareness (SSA) research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain the Starfire Optical Range (SOR) and Maui Space Surveillance Site (MSSS) facilities and experimental equipment in a mission-ready state. Continue research on laser-ranging to objects in geosynchronous orbit using active sensing techniques. Starting in FY 2021, work in Program Element 0603605F, Project 633151, High Power Solid State Laser Technology, Optical Space Situational Awareness and Satellite Vulnerability efforts will be performed under in Program Element 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, | 25.653 | 26.641 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>624866 / *Lasers & Imaging Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Optical Space Situational Awareness and Satellite Vulnerability effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts.<br>***FY 2022 Plans:***<br>This research activity is transferring to United States Space Force Program Element C6601SF.<br><br>Continue to mature daylight detection of satellites allowing custody through daytime hours when satellites cannot normally be detected by ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically-rapid course-of-action decision-making enabling protection methods. Continue research & development of laser-enabled space domain awareness (SDA) focused on full-dark imaging using laser illumination. Continue development of laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain the Starfire Optical Range (SOR) facilities and experimental equipment in a mission-ready state.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $26.641M. Funding decreased due to transfer of activity to BA2 Program 01206601SF Space Technology, Project 628809, Spacecraft Vehicles Technology and BA2 Program 1206601SF Space Technology, Project 624866, Lasers & Imaging Technology, and BA2 Program 060205F Directed Energy Technology, Project 625173, Laser Technology. All moves resulting from creation of the Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 82.277 | 94.088 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** DE Center of Excellence | 0.000 | 2.500 |
| ***FY 2020 Accomplishments:*** Non Applicable | | |
| ***FY 2021 Plans:*** Perform directed work under congressional add | | |
| **Congressional Adds Subtotals** | 0.000 | 2.500 |

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

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>624866 / *Lasers & Imaging Technology* |

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

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602605F / *Directed Energy Technology* | Project (Number/Name)<br>624867 / *Advanced Weapons & Survivability Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624867: *Advanced Weapons & Survivability Technology* | - | 32.020 | 33.787 | 51.185 | 0.000 | 51.185 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project explores the use of High Power Microwave and other unconventional/innovative weapon concepts to support applications such as non-lethal counter-personnel and electronic warfare including disruption, degradation, and damage of electronic infrastructure on the Department of the Air Force platforms. This research includes weapon technology that can provide covert effects and/or no collateral or human damage. The project also investigates the effects of potential adversary High Power Microwave weapons and how to mitigate those effects on US assets, as well as producing and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. This project includes but is not limited to high power microwaves, plasmas, particle beams, and millimeter waves.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Power Microwave and Unconventional Weapon Technologies | 14.974 | 13.750 | 19.641 |
| ***Description:*** Investigate technologies for High Power Microwave and unconventional weapon components. Investigate High Power Microwave and other unconventional weapon concepts using innovative technologies. Investigate advanced technologies that support force protection tactical applications, including non-kinetic/non-lethal counter-electronics applications. | | | |
| ***FY 2021 Plans:***<br>Define measures of effectiveness and performance of an ultra-short pulsed laser system. Continue effects testing on electronic target classes for the joint high power microwave program with the Navy. Continue to develop and test high power microwave components for ground and aerial high power microwave demonstrators. Continue to develop and test smaller, higher power, source technology for the next generation Department of the Air Force high power microwave demonstration. Continue to support the modeling, simulation, and analysis (MS&A) tools that have been transitioned to the broader modeling, simulation, and analysis community. | | | |
| ***FY 2022 Plans:***<br>Continue to develop an ultra-short pulsed laser system. Initiate research and development to integrate High Power Microwave technology into an airborne platform for the next generation Department of the Air Force airborne High Power Microwave technology demonstration. Continue to develop and test high power microwave components for ground and aerial high power microwave demonstrators. Continue to develop and test smaller, higher power, source technology for the next generation Department of the Air Force high power microwave demonstration. Continue to support the modeling, simulation, and analysis (MS&A) tools that have been transitioned to the broader modeling, simulation, and analysis community. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>624867 / *Advanced Weapons & Survivability Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $5.891 million. Funding increased due to planned efforts and facilities use. | | | |
| ***Title:*** High Power Microwave Effects and Mitigation Research<br><br>***Description:*** Assess the effects/lethality of High Power Microwave technologies. Develop and apply sophisticated models to enhance the development of High Power Microwave and related technology. Develop tools and perform assessments which allow comparisons among Directed Energy concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Investigate technologies to counter the effects of High Power Microwaves.<br><br>***FY 2021 Plans:***<br>Validate and update software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Develop a data base of high power sources. Assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Validate and update the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.<br><br>***FY 2022 Plans:***<br>Complete validation of software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Continue to populate data base of high power sources. Continue to assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Continue to assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Complete validation of the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $11.507 million. Funding increased due to planned efforts associated with effects testing and system-level modelling. | 17.046 | 20.037 | 31.544 |
| **Accomplishments/Planned Programs Subtotals** | 32.020 | 33.787 | 51.185 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602605F / *Directed Energy Technology* | Project (Number/Name)<br>625173 / *Laser Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625173: *Laser Technology* | - | 0.000 | 0.000 | 70.684 | 0.000 | 70.684 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project explores the technical feasibility of moderate to high power lasers, including beam control, for applications such as aircraft protection, force protection, and precision engagement from the Department of the Air Force platforms. This project investigates the effects of laser weapons on a wide range of systems and components as well as producing, modifying, validating and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. Additionally, this project conducts research supporting ground-based optical space situational awareness.

In FY 2022, a portion of PE 0602605F, Directed Energy Technology, the optical space domain awareness and satellite vulnerability efforts of PE 0602605F, Directed Energy Technology, Project 624866, Laser Technology, was transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624866, Lasers & Imaging Technology from Appropriation 3600, Budget Activity 2 due to the creation of a new Appropriation for Space Force. In addition, the funds associated with High Energy Laser Technologies and Directed Energy Assessments were moved to PE 0602605F, Directed Energy Technology, Project 625173, Laser Technology.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Laser Technology | 0.000 | 0.000 | 70.684 |
| ***Description:*** Develop and demonstrate High Energy Laser device technologies for the Department of the Air Force applications. Develop and demonstrate laser beam control technologies including atmospheric propagation and pointing and tracking. Perform laser system level modeling and simulation validated by laser effects and vulnerability testing. Develop tools and perform assessments which allow comparisons among concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Integrate optical beam control technologies with laser device technologies and demonstrate the combined technologies. Develop and use modeling, testing and diagnostic technologies to better understand the vulnerability of adversary weapon systems to High Energy Lasers. | | | |
| ***FY 2021 Plans:***<br>Continue to develop beam control technologies including aero-effects mitigation techniques based on transonic and supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with laser effects testing to establish system requirements and validate models. Complete System Requirements Review/Concept Design Review (SRR/CoDR) for 150 kW compact laser system. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users. Transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support the Department of the Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>625173 / *Laser Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.<br>***FY 2022 Plans:***<br>Continue to incorporate physics-based modeling tools to establish a predictive physics-based End-to-End model that covers all elements of laser weapon systems (LWS)—photon "birth to death". In FY22, the End-to-End model will incorporate a high fidelity surrogate model for laser systems & damage effects. In FY22, continue to develop novel high energy laser technologies including power scaling of monolithic fiber amplifiers. Demonstrate a 5 kilowatt at 10 gigahertz Fiber Amplifier with Bend Insensitive Fiber and demonstrate Multi-kilowatt Class 2 micrometer Fiber Amplifier. Additionally, develop fiber optic amplifiers more resistant to nonlinear effects than currently available fibers. This effort requires advanced modeling to evaluate fiber designs, manufacturing maturity efforts for microstructure and nano-doped glass fibers. Specifically, in FY22, deliver 4 kilowatt nanoparticle fiber. Continue to develop laser vulnerability models for high-priority emerging threat systems. Test external customer beam control components in the Aero Effects and Beam Control (AEBC) Comprehensive Aero-optics Turbulence Simulator (CATS). Demonstrate a 10 Watt average power diode pump array. Approximately 5 watts of average power from a Middle Wavelength Infrared pump source which can be used to further scale the power of direct semiconductor pumped Ferrum doped zinc selenide lasers. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users. Continue to transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support the Department of the Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities for air base defense, and high value airborne asset protection to help users plan weapon investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets. Conduct table top exercises and focused wargames to develop concepts of employment for directed energy weapons in representative scenarios and vignettes.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 70.684 million. Funding is increased due to movement from BA2, Program 060205F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology. Funds moved as a result of the creation of the Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 0.000 | 70.684 |

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

N/A

**Remarks**

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602605F / *Directed Energy Technology* | **Project (Number/Name)**<br>625173 / *Laser Technology* |

**D. Acquisition Strategy**

Non Applicable

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602788F / *Dominant Information Sciences and Methods* | | | | | | | |
| **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 | - | 214.376 | 215.275 | 169.110 | 0.000 | 169.110 | - | - | - | - | - | - |
| 625315: *C4I Dominance Technology* | - | 132.669 | 91.165 | 93.030 | 0.000 | 93.030 | - | - | - | - | - | - |
| 625319: *Cyberspace Dominance Technology* | - | 60.281 | 63.926 | 52.234 | 0.000 | 52.234 | - | - | - | - | - | - |
| 62OMMS: *Research Site Support* | - | 21.426 | 60.184 | 23.846 | 0.000 | 23.846 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops enterprise-centric information technology for the Department of the Air Force. Advances in enterprise-centric information technologies are required to increase warfighter readiness and effectiveness by providing the right information, at the right time, in the right format, anytime, anywhere in the world. The Connectivity and Protection Tech project provides the technologies for multi-level, secure, seamless networks; advanced communications processors; anti-jam and low probability of intercept techniques, as well as technologies that deter any adversary from attacking computer systems while allowing access to, presence on, manipulation of, and operational effects on adversary computer systems. This project also develops the technology base for the next generation of ultra-wide-bandwidth, multi-channeled, air- and space-based communications networks. The Information Management and Computational Tech project provides advances in information management and dissemination technologies to ensure the delivery of high-quality, timely, secure information to the warfighter, and develop technologies to produce both advanced on demand computational processing and computer architectures with greater capacity and sophistication for addressing dynamic mission objectives under constraints imposed by Department of the Air Force systems. The Information Decision Making Tech project develops the technology to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations. The Operational Awareness Tech project develops technologies that improve their capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. The Research Site Support project provides the Rome Research Site infrastructure at Rome, New York and provides for the continued operations of all Rome Research Site properties, buildings, and services necessary for the research mission. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0622041F, 0602605F, 1206601SF, and 0602298F.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 216.062 | 178.668 | 174.121 | 0.000 | 174.121 |
| Current President's Budget | 214.376 | 215.275 | 169.110 | 0.000 | 169.110 |
| Total Adjustments | -1.686 | 36.607 | -5.011 | 0.000 | -5.011 |
| • Congressional General Reductions | 0.000 | -0.393 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 37.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.607 | 0.000 | | | |
| • SBIR/STTR Transfer | -2.293 | 0.000 | | | |
| • Other Adjustments | 0.000 | 0.000 | -5.011 | 0.000 | -5.011 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 625315: *C4I Dominance Technology* | | |
| Congressional Add: *Program Increase- Artificial Intelligence/Machine Learning Accelerator* | 8.000 | 0.000 |
| Congressional Add: *Program Increase- Combat Cloud Technology* | 2.500 | 0.000 |
| Congressional Add: *Program Increase- Quantum Communications* | 4.000 | 0.000 |
| Congressional Add: *Program Increase- Quantum Cryptography* | 7.000 | 0.000 |
| Congressional Add: *Program Increase* | 5.000 | 0.000 |
| Congressional Add: *Program Increase- Quantum Network Testbed* | 0.000 | 0.000 |
| Congressional Add: *Program Increase- Quantum Information Science Innovation Center* | 8.000 | 0.000 |
| Congressional Add Subtotals for Project: 625315 | 34.500 | 0.000 |
| **Project:** 625319: *Cyberspace Dominance Technology* | | |
| Congressional Add: *Program Increase- Trusted UAS Traffic Management and c-SUAS Testbed* | 0.000 | 0.000 |
| Congressional Add Subtotals for Project: 625319 | 0.000 | 0.000 |
| **Project:** 62OMMS: *Research Site Support* | | |
| Congressional Add: *Program Increase- Quantum Cryptography* | 0.000 | 7.000 |
| Congressional Add: *Program Increase- Quantum Network Testebed* | 0.000 | 10.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add: *Program Increase- Quantum Information Science Innovation Center* | 0.000 | 10.000 |
| Congressional Add: *Program Increase- trusted UAS traffic management and c-SUAS testbed* | 0.000 | 10.000 |
| Congressional Add Subtotals for Project: 62OMMS | 0.000 | 37.000 |
| Congressional Add Totals for all Projects | 34.500 | 37.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602788F / *Dominant Information Sciences and Methods* | Project (Number/Name)<br>625315 / *C4I Dominance Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625315: *C4I Dominance Technology* | - | 132.669 | 91.165 | 93.030 | 0.000 | 93.030 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The Department of the Air Force requires advanced technologies which support the Department of the Air Force five core missions and enable the Department of the Air Force to achieve Global Vigilance, Global Reach, and Global Power in support of national security objectives. The technologies developed under this project enable the National Defense Strategy and Department of the Air Force future operating concepts which require operational agility (the ability to rapidly generate—and shift among—multiple solutions for a given challenge), creating combinations of air, space, and cyberspace capabilities to achieve desired effects in the battlespace.

This project provides the technologies for secure, self-configuring, self-healing, seamless networks; advanced communications processors; anti-jam and low probability of intercept communications techniques; agile and dynamic policy-based network management capabilities; and modular, programmable, low-cost software radios. In addition, it develops both the technology base for ultra-wide bandwidth and multi-channeled communications networks (both air and space based) on and between platforms.

This project provides the technologies which enable the ability to globally share, discover, and access information across organizational, functional, and coalition boundaries and between and among domains, the timely delivery of information to tactical assets, the tailoring and prioritization of information based on mission needs and importance, and the scaling, robustness, and collaboration features required of the Department of the Air Force net-centric information management environment.

This project advances technologies enabling the effective execution of military objectives that will vastly improve the ability to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations (air, space, and cyberspace) at all levels of war (strategic, operational, and tactical) and during all phases of conflict. This project provides technologies for anticipatory decision support; course of action development, planning, scheduling, and assessment; and the real-time effective portrayal of complex data sets.

This project improves and automates the capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. This project provides not only a network-centric, collaborative intelligence analysis capability that enables the fusion of multi-intelligence and sensor sources to provide timely situational awareness, understanding, and anticipation of the threats in the battlespace, but also the advanced, novel exploitation technologies needed to intercept, collect, locate, and process both covert and overt raw data from intelligence and sensor sources.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Assured Communications & Networks | 23.182 | 24.492 | 25.462 |
| ***Description:*** Develop communications, networking, and signal processing technologies with improved survivability and capacity to provide secure, adaptive, covert, anti-jam, and assured global battlespace connectivity tailored to anti-access and area-denial | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| environments and contested operations. Includes the research and development to advance existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.<br><br>***FY 2021 Plans:***<br>Continue the research and development of technologies for robust, adaptive, and mission aware airborne networks. Continue the investigation of high frequency pathways (for example, the V and W band of the electromagnetic spectrum) to support aerial and space-based beyond line of sight communications. Continue the research and development of dynamic map-to-mission for secure message exchange operations continuity and agile info management. Continue development of a waveform testbed and flight test a new multi-waveform radio. Continue research and development to measure propagation at millimeter wave frequencies to validate previously developed models and enable future definition of military satellite communications systems. Continue ionospheric research, propagation modeling and simulation. Develop an ultra-wide band protocol stack to enable future ultra wide-band communications. Develop a directional radio prototype, with optimized user discovery and network interference control interface.<br><br>***FY 2022 Plans:***<br>Continue the research and development of technologies for robust, adaptive, and mission aware airborne networks. Maintain the research and development of large-scale hardware-in-the-loop verification of developed directional networking protocols. Advance the research and development of propagation models. Initiate the development of a network stack suitable for high-bandwidth terahertz links. Launch the development, verification, and validation of advanced, airborne high-frequency antenna/ionospheric structure. Initiate the development, verification, and test of advanced waveforms. Establish the development, verification, and test of software-defined radio prototypes. Continue development of enhanced assurance and filtration offloading. Extend the development of advanced, airborne high-frequency antenna/ionospheric structures. Continue to develop, verify, and validate software-defined radio prototypes.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.970 million. Justification for the increase is described in the plans above. | | | |
| ***Title:*** Data to Decisions<br><br>***Description:*** Investigate and develop technologies for decision quality information dissemination services via publish, subscribe, and query across the Global Information Grid to enterprise and tactical assets and coalition partners.<br><br>***FY 2021 Plans:***<br>Continue the research and development of data analytics and strategic indications and warnings technologies (including large data alignment, indexing and search on textual data, large-scale and disparate data sources, both structured and unstructured data, and employment of various ontologies and machine learning techniques). Continue to advance research and development | 12.993 | 14.210 | 15.199 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| for cloud-based data and information sharing environment for optimized processing and automated association capability. Continue to focus signals intelligence characterization on audio and other electronic signals. Continue research and development in exploitation technologies using audio processing for language modeling and deep learning techniques. Continue research on enhanced emitter feature extraction capabilities and development of automated electronics intelligence analysis toolsets. Develop network dynamics algorithms.<br>***FY 2022 Plans:***<br>Continue the research and development of data analytics and strategic indications and warnings technologies (including large data alignment, indexing and search on textual data, large-scale and disparate data sources, both structured and unstructured data, and employment of various ontologies and machine learning techniques). Maintain the development of a user customizable entity, event, and relation text extraction capability with automatic performance estimates of the user-customized extractors on new documents and mission areas. Initiate research and development of a Request for Information (RFI) dialog system that can help answer Requests for Information (RFI) for single service applications across 10 essential Intelligence enterprise identified RFIs. Develop a Multi-Int Intelligence, Surveillance, and Reconnaissance ontology connecting Air Force analytics, Application Programming Interfaces, and services. Research and develop an initial integrated threat detection system based on vetted events from PAI fused and corroborated with ISR sources. Continue the research and development of autonomous, heterogeneous, distributed multi-sensor management and upstream data fusion for improved target detection, tracking and classification. Sustain the development of counter Small Unmanned Air systems (C-SUAS) detection and identification, via acoustics, and algorithm work.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.989 million. Justification for the increase is described in the plans above. | | | |
| ***Title:*** Processing Technologies | 0.000 | 6.481 | 7.463 |
| ***Description:*** Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems.<br><br>Starting in FY 2021, the remaining non-cyber work that was performed under Project 625319, Cyberspace Dominance Technology, in the Processing Technologies effort within this PE will now be performed within this effort.<br>***FY 2021 Plans:***<br>Develop the application of novel neuromorphic systems for robust machine learning. Continue to advance research and development of the neuromorphic processor and validate capabilities for dynamic learning on mobile and power-constrained platforms.<br>***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Advance the application of novel neuromorphic systems for robust machine learning. Continue to advance research and development of the neuromorphic processor and validate capabilities for dynamic learning on mobile and power-constrained platforms. Initiate the development of a prototype integrated with existing embedded high performance computing systems. Commence the development and delivery of a Neuromorphic High-Performance-Computing (Brain-in-the-Box).<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.982 million. Justification for the increase is described in the plans above. | | | |
| ***Title:*** Multi-Domain Command & Control (MDC2)<br>***Description:*** Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns. Investigate, analyze, and develop technologies for planning, execution, and automatic rapid reconfiguration of distributed intelligent and integrated command and control information systems to achieve the commander's intent throughout varying crisis levels.<br>***FY 2021 Plans:***<br>Continue research for applying machine learning techniques to enhance and optimize space operations. Develop a system for distributed command and control, enabling cyber operators viable options for decision making in the multi-domain arena. Leverage prior efforts in developing a series of experiments in the area of multi-domain command and control.<br>***FY 2022 Plans:***<br>Continue research for applying machine learning techniques to enhance and optimize space operations. Advance research and development to refine the mathematical framework and provide a method for evaluating and presenting multi-domain courses of action to maximize operational effects for decisive advantage. Maintain the development of tools, technology, and a framework for execution management of operational center process workflows and applications. Sustain the research and development of a novel composable planning paradigm to overcome the serial and time-intensive nature of existing planning techniques.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.949 million. Justification for the increase is described in the plans above. | 17.577 | 18.782 | 19.731 |
| ***Title:*** Artificial Intelligence/Autonomy/Machine Learning<br>***Description:*** Perform research and development (R&D) to harness the speed and scale of computers and machines to address problems of complexity.<br>***FY 2021 Plans:***<br>Research and develop machine learning approaches for supporting and performing operations in complex adversarial environments. Conduct research to understand operations needs of machine learning algorithms and systems with the multi- | 14.496 | 15.700 | 16.699 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| domain command and control connect. Demonstrate analytical and simulation framework for large-scale swarms that considers potential constraints on communications, on-board processing, sensors, and flight systems.<br>***FY 2022 Plans:***<br>Advance the research and development of machine learning approaches for supporting and performing operations in complex adversarial environments. Maintain the research to understand operational needs of machine learning algorithms and systems with the multi-domain command and control connect. Continue to research the application of Interactive Learning techniques to the auto-planning problem and develop an IL based planning capability to augment existing auto-planning tools. Sustain the research and development of machine learning approaches for supporting and performing operations in complex adversarial environments.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.999 million. Justification for the increase is described in the plans above. | | | |
| ***Title:*** Nuclear C3 Modernization<br>***Description:*** Perform research and development (R&D) to advance existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.<br>***FY 2021 Plans:***<br>Develop advanced, airborne high-frequency antenna/ionospheric structure. Test advanced waveforms. Develop, verify, and validate software-defined radio prototypes.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed in PE 0602788F, Dominant Information Sciences and Methods, Project 625315, C4I Dominance Technology, Assured Communications & Networks effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $4.010 million. Starting in FY 2022, this work will be performed in PE 0602788F, Dominant Information Sciences and Methods, Project 625315, C4I Dominance Technology, Assured Communications & Networks effort. | 3.811 | 4.010 | 0.000 |
| ***Title:*** Quantum Information Science<br>***Description:*** Perform research and development (R&D) that will utilize quantum physics for the storage, transmission, manipulation, computing, or measurement of information in ways that offer advantages to classical capabilities.<br>***FY 2021 Plans:*** | 6.443 | 7.490 | 8.476 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue research and development in the area of supreme and quantum computing information sciences. Demonstrate entangling gates within a trapped ion based network node and perform remote entangling operations between independent network nodes. Conduct performance of interface using trapped ion, superconducting, and photon-based qubit. Develop compact memory-and photon-based network components to be used in future field demonstrations.<br>***FY 2022 Plans:***<br>Continue research and development in the area of supreme and quantum computing information sciences. Maintain development of further reducing SWaP of network node demonstrations. Initiate demonstration of quantum information processing on a single chip by using developed quantum photonics processor with photon sources.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.986 million. Justification for the increase is described in the plans above. | | | |
| ***Title:*** Future AF Capabilities Applied Research<br>***Description:*** Investigate, design, and develop science and technologies supporting future Department of the Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).<br><br>The National Defense Strategy and the Department of the Air Force Science and Technology 2030 Strategy will inform investments over the FYDP.<br>***FY 2021 Plans:***<br>Starting in FY 2021, the Dominant Information Science and Methods portion of this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 19.667 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 98.169 | 91.165 | 93.030 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase- Artificial Intelligence/Machine Learning Accelerator<br>***FY 2020 Accomplishments:*** Conduct congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable. | 8.000 | 0.000 |
| ***Congressional Add:*** Program Increase- Combat Cloud Technology<br>***FY 2020 Accomplishments:*** Conduct congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable. | 2.500 | 0.000 |
| ***Congressional Add:*** Program Increase- Quantum Communications<br>***FY 2020 Accomplishments:*** Conduct congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable. | 4.000 | 0.000 |
| ***Congressional Add:*** Program Increase- Quantum Cryptography<br>***FY 2020 Accomplishments:*** Conducted congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. | 7.000 | 0.000 |
| ***Congressional Add:*** Program Increase<br>***FY 2020 Accomplishments:*** Conduct congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable. | 5.000 | 0.000 |
| ***Congressional Add:*** Program Increase- Quantum Network Testbed<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. | 0.000 | 0.000 |
| ***Congressional Add:*** Program Increase- Quantum Information Science Innovation Center<br>***FY 2020 Accomplishments:*** Conducted congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. | 8.000 | 0.000 |
| **Congressional Adds Subtotals** | 34.500 | 0.000 |

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

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625315 / *C4I Dominance Technology* |

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

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602788F / *Dominant Information Sciences and Methods* | Project (Number/Name)<br>625319 / *Cyberspace Dominance Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625319: *Cyberspace Dominance Technology* | - | 60.281 | 63.926 | 52.234 | 0.000 | 52.234 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The Department of the Air Force requires technologies to deliver a full range of options in cyberspace on par with air and space dominance in each of the areas of cyber-attack, cyber defense, and cyber support to achieve the strategic capability of cyber dominance. The Department of the Air Force requires the development of superior, intelligent, on-demand computing to enable information superiority to include advances in secure information sharing across domains and boundaries as well as technologies that successfully deter any adversary from attacking computer systems anytime, anywhere by ensuring the Department of the Air Force's ability to: access, maintain presence on, and deliver effects to adversary systems; detect, defend, and respond to attacks on friendly computer systems and provide forensic analysis concerning those attack attempts; and provide cyber situational awareness to Department of the Air Force Commanders. In addition, the Department of the Air Force requires technology development that produces computing architectures with greater capacity and sophistication for addressing constrained, dynamic mission objectives; game-changing computing power to the warfighter, disruptive computing power at the tactical edge and for federated grid services; and interactive and real-time computing improving the usability of high-performance computing to the Department of the Air Force. It includes technologies in computational sciences and engineering, computer architectures and software intensive systems.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Cyber Defense Technologies | 20.531 | 21.432 | 32.225 |
| ***Description:*** Develop cyber defense and supporting technologies to detect, defend, and respond to attacks on computer systems as well as provide forensic concerning attacks.<br><br>***FY 2021 Plans:***<br>Continue research in the area of autonomous integrated cyber operations. Continue applied research in the area of biologically resilient cyber technologies. Continue research into mission-specific block-chain capabilities, and the alignment of cyber resilient services and dynamic management tailored towards unmanned aerial systems. Develop radical architectural and infrastructural changes from computational diversity, to deliver a quantifiable improvement to cybersecurity.<br><br>***FY 2022 Plans:***<br>Continue research in the area of autonomous integrated cyber operations. Advance applied research in the area of biologically resilient cyber technologies. Extend research into mission-specific block-chain capabilities, and the alignment of cyber resilient services and dynamic management tailored towards unmanned aerial systems. Maintain the development of radical architectural and infrastructural changes from computational diversity, to deliver a quantifiable improvement to cybersecurity. Continue to sustain research and validation of a cyber-hardened (robust, secure) processor for embedded weapon systems. Continue to maintain applied research to create trusted and resilient embedded systems that are capable of identifying, localizing, | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625319 / *Cyberspace Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| and automatically repairing previously unknown and/or unintended vulnerabilities. Sustain development of software using evolutionary approaches to make embedded systems tolerant to unexpected and unforeseen situations. Continue to investigate research concepts and capabilities for cyber survivability techniques and algorithms for counter-unmanned aerial systems. Extend development of a counter-unmanned aerial systems open architecture to enable interoperability. Maintain evolution of autonomous machine learning functions. Continue the validation and demonstration of automated workflows into defensive cyber operations systems. Sustain development of a model-assisted concolic firmware exploration and threat models based on device behavior. Conduct large scale device analysis and demonstration on AF-relevant system. Create a capability to model, intercept, and synchronize the state of all embedded devices connected on a single bus.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $10.793 million. Starting in FY 2022, the work within this PE, under Project 625319, Cyberspace Dominance Technology, in the Advanced Architectures Technologies effort, Survivability Technologies effort, and Cyber Technology for Spectrum Warfare effort, will all be performed within this PE, under Project 625319, Cyberspace Dominance Technology, Cyber Defense Technologies effort. | | | |
| ***Title:*** Cyber Offense Technologies | 17.037 | 20.121 | 20.009 |
| ***Description:*** Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems.<br>***FY 2021 Plans:***<br>Continue to advance research and development of new, leading-edge technologies that are game changing and employ dominant power for cyber offensive operations. Continue increased activity in capabilities for multi-function, non-kinetic cyber effects against adversarial systems. Continue to demonstrate ground-based and airborne delivery of disrupt, deny, degrade, destroy, or deceive effects that are both cyber and physical/kinetic. Initiate implementation of automated extension of attack model.<br>***FY 2022 Plans:***<br>Sustain research and development of new, leading-edge technologies that are game changing and employ dominant power for cyber offensive operations. Continue to increase research and development in capabilities for multi-function, non-kinetic cyber effects against adversarial systems. Continue to demonstrate ground-based and airborne delivery of disrupt, deny, degrade, destroy, or deceive effects that are both cyber and physical/kinetic. Maintain the advancement of research in systems to perform blind data discovery associated with the Internet of Things. Advance the identification of items of interest associated with the Internet of Things. Extend research for specific items of interest within the Internet of Things. Complete the Mission tool framework and automated vulnerability discovery framework.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625319 / *Cyberspace Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $0.112 million. Justification for the decrease is described in the plans above. | | | |
| ***Title:*** Advanced Architectural Technologies<br>***Description:*** Develop the architectural mechanisms that form the basis for predictable software and high assurance systems.<br>***FY 2021 Plans:***<br>Continue to sustain research and validation of a cyber-hardened (robust, secure) processor for embedded weapon systems. Continue to maintain applied research to create trusted and resilient embedded systems that are capable of identifying, localizing, and automatically repairing previously unknown and/or unintended vulnerabilities. Continue development of software using evolutionary approaches to make embedded systems tolerant to unexpected and unforeseen situations.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Defense Technologies effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $8.624 million. Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Defense Technologies effort. | 7.689 | 8.624 | 0.000 |
| ***Title:*** Processing Technologies<br>***Description:*** Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems.<br>***FY 2021 Plans:***<br>Starting in FY 2021, the non-cyber work will be performed within this PE, under Project 625315, C4I Dominance Technology, in the Processing Technologies effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 4.715 | 0.000 | 0.000 |
| ***Title:*** Survivability Technologies<br>***Description:*** Develop methods and technologies for controlled operation of information systems during attacks and fault conditions, minimizing vulnerabilities of cyber attacks, and guaranteeing the accuracy and correctness of data and codes. | 3.011 | 3.989 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625319 / *Cyberspace Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue to investigate research concepts and capabilities for cyber survivability techniques and algorithms for counter-unmanned aerial systems. Continue development of a counter-unmanned aerial systems open architecture to enable interoperability. Continue with evolution of autonomous machine learning functions. Continue the validation and demonstration of automated workflows into defensive cyber operations systems.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Defense Technologies effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $3.989 million. Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Defense Technologies effort. | | | |
| ***Title:*** Cross-Domain Technologies<br>***Description:*** Develop secure cross-domain discovery services for access to services outside the existing domain. Develop the tools to allow collaboration of workflows required by the Air Force net-centric information management system.<br>***FY 2021 Plans:***<br>Continue the research and development in cross-domain solution technologies by developing content filtering, with an emphasis on improving support for rapid inclusion of new data types with minimal requirements for lengthy data type threat assessments and minimal custom coding. Continue research and development for machine to machine interfaces. Continue to extend the development of cross-domain solution command and control capabilities to manage cross-domain solution risks based upon changes in mission and threat for diversified platforms via hardware abstraction, containerization/separation of the operation system (mobile, desktop, server).<br>***FY 2022 Plans:***<br>Much of the technology covered under this effort has matured to the level of advanced technology. Starting in FY 2022, the remaining work will be performed within this PE, under Project 625315, C4I Dominance Technologies, in the Assured Communications & Networks effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $6.012 million. Starting in FY 2022, this work will be performed within this PE, under Project 625315, C4I Dominance Technologies, in the Assured Communications & Networks effort. | 5.944 | 6.012 | 0.000 |
| ***Title:*** Cyber Technologies for Spectrum Warfare | 1.354 | 3.748 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>625319 / *Cyberspace Dominance Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop technologies combining electronic warfare, signals intelligence, communications, and cyber technologies that provide synergistic access, exploitation and effects across air and cyber domains in congested and contested environments.<br><br>***FY 2021 Plans:***<br>Continue to advance research in systems to perform blind data discovery associated with the Internet of Things. Continue with identification of items of interest associated with the Internet of Things. Continue research for specific items of interest within the Internet of Things.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Offense Technologies effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $3.748 million. Starting in FY 2022, this work will be performed within this PE, under Project 625319, Cyberspace Dominance Technology, in the Cyber Offense Technologies effort. | | | |
| **Accomplishments/Planned Programs Subtotals** | 60.281 | 63.926 | 52.234 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase- Trusted UAS Traffic Management and c-SUAS Testbed<br><br>***FY 2020 Accomplishments:*** Not applicable.<br><br>***FY 2021 Plans:*** Conduct congressionally directed efforts. | 0.000 | 0.000 |
| **Congressional Adds Subtotals** | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 0602788F / *Dominant Information Sciences and Methods* | Project (Number/Name)<br>62OMMS / *Research Site Support* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62OMMS: *Research Site Support* | - | 21.426 | 60.184 | 23.846 | 0.000 | 23.846 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The Air Force Research Laboratory Information Directorate leads the discovery, development and implementation of information science and technology to drive transformation within the Department of the Air Force and across the Department of Defense. The focus of the work is to provide the warfighter with the required technology-based capabilities to defend the Nation by unleashing the power of innovative information science and technology to anticipate, find, fix, track, target, engage, and assess anything, anytime, anywhere. Since the site is a single-purpose location which is not located on a military installation, the Information Directorate has unique requirements for supporting its science and technology mission. As the host unit, the directorate is responsible to provide the Rome Research Site infrastructure at Rome, New York and provide for the continued operations of all Rome Research Site properties, buildings, and services necessary for the research mission. Operations include: logistics and communication services, utilities, maintenance of facilities and structures, safety and security of the workforce and visiting researchers, and ensures compliance with the laws, regulations, and directives that pertain to site operations. These services are host unit responsibilities and are necessary to provide a safe and effective environment for the Research Site's workforce and mission.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Rome Research Infrastructure | 21.426 | 23.184 | 23.846 |
| ***Description:*** Provide the necessary services and support including, but not limited to: fire inspections, refuse collection, water, electricity, steam, heat, custodial, and grounds maintenance services to the Research Site. Provide the necessary support for the maintenance and repair of Research Site facilities (buildings and other structures), vehicle and equipment lease and security/ safety inspections and services as necessary for compliance and safety/security of personnel and research assets. Provide the Research Site with long haul communications (using the Government Services Administration set of Networx contracts for Continental United States), trunk connectivity and wireless communications. | | | |
| ***FY 2021 Plans:***<br>Continue to provide civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Continue to provide facilities, facility operations, facility sustainment, support equipment, contracts, and associated costs to plan, manage and execute the following functions: fire prevention, disaster preparedness, plant operation and purchase of commodity, refuse collection, pavement clearance of snow and ice, grounds maintenance including landscaping, real property special inspections, pest control, and custodial services. Continue to provide Real Property Management and Engineering Services, including: (1) Facility Management and Administration and (2) Installation Engineering Services. Facility Management includes public works management costs, contract management, material procurement, facility data management, furnishings management costs, and real estate management. Installation Engineering Services includes annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non Site Recovery | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>62OMMS / *Research Site Support* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Management service calls. Continue to provide basic installation communication services, including long haul trunk and telecommunications services. Continue to provide site vehicle lease for logistics, security, and mission support under the Government Services Administration.<br><br>***FY 2022 Plans:***<br>Continue to provide civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Continue to provide facilities, facility operations, facility sustainment, support equipment, contracts, and associated costs to plan, manage and execute the following functions: fire prevention, disaster preparedness, plant operation and purchase of commodity, refuse collection, pavement clearance of snow and ice, grounds maintenance including landscaping, real property special inspections, pest control, and custodial services. Continue to provide Real Property Management and Engineering Services, including: (1) Facility Management and Administration and (2) Installation Engineering Services. Facility Management includes public works management costs, contract management, material procurement, facility data management, furnishings management costs, and real estate management. Installation Engineering Services includes annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non Site Recovery Management service calls. Continue to provide basic installation communication services, including long haul trunk and telecommunications services. Continue to provide site vehicle lease for logistics, security, and mission support under the Government Services Administration.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.662 million. Justification for the increase is due to additional site support costs as described in the plans above. | | | |
| **Accomplishments/Planned Programs Subtotals** | 21.426 | 23.184 | 23.846 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase- Quantum Cryptography<br><br>***FY 2020 Accomplishments:*** Not applicable.<br><br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 625315, C4I Dominance Technology. | 0.000 | 7.000 |
| ***Congressional Add:*** Program Increase- Quantum Network Testebed | 0.000 | 10.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 0602788F / *Dominant Information Sciences and Methods* | **Project (Number/Name)**<br>62OMMS / *Research Site Support* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 625315, C4I Dominance Technology. | | |
| ***Congressional Add:*** Program Increase- Quantum Information Science Innovation Center<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 625315, C4I Dominance Technology. | 0.000 | 10.000 |
| ***Congressional Add:*** Program Increase- trusted UAS traffic management and c-SUAS testbed<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 625319, Cyberspace Dominance Technology. | 0.000 | 10.000 |
| **Congressional Adds Subtotals** | 0.000 | 37.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 0602890F / *High Energy Laser Research* | | | | | | | |
| **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 | - | 47.462 | 29.155 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 625096: *High Energy Laser Research* | - | 47.462 | 29.155 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program funds Department of Defense Directed Energy applied research through the Joint Directed Energy Transition Office. This program is part of an overall Department of Defense Directed Energy Science and Technology program. Directed Energy weapon systems have many potential advantages including speed of-light delivery, low collateral damage, significant magazine depth, low incremental cost per kill. Directed Energy Weapon Systems have the potential to perform a wide variety of military missions including high value asset and base protection, precision strike and platform self-protection versus a wide variety of missile, rocket, artillery, mortar and air platforms. Efforts under this program are generally chosen for their potential to have an impact on multiple Directed Energy Weapon systems and multiple Service missions while complementing Service/Agency efforts that are directed at specific Service needs. A broad range of technologies are addressed in key areas such as laser sources, microwave sources, laser beam control, antennas, waveguides, modeling and simulation, and lethality mechanisms. This program provides the enabling technology necessary to demonstrate advanced concepts for high power microwave sources, antennas and waveguides for mission areas not considered to date. The high power microwave lethality, hardware and software improvements and modeling and simulation advances provided by this program are essential to expand and build upon current architectures. This program supports the Senior Official as required. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

For FY 2022 this devolved PE is transferring back to OSD under BA2 Program 62890D8Z. This move is at the request of OSD so that they may better integrate with current OSD Directed Energy efforts and participate in OSD budget processes.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601S.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 48.221 | 45.088 | 46.019 | 0.000 | 46.019 |
| Current President's Budget | 47.462 | 29.155 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | -0.759 | -15.933 | -46.019 | 0.000 | -46.019 |
| • Congressional General Reductions | 0.000 | -0.053 | | | |
| • Congressional Directed Reductions | 0.000 | -20.880 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 5.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.759 | 0.000 | | | |
| • Other Adjustments | 0.000 | 0.000 | -46.019 | 0.000 | -46.019 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 625096: *High Energy Laser Research* | | |
| Congressional Add: *Program increase - Directed energy fiber lasers* | 4.000 | 4.920 |
| Congressional Add Subtotals for Project: 625096 | 4.000 | 4.920 |
| Congressional Add Totals for all Projects | 4.000 | 4.920 |

**Change Summary Explanation**

Activities supporting high energy laser research decreased in FY 2022 by 29.155 million to zero. Planned activities transferred to the Office of the Secretary of Defense Program Element 0602890D8Z.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| ***Title:*** Directed Energy Technologies | 7.598 | 4.242 | 0.000 | - | 0.000 |
| ***Description:*** Mature technologies that will provide system level performance commensurate with fieldable directed energy devices.<br><br>***FY 2021 Plans:***<br>Continue to develop high reliability, lower cost, efficient and high temperature diode pump sources. Continue to scale alternate laser wavelengths to additional militarily relevant uses and power levels. Continue investigations into next generation high power fiber technologies. Continue to reduce technical risk in solid state lasers for | | | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| inclusion in future laser weapon systems. Continue trade space analysis to understand performance, fielding, robustness and integration issues for military platforms. Continue to investigate, analyze trade space, and reduce technical risk for high power microwave devices. Continue to study radiofrequency and microwave capabilities and effects against various threats. Continue analysis and trades studies to determine the most effective radiofrequency and microwave parameters and system components needed to defeat classes of selected targets.<br>***FY 2022 Base Plans:***<br>For FY 2022 this effort is moving to OSD PE 62890D8Z<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>For FY 2022 this effort is moving to OSD PE 62890D8Z | | | | | |
| ***Title:*** Advanced Directed Energy Technologies | 6.148 | 3.451 | 0.000 | 0.000 | 0.000 |
| ***Description:*** Investigate new technologies that have revolutionary potential for high energy lasers and high power microwaves.<br>***FY 2021 Plans:***<br>Continue to explore advanced concepts for directed energy technologies that will improve efficiency and decrease mass and volume for future weapon systems. Continue to evaluate materials for high energy laser applications. Continue to improve understanding of laser technologies to include material interaction and propagation. Continue to scale electrically pumped lasers to higher kilowatt class power levels. Continue to characterize and understand the physics of high energy laser atmospheric propagation in adverse environmental conditions such as fog, rain, smoke and dust. Continue to evaluate and test Avoidance and Air Space De-confliction systems on directed energy test ranges. Continue to collaborate with the international directed energy community on progress in the development and application of high energy laser technologies for military missions. Validate predictive models through analysis of atmospheric propagation data and measurements. Continue to validate predictive models through analysis of atmospheric propagation data and measurements. Continue to study the desired radiofrequency and microwave effects that drive the radiofrequency and microwave component and system design, including power. Improve understanding of required power system components including power generation and storage, high temperature / high power devices, power converters, and power conditioning. The ongoing radiofrequency and microwave effects and power components work is coordinated with and, as appropriate, leveraged by radiofrequency and microwave and power/energy programs across the Services and Agencies. Continue to characterize and understand the physics of high power | | | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| microwave propagation in adverse environmental conditions. Continue to collaborate with the international directed energy community on progress in the development and application of high power radiofrequency directed energy weapon (DEW) technologies for military missions.<br>***FY 2022 Base Plans:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z<br>***FY 2022 OCO Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z | | | | | |
| ***Title:*** Directed Energy Propagation Technologies<br>***Description:*** Develop technology to support high performance beam control systems and integrated demonstrations.<br>***FY 2021 Plans:***<br>Continue to develop beam control technologies for high energy laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Continue the development of a predictive avoidance fire control system for use on multiple platforms. Continue to develop kill assessment technologies. Continue to develop hardware and technologies to improve throughput efficiency of the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Continue to select and develop additional concepts for Service-specific applications. Continue to develop theoretical physical models describing the propagation of a high power microwave pulse through the atmosphere to understand the reflection characteristics of the high power microwave propagation. Continue to study and understand the dynamic behavior of the propagation of high power microwave pulses and the effects on the intensity, frequency, and width of the pulse and the physical processes occurring during the interaction of the pulse with the air. Continue to select and develop additional concepts for Service-specific applications. Continue to develop kill assessment technologies. Continue to develop hardware and technologies to improve throughput efficiency of the antenna, decrease component weight, and improve tracking and compensation through the atmosphere.<br>***FY 2022 Base Plans:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 21.784 | 12.011 | 0.000 | - | 0.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| For FY 22 this effort is moving to OSD PE 62890D8Z | | | | | |
| ***Title:*** Directed Energy Lethality Research<br>***Description:*** Conduct directed energy vulnerability experiments on materials, components, and targets. Develop a lethality database, and integrate into a systems-level architecture plan and lethality models.<br><br>***FY 2021 Plans:***<br>Continue to integrate lethality data into campaign-level high energy laser system models. Continue to conduct high energy laser vulnerability experiments on materials, components, and targets. Continue to develop a suite of high energy laser weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given high energy laser weapon platform and engagement. Continue to develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards. Continue to develop new predictive modeling software tools to assess the effectiveness of high power microwave weapons on electronic systems of interest for blue-on-red or red-on-blue engagements. Continue to understand and evaluate statistical and deterministic cavity coupling algorithms to estimate the temporal and spectral characteristics of the high power microwave energy coupled into complicated enclosures. Continue to leverage advancements in predictive circuit effects, garnered through several Service and Agency-funded programs, to model and predict the response of complicated electronics to the incident high power microwave stimulus. Continue to develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.<br><br>***FY 2022 Base Plans:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z<br><br>***FY 2022 OCO Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z | 4.018 | 2.282 | 0.000 | 0.000 | 0.000 |
| ***Title:*** Directed Energy Modeling<br>***Description:*** Maintain and evaluate high-fidelity engineering models for high energy laser and high power microwave system scenario evaluation and incorporation into the directed energy toolkit. Provide atmospheric propagation and directed energy system modeling for mission-level war-gaming activities. | 3.914 | 2.249 | 0.000 | 0.000 | 0.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue to provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser system models. Continue to collaborate with Service-sponsored field-test planning to correlate model predictions with measured data for surface, maritime and aerospace environments. Continue to incorporate atmospheric data into theater models to support performance characterization tables. Continue to conduct verification and validation planning to support advanced beam control objectives, diagnostics and warfighter tools. Continue to collaborate with Service and Agency sponsored High Power microwave survivability / lethality community's interest in, and use of, high power microwave engagement models. Continue to provide maintenance, verification, validation, and accreditation for updated system level standalone model that can be used to estimate the probability of electronic upset or damage as a function of the high power microwave power density on the target and associated range. Continue to provide the warfighter tools to determine the power density required on a target to produce a functional kill and understand the required parameters of the high power microwave, such as power, frequency/wavelength, modulation, and engagement angle for the kill. Continue to incorporate atmospheric data into theater models to support performance characterization tables. Continue to conduct verification and validation planning to support advanced beam propagation objectives, diagnostics and warfighter tools.<br>***FY 2022 Base Plans:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z<br>***FY 2022 OCO Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>For FY 22 this effort is moving to OSD PE 62890D8Z | | | | | |
| **Accomplishments/Planned Programs Subtotals** | 43.462 | 24.235 | 0.000 | 0.000 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - Directed energy fiber lasers | 4.000 | 4.920 |
| ***FY 2020 Accomplishments:*** Conduct Congressional directed efforts. | | |
| ***FY 2021 Plans:*** Conduct Congressional directed efforts. | | |
| **Congressional Adds Subtotals** | 4.000 | 4.920 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 0602890F / *High Energy Laser Research* |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | | | | | R-1 Program Element (Number/Name)<br>PE 1206601F / *Space Technology* | | | | | | | |
| **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 | - | 155.984 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 621010: *Space Survivability & Surveillance* | - | 40.282 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 624846: *Spacecraft Payload Technologies* | - | 19.047 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 625018: *Spacecraft Protection Technology* | - | 23.753 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 628809: *Spacecraft Vehicle Technologies* | - | 72.902 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity 02 due to the creation of a new Appropriation for Space Force.

This program focuses on four major areas. First, the space survivability and surveillance area develops technologies to understand space weather and the geophysics environment for mitigation and exploitation of these effects to Air Force systems. Second, the spacecraft payload technologies area improves satellite payload operations by developing advanced component and subsystem capabilities. Third, the spacecraft protection area develops technologies for protecting United States space assets in potential hostile settings. The last major area, spacecraft vehicles, focuses on spacecraft platform and control technologies, and their interactions. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

This work will still be executed by the Air Force Research Laboratory Space Vehicles (AFRL/RV) Technology Directorate located at Kirtland Air Force Base, New Mexico. This is an administrative realignment and not a New Start.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research* | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 161.667 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 155.984 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | -5.683 | 0.000 | 0.000 | 0.000 | 0.000 |
| • Congressional General Reductions | 0.000 | 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 | 0.456 | 0.000 | | | |
| • SBIR/STTR Transfer | -1.776 | 0.000 | | | |
| • Other Adjustments | -4.363 | 0.000 | 0.000 | 0.000 | 0.000 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 625018: *Spacecraft Protection Technology* | | |
| Congressional Add: *Program increase-space situational awareness research* | 4.872 | 0.000 |
| Congressional Add Subtotals for Project: 625018 | 4.872 | 0.000 |
| **Project:** 628809: *Spacecraft Vehicle Technologies* | | |
| Congressional Add: *Program increase - operational cryogenic upper stage augmentation kit* | 9.744 | 0.000 |
| Congressional Add: *Program increase - thin-film photovoltaic energy* | 6.821 | 0.000 |
| Congressional Add: *Resilient space structure architecture* | 14.616 | 0.000 |
| Congressional Add Subtotals for Project: 628809 | 31.181 | 0.000 |
| Congressional Add Totals for all Projects | 36.053 | 0.000 |

**Change Summary Explanation**

There is no change between FY 2021 and FY 2022. The following statement is for historical context.

In FY 2021, work formerly performed under this program was moved to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, due to the creation of a new Appropriation for Space Force.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 1206601F / *Space Technology* | Project (Number/Name)<br>621010 / *Space Survivability & Surveillance* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 621010: *Space Survivability & Surveillance* | - | 40.282 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops technologies to understand and control the space environment for warfighter's future capabilities. The focus is on characterizing and forecasting the battlespace environment for more realistic space system design, modeling, and simulation, as well as the battlespace environment's effect on space systems' performance. This includes technologies to specify and forecast the space environment for planning operations, ensure uninterrupted system performance, optimize space-based surveillance operations, and provide capability to mitigate or exploit the space environment for both offensive and defensive operations. Finally, this project includes the seismic research program that supports national requirements for monitoring nuclear explosions.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Space Environment Research<br>***Description:*** Develop techniques, forecasting tools, sensors, and technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense operational space and radar systems.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Space Environment Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 18.146 | 0.000 | 0.000 |
| ***Title:*** Surveillance Technologies<br>***Description:*** Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems. | 6.020 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>621010 / *Space Survivability & Surveillance* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Surveillance Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Radiation Remediation Research<br>***Description:*** Conduct Radiation Belt Remediation research through development and validation of analytical performance models for remediation of Earth radiation belts following high altitude nuclear detonation.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Radiation Remediation Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 1.770 | 0.000 | 0.000 |
| ***Title:*** Seismic Technologies<br>***Description:*** Develop seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Seismic Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 5.809 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>621010 / *Space Survivability & Surveillance* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable | | | |
| ***Title:*** Alternative Navigation Technologies | 8.537 | 0.000 | 0.000 |
| ***Description:*** Develop new technologies based on cold atom physics that provide autonomous jam-proof precision inertial navigation to augment Global Positioning System in case of Global Positioning System-denial. Develop atomic clocks based on new technologies to replace legacy Global Positioning System atomic clocks.<br><br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Alternative Navigation Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 40.282 | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 1206601F / *Space Technology* | Project (Number/Name)<br>624846 / *Spacecraft Payload Technologies* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624846: *Spacecraft Payload Technologies* | - | 19.047 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops advanced technologies that enhance spacecraft payload operations by improving component and subsystem capabilities. The project focuses on development of advanced, space-qualified, survivable electronics, and electronics packaging technologies; development of advanced space data generation and exploitation technologies, including infrared sensors; and development of high-fidelity space simulation models that support space-based surveillance and space asset protection research and development for the warfighter.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Space-Based Detector Technologies | 3.983 | 0.000 | 0.000 |
| ***Description:*** Develop advanced infrared device technologies that enable hardened space detector arrays with improved detection to perform acquisition, tracking, and discrimination of space objects and missile warning.<br><br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Space-Based Detector Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Space Electronics Research | 4.450 | 0.000 | 0.000 |
| ***Description:*** Develop technologies for space-based payload components such as radiation-hardened electronic devices, microelectro-mechanical system devices, and advanced electronics packaging.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>624846 / *Spacecraft Payload Technologies* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| For FY 2021, this work will be performed under the Space Electronics Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Modeling and Simulation Tools for Space Applications<br>***Description:*** Develop modeling and simulation tools for space-based ground surveillance systems, rendezvous and proximity operations, imaging of space systems, disaggregated satellite architecture, and space control payloads.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Modeling and Simulation Tools for Space Applications effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 5.564 | 0.000 | 0.000 |
| ***Title:*** Alternative Positioning, Navigation, and Timing Technology<br>***Description:*** Identify and develop technologies that enable new, or enhance existing, United States positioning, navigation, and timing satellite capabilities by increasing resiliency and availability of accuracy, and/or increasing the affordability of providing current capabilities. Develop technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Alternative Positioning, Navigation, and Timing Technology effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.<br>***FY 2022 Plans:*** | 5.050 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>624846 / *Spacecraft Payload Technologies* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 19.047 | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 1206601F / *Space Technology* | Project (Number/Name)<br>625018 / *Spacecraft Protection Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 625018: *Spacecraft Protection Technology* | - | 23.753 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops the technologies for protecting United States space assets in potentially hostile environments to assure continued space system operation without performance loss in support of warfighter requirements. The project focuses on identifying and assessing spacecraft system vulnerabilities, developing threat warning technologies, and development of technologies to mitigate the effects of both intentional and unintentional threats.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Threat Warning Research | 18.881 | 0.000 | 0.000 |
| ***Description:*** Develop satellite threat warning technologies and tools for space defense. Exploit on-board inherent satellite resources, satellite-as-a-sensor, and self-aware satellite technologies. Develop technologies to detect, assess, and respond to threats and anomalies.<br><br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Threat Warning Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 625018, Spacecraft Protection Technology.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 18.881 | 0.000 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase-space situational awareness research | 4.872 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>625018 / *Spacecraft Protection Technology* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed effort.<br>***FY 2021 Plans:*** Not applicable. | | |
| **Congressional Adds Subtotals** | 4.872 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 2 | R-1 Program Element (Number/Name)<br>PE 1206601F / *Space Technology* | Project (Number/Name)<br>628809 / *Spacecraft Vehicle Technologies* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 628809: *Spacecraft Vehicle Technologies* | - | 72.902 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project focuses on spacecraft platforms (for example: structures, power, and thermal management); satellite control (signal processing and control); and space experiments of maturing technologies for space qualification.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Space Power/Thermal Research | 4.054 | 0.000 | 0.000 |
| ***Description:*** Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts.<br><br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Space Power/Thermal Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Space Structures and Controls Research | 10.115 | 0.000 | 0.000 |
| ***Description:*** Develop revolutionary and enabling technologies, including lighter weight, lower cost, high performance structures for space platforms; guidance, navigation, and controls hardware and software for next generation of space superiority systems.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>628809 / *Spacecraft Vehicle Technologies* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| For FY 2021, this work will be performed under the Space Structures and Controls Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Space Experiments<br>***Description:*** Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Space Experiments effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 21.597 | 0.000 | 0.000 |
| ***Title:*** Space Communication Technologies<br>***Description:*** Develop technologies for next-generation space communications terminals and equipment and methods/techniques to enable future space system operational command and control concepts.<br>***FY 2021 Plans:***<br>For FY 2021, this work will be performed under the Space Communication Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 5.955 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 41.721 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 2 | **R-1 Program Element (Number/Name)**<br>PE 1206601F / *Space Technology* | **Project (Number/Name)**<br>628809 / *Spacecraft Vehicle Technologies* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - operational cryogenic upper stage augmentation kit<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed effort<br>***FY 2021 Plans:*** Conduct Congressional directed effort. | 9.744 | 0.000 |
| ***Congressional Add:*** Program increase - thin-film photovoltaic energy<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed effort.<br>***FY 2021 Plans:*** Not applicable. | 6.821 | 0.000 |
| ***Congressional Add:*** Resilient space structure architecture<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed effort<br>***FY 2021 Plans:*** Not Applicable. | 14.616 | 0.000 |
| **Congressional Adds Subtotals** | 31.181 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603032F / *Future AF Integrated Technology Demos* | | | | | | | |
| **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 | - | 0.000 | 147.350 | 131.643 | 0.000 | 131.643 | - | - | - | - | - | - |
| 630320: *Air Force Vanguards* | - | 0.000 | 147.350 | 131.643 | 0.000 | 131.643 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This Program develops and delivers transformational operational capabilities through advanced technology solutions which focus on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

Department of the Air Force Vanguard programs are focused, priority initiatives with enterprise commitment which incorporate multidisciplinary solutions to advance and accelerate emerging Science and Technology driven capabilities and warfighting concepts. High risk by design, Vanguards seek to answer specific questions to inform future acquisition programs and identify gaps where additional research is still needed.

Air Force Futures (A5/7), partnered with the Assistant Secretary of the Air Force for Acquisition and the Air Force Research Laboratory, is chartered to identify and recommend emerging technologies as Vanguard candidates through a deliberate, multidisciplinary and multifunctional process. The annual Transformational Component investment process is co-chaired by the Under Secretary of the Air Force, Vice Chief of Staff of the Air Force, and Vice Chief of Space Operations. The Future Transformational Capabilities major thrust enables the Department of the Air Force to respond to these emerging Science and Technology investment opportunities within the budget cycle and "on-ramp" new Vanguards.

The current Air Force Vanguard programs are Skyborg, Golden Horde, Navigation Technology Satellite 3 (NTS-3), and Rocket Cargo. Skyborg will integrate artificial intelligence into autonomous unmanned air vehicles to enable future manned-unmanned teaming. Golden Horde will transition the demonstrated networked collaborative autonomous weapon core capability into a digital ecosystem for additional advancement. NTS-3 will experiment on key aspects for new GPS receivers which incorporate multiple signals and readily adapt to warfighter needs. Rocket Cargo will demonstrate new trajectories and ways to fly large rockets, the ability to land rockets at austere locations, and design & test an ejectable pod for air drop.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603032F / *Future AF Integrated Technology Demos* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 0.000 | 157.619 | 87.812 | 0.000 | 87.812 |
| Current President's Budget | 0.000 | 147.350 | 131.643 | 0.000 | 131.643 |
| Total Adjustments | 0.000 | -10.269 | 43.831 | 0.000 | 43.831 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | -10.269 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 0.000 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | 0.000 | 0.000 | | | |
| • Other Adjustments | 0.000 | 0.000 | 43.831 | 0.000 | 43.831 |

**Change Summary Explanation**

FY2021 decrease of 10.269 million Congressional Directed Reduction due to Unjustified request-Future Transformational Capabilities in the amount of 10.000 million and Undistributed Mark in the amount of 0.269 million.

FY2022 increase of 36.528 million to fund Rocket Cargo and provide additional support to the Skyborg and Navigation Technology Satellite 3 (NTS-3) efforts.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Future Transformational Capabilities | 0.000 | 0.000 | 9.063 |
| ***Description:*** Identify game-changing transformational Science and Technology investment opportunities through the WARfighter-TECHnologist (WARTECH) process. The WARTECH process brings together technologists and DAF requirement officials to assess the best intersection of technology readiness and DAF future force design priorities. Select programs will be designated Vanguards indicating enterprise-level priority and a transition partner endorses the program. Future Transformational Capability funds will be used to kick-start newly designated Vanguard programs to accelerate capability development and transition and respond to emerging technology opportunities within the budget cycle. | | | |
| ***FY 2021 Plans:***<br>Utilize the WARTECH process to identify, scope, curate and consider six prioritized topic areas (down-selected from fourteen topics areas) for investment consideration. These topics include: Plan Tonight to Fight Tomorrow; Real-time Battlespace Awareness; Integrated, Layered Base Defense; Hypersonic, Multi-Mission ISR/Strike; Space Logistics and Mobility; and Space Domain Awareness. These six topics will be matured and candidate programs developed for consideration by DAF for formal programming, budgeting, and execution. | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603032F / *Future AF Integrated Technology Demos* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Kick-start one or more of the six WARTECH topics and initiate Transformational Component Vanguard program(s) identified through the FY21-22 WARTECH process and approved by DAF.<br>Perform modeling, simulation, and analyses used to establish the future force effect of candidate Transformational Component investments and continue the next cycle of WARTECH process.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 9.063 million. Note FY 2021 funding allocated to Rocket Cargo major thrust. | | | |
| ***Title:*** Navigation Technology Satellite 3 (NTS-3)<br>***Description:*** Develop and demonstrate advanced space-based navigation system technologies to provide resilient navigation support in contested environments. The demonstration includes a space-based test vehicle, ground based enterprise command and control, and agile software defined receivers for the user.<br>***FY 2021 Plans:***<br>Continue development of advanced space-based navigation technology demonstration for Space launch in FY 2022. Complete spacecraft bus. Complete assembly of the spacecraft; prepare for ground test verification campaign. Verify user terminal processing of all signal definitions for one year of on-orbit experimentation. Deliver all ground control system software for integration in mission operations center. Deliver developmental user terminals to verify utility of agile signals in support of experimental objectives and establishing relevance to future concepts of operations.<br>***FY 2022 Plans:***<br>Complete development of advanced space-based navigation technology demonstration. Complete Ground Control System software and hardware, and integrate in New Mexico and Colorado ground control sites. Complete final software defined receiver hardware and release final user equipment software, and conduct end-to-end system functional test and space signal validation. Complete final system integration, test, and launch. Complete spacecraft final integration, environmental testing, and functional tests, and ship to launch site for anticipated launch. Complete system End-to-End Integration and Test. Initiate entire system checkout, once on-orbit, to prepare for experimentation with potential for follow-on residual operations led by a non-Air Force Research Laboratory organization.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $33.022 million. Funding decreased due to the transition from finishing technology development and beginning test & payload integration phase ahead of launch. | 0.000 | 49.132 | 16.110 |
| ***Title:*** Skyborg<br>***Description:*** Skyborg is an autonomous, attritable vehicle architecture suite which will enable the Air Force to posture, produce and sustain multi-mission sorties at sufficient tempo to thwart adversary attempts at quick, decisive action in contested and | 0.000 | 48.400 | 58.570 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603032F / *Future AF Integrated Technology Demos* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| highly contested environments. Skyborg is organized into three main lines of effort (LOEs). LOE 1 develops, demonstrates, and prototypes the Autonomy Core System (ACS) consisting of Skyborg autonomy architecture and software, enabling machine-machine and manned-unmanned teaming, while also ensuring openness, modularity, and expandability of the Skyborg autonomy mission systems suite. The ACS LOE also develops, demonstrates, and prototypes the hardware components and Open Architecture standards needed to allow modular sensor, communication, and other payload integration into the Skyborg autonomy and vehicle architectures in systems integration laboratories and platforms. LOE 2 (Low-cost vehicles) develops, demonstrates, and prototypes new low cost attritable vehicle concepts and technologies for expeditionary mass generation including sortie generation employment concepts. LOE 3 (Operational Experimentation) conducts analysis and experimentation on concepts of operations and concepts of employment for attritable, autonomous, unmanned systems and assesses the openness, and modular capabilities / sensors integration for autonomous, attritable, aircraft and mission systems.<br><br>***FY 2021 Plans:***<br>Initiate development and demonstration of integrated software and hardware architecture and components. Continue flight demonstration of low cost unmanned aerospace systems capable of interoperations with different assets. Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems. Continue demonstration of teaming concepts and technologies among cooperative human-machine teams in networked simulation environments. Initiate integration and demonstration of operational concepts and employment for autonomous attributable aircraft. Initiate integration and demonstrate military utility of multiple lines of effort in an operationally representative exercise.<br><br>***FY 2022 Plans:***<br>Continue development and demonstration of Skyborg Autonomy Core System hardware and software open architecture and components. Continue maturation and transition of human-machine interfaces, human systems interfaces and live, virtual & constructive technologies for command and control of autonomous systems. Continue demonstration and transition of government open architectures for autonomous unmanned systems. Continue demonstration and transition of a DevSecOps pipeline for the Skyborg Autonomy Core system software architecture. Complete development and demonstration of technologies for situational awareness, advanced autonomous behaviors, and survivability for unmanned systems. Complete demonstration of teaming concepts and technologies among cooperative human-machine teams in networked simulation environments. Continue integration, demonstration and transition of a digital engineering enterprise autonomous low-cost weapon system model and system integration laboratory.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $10.17 million. Funding increased due to planned program requirements and the development and maturation activities described above. | | | |
| ***Title:*** Golden Horde | 0.000 | 40.087 | 0.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603032F / *Future AF Integrated Technology Demos* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Integrate networked collaborative technologies into selected inventory weapon systems. Technologies can include new payloads, weapon datalinks/radios, and autonomous behaviors that are bounded by operator-defined mission rules of engagement. Supports the integration of Air Force weapons into the Joint All-Domain Command/Control network. Perform proof-of-concept demonstrations via simulations, virtual and live testing, and operational analysis, experiments and wargames to show the value of collaborative weapons in increasing combat power across the spectrum of conflict. Work with operational users to define Concepts of Operation (CONOPs).<br><br>***FY 2021 Plans:***<br>Continue to integrate networked collaborative technologies into selected weapon systems. Continue to develop technologies including new payloads, weapon datalinks/radios, and collaborative software development. Conitune to support and define the integration of Air Force weapons into the Joint All-Domain Command/Control network. Continue to implement proof-of-concept demonstrations via simulations, live testing, operational analysis, experiments, and war-games to demonstrate the viability of collaborative weapons in highly contested environments. Continue to work with operational users to define Concepts of Operation (CONOPs) in future force structures and future employment scenarios.<br><br>***FY 2022 Plans:***<br>Vanguard effort will complete efforts in FY 2022 through final demonstrations of networked collaborative technologies via simulations, testing, operational analysis, experiments and war-games. Complete work with operational users to define Concepts of Operation (CONOPs) in future force structures and future employment scenarios.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 40.087 million. Funding decreased due to the transition of technology development and initiation of final demonstrations of networked collaborative technologies with development and acquisition users. | | | |
| ***Title:*** Rocket Cargo | - | 9.731 | 47.900 |
| ***Description:*** The Department of the Air Force seeks to leverage the current multi-billion dollar commercial investment to develop the largest rockets ever, and with full reusability to develop and test the capability to leverage a commercial rocket to deliver AF cargo anywhere on the Earth in less than one hour, with a 100-ton capacity. The Air Force is not investing in the commercial rocket development, but rather investing in the Science & Technology needed to interface the capability with DoD logistics needs, and extend the commercial capability to DoD-unique missions. Provides a new, faster and cheaper solution to the existing TRANSCOM Strategic Airlift mission. Enables AFSOC to perform current Rapid-Response Missions at lower cost, and meet a one-hour response requirement. Rocket Cargo uses modeling, simulation, and analysis to conduct operational analysis, verify military utility, performance, and operational cost. S&T will include novel "loadmaster" designs to quickly load/unload a rocket, rapid launch capabilities from unusual sites, characterization of potential landing surfaces and approaches to rapidly improve those surfaces, adversary detectability, new novel trajectories, and an S&T investigation of the potential ability to air drop a | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603032F / *Future AF Integrated Technology Demos* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| payload after reentry. This is not a rocket engine or launch vehicle development program. It is an S&T effort to leverage the commercial development into a novel new DoD capability.<br><br>***FY 2021 Plans:***<br>Utilize modeling, simulation, and analysis to conduct operational analysis of Rocket Cargo concepts, trajectories, and design considerations and verify military utility, performance, and operational cost. Gather operational data from on-going commercial large-scale, instrumented, reusable launch events.<br><br>***FY 2022 Plans:***<br>Mature effort in leveraging commercial space launch to create military capability in Rocket-based Cargo delivery. Complete S&T testing leveraging the current commercial prototype testing. Perform site measurements needed to integrate the capability onto DoD missions including plume-surface physics and toxicity, loads, detectability, and acoustics. Also, complete initial AFRL wind tunnel testing to assess novel trajectories needed for air-drop capability, and high-speed separation physics. Under contract and CRADA, partner with Commercial to test and demonstrate an initial one-way transport capability to an austere site. Seek to perform an early end-to-end test to fully identify the technical challenges. In addition, complete Industry outreach for loadmaster concepts including novel container designs, load/unload concepts, and testing the compatibility of AF cargo with rocket launch and space environments. Issue solicitation and award contracts.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $38.169 million. Funding increased due to planned program requirements and the development and maturation activities described above. | | | |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 147.350 | 131.643 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603112F / *Advanced Materials for Weapon 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 | - | 58.657 | 60.059 | 31.905 | 0.000 | 31.905 | - | - | - | - | - | - |
| 632100: *Laser Hardened Materials* | - | 18.307 | 0.000 | 14.446 | 0.000 | 14.446 | - | - | - | - | - | - |
| 633153: *Non-Destructive Inspection Development* | - | 8.501 | 0.000 | 4.600 | 0.000 | 4.600 | - | - | - | - | - | - |
| 633946: *Materials Transition* | - | 31.849 | 60.059 | 12.859 | 0.000 | 12.859 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates advanced materials and process technologies to satisfy Department of the Air Force requirements in areas such as survivability, readiness, affordability, and new processes and materials. These projects ensure the Department of the Air Force weapon systems are ready and able when needed.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 60.086 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 58.657 | 60.059 | 31.905 | 0.000 | 31.905 |
| Total Adjustments | -1.429 | 60.059 | 31.905 | 0.000 | 31.905 |
| • Congressional General Reductions | 0.000 | 0.000 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 25.000 | | | |
| • Congressional Directed Transfers | 0.000 | 35.169 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -1.429 | 0.000 | | | |
| • Other Adjustments | 0.000 | -0.110 | 31.905 | 0.000 | 31.905 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 632100: *Laser Hardened Materials* | | |
| Congressional Add: *Advanced ballistic eyewear* | 2.436 | - |
| Congressional Add Subtotals for Project: 632100 | 2.436 | - |
| **Project:** 633153: *Non-Destructive Inspection Development* | | |
| Congressional Add: *Artificial intelligence enhanced life cycle management* | 1.949 | 0.000 |
| Congressional Add Subtotals for Project: 633153 | 1.949 | 0.000 |
| **Project:** 633946: *Materials Transition* | | |
| Congressional Add: *Program increase - Metals Affordability Research* | 9.744 | 10.000 |
| Congressional Add: *Program Increase - Composites technology* | 8.770 | 6.000 |
| Congressional Add: *Additive manufacturing for aerospace components* | 0.000 | 5.000 |
| Congressional Add: *Advanced ballistic eyewear* | 0.000 | 4.000 |
| Congressional Add Subtotals for Project: 633946 | 18.514 | 25.000 |
| Congressional Add Totals for all Projects | 22.899 | 25.000 |

**Change Summary Explanation**

Increase in FY 2022 is due Congressional realignment of advanced materials efforts back to this program element.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603112F / *Advanced Materials for Weapon Systems* | Project (Number/Name)<br>632100 / *Laser Hardened Materials* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 632100: *Laser Hardened Materials* | - | 18.307 | 0.000 | 14.446 | 0.000 | 14.446 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates advanced materials technologies that enhance protection for Department of the Air Force personnel to ensure safety and to enable them to perform required missions in threat environments. Advanced materials technologies also enhance protection for Department of the Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Aerospace Systems Protection | 7.459 | 0.000 | 8.387 |

***Description:*** Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of Department of the Air Force systems.

***FY 2021 Plans:***

Continue to assess the demonstrated results and transition the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/near, short-wave, and mid-wave infrared detectors. Continue transitioning new technologies and integrate the developments into light, operator friendly survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue analyzing the high-performance properties of damage limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue to transition developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continue to advance the employment and integration of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Transition and continue technology development and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions. Initiate development of materials for survivable next generation aircraft sensor systems.

***FY 2022 Plans:***

Continue to validate and assess the demonstrated results and transition the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/near, short-wave, and mid-wave infrared detectors. Continue transitioning new technologies and integrate the developments into light, operator friendly survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue analyzing the high-performance properties of damage limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue to transition developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continue to advance the employment and integration

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>632100 / *Laser Hardened Materials* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Transition and continue technology development and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions. Continue development of materials for survivable next generation aircraft sensor systems.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding increased compared to FY 2021 by $8.387 million. Funding increase is due to increased emphasis on Aerospace Systems Protection. | | | |
| ***Title:*** Aircrew Protection<br>***Description:*** Develop and demonstrate materials technologies that enhance protection for Department of the Air Force personnel to ensure safety and to enable crews to perform required missions in a threat environment.<br>***FY 2021 Plans:***<br>Continue to develop, validate, demonstrate, and transition laser protection materials and technologies for personnel protection. Continue to validate and develop light-weight helmet-mounted sensor hardening materials focusing on next-generation nighttime specialized sensors. Continue to advance transition efforts and development of visor based aircrew protection materials with agile protection. Continue to evaluate and assess new materials and advances in characterization and demonstration of eye protection technologies using computational materials science tools. Continue to transition, validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. Continue development and testing of materials technologies to protect against nuclear flash blindness.<br>***FY 2022 Plans:***<br>Continue to develop, validate, demonstrate, and transition laser protection materials and technologies for personnel protection. Continue to validate and develop light-weight helmet-mounted sensor hardening materials focusing on next-generation nighttime specialized sensors. Continue to advance transition efforts and development of visor based aircrew protection materials with agile protection. Continue to evaluate and assess new materials and advances in characterization and demonstration of eye protection technologies using computational materials science tools. Continue to transition, validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. Continue development and testing of materials technologies to protect against nuclear flash blindness.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $6.059 million. Funding increased due to increased emphasis aircrew protection. | 8.412 | 0.000 | 6.059 |
| **Accomplishments/Planned Programs Subtotals** | 15.871 | 0.000 | 14.446 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>632100 / *Laser Hardened Materials* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Advanced ballistic eyewear | 2.436 | - |
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts. | | |
| **Congressional Adds Subtotals** | 2.436 | - |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603112F / *Advanced Materials for Weapon Systems* | Project (Number/Name)<br>633153 / *Non-Destructive Inspection Development* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633153: *Non-Destructive Inspection Development* | - | 8.501 | 0.000 | 4.600 | 0.000 | 4.600 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates advanced nondestructive inspection and evaluation technologies to monitor performance integrity and to detect failure causing conditions in weapon systems components and materials. Nondestructive inspection and evaluation capabilities greatly influence and/or limit many design, manufacturing, and maintenance practices. This project provides technology to satisfy Department of the Air Force requirements to extend the lifetime of current systems through increased reliability and cost-effectiveness at field and depot maintenance levels. Equally important is assuring manufacturing quality, integrity, and safety requirements are built in.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Advanced Engine Inspection Technologies | 1.638 | 0.000 | 0.000 |
| ***Description:*** Develop and demonstrate advanced technologies to improve capabilities to inspect for cracks and other damage to extend the total safe life of turbine engines.<br><br>***FY 2021 Plans:***<br>Completed development of nondestructive inspection/evaluation tools including additive manufacturing processes, and the assessment of materials and damage state of critical turbine engine components for the purpose of extending their useful life without increasing the risk of in-flight fracture. Completed the validation process for model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrated tool automation for high confidence repeatable results, including advanced manufacturing processes.<br><br>***FY 2022 Plans:***<br>Technical work in this effort completed in FY 2021.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not Applicable | | | |
| ***Title:*** Special Material Inspection Technologies | 1.245 | 0.000 | 0.751 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633153 / *Non-Destructive Inspection Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability.<br><br>***FY 2021 Plans:***<br>Continue the transition process to depots and flight lines for improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Continue to validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation for robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.<br><br>***FY 2022 Plans:***<br>Continue the transition process to depots and flight lines for improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage to special materials that enables/ensures more affordable coatings assessment. Continue to validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation for robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.751 million. Funding increased due to increased emphasis special materials inspection technologies. | | | |
| ***Title:*** Advanced System Monitoring Technologies | 3.669 | 0.000 | 2.212 |
| ***Description:*** Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems.<br><br>***FY 2021 Plans:***<br>Continue to demonstrate advanced analytical methods to more accurately assess the location, and register spatial location, of damage detected using nondestructive inspection data and results. Develop augmented reality technologies to improve the process of performing non-destructive evaluation tasks, acquiring and archiving data and reporting results, and enabling improved inspector guidance and visualization. Continue development and transition of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for compiling, reporting, collecting and rapidly analyzing digital nondestructive testing and evaluation data necessary for improved damage detection and characterization. Demonstrate and transition technologies to locate damage to composite structures without coating removal and | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633153 / *Non-Destructive Inspection Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| to inspect composite structures with complex geometry. Continue the transition and integration of computational materials science tools with provide data necessary for life prediction methods to enable risk-based life management.<br><br>***FY 2022 Plans:***<br>Continue to demonstrate advanced analytical methods to more accurately assess the location, and register spatial location, of damage detected using nondestructive inspection data and results. Develop augmented reality technologies to improve the process of performing non-destructive evaluation tasks, acquiring and archiving data and reporting results, and enabling improved inspector guidance and visualization. Continue development and transition of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for compiling, reporting, collecting and rapidly analyzing digital nondestructive testing and evaluation data necessary for improved damage detection and characterization. Demonstrate and transition technologies to locate damage to composite structures without coating removal and to inspect composite structures with complex geometry. Continue the transition and integration of computational materials science tools with provide data necessary for life prediction methods to enable risk-based life management.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 2.212 million. Increased funding due to increased emphasis on advances systems monitoring technologies. | | | |
| ***Title:*** Transformational Technology Development<br><br>***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: technologies for inspection and evaluation to detect failures and influence design, manufacturing, and maintenance. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:***<br>N/A. This effort is starting in FY 2022.<br><br>***FY 2022 Plans:*** | 0.000 | 0.000 | 1.637 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633153 / *Non-Destructive Inspection Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 22 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.637 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| **Accomplishments/Planned Programs Subtotals** | 6.552 | 0.000 | 4.600 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Artificial intelligence enhanced life cycle management | 1.949 | 0.000 |
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts. | | |
| ***FY 2021 Plans:*** Not applicable | | |
| **Congressional Adds Subtotals** | 1.949 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603112F / *Advanced Materials for Weapon Systems* | Project (Number/Name)<br>633946 / *Materials Transition* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633946: *Materials Transition* | - | 31.849 | 60.059 | 12.859 | 0.000 | 12.859 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates advanced materials and processing technologies for fielded and planned Department of the Air Force weapon, airframe, and propulsion applications. Advanced materials and processes that have matured beyond applied research are characterized, critical data are collected, and critical evaluations in the proposed operating environment are performed. This design and scale-up data improves the overall affordability of promising materials and processing technologies, providing needed initial incentives for their industrial development.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Air Vehicle Materials Technologies | 7.599 | 19.283 | 10.999 |
| ***Description:*** Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, Low Observable (LO) performance, power generation management, survivability, and affordability of air vehicles.<br><br>***FY 2021 Plans:***<br>Continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. Continue development and characterization for transitioning materials to protect infrared apertures on next generation hardened assets. Continue to validate and verify results of microstructure sensitive lifing methodologies that lower life cycle cost and advance performance characteristics of airframe and engine components in order to initiate development of next generation modeling tools that incorporate residual stress effects on component life. Initiate development and characterization of materials for application in nuclear systems and protected infra-red apertures for next-generation hardened assets.<br><br>***FY 2022 Plans:***<br>Continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. Continue development and characterization for transitioning materials to protect infrared apertures on next generation hardened assets. Continue to validate and verify results of microstructure sensitive lifing methodologies that lower life cycle cost and advance performance characteristics of airframe and engine components in order to initiate development of next generation | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633946 / *Materials Transition* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| modeling tools that incorporate residual stress effects on component life. Continue development and characterization of materials for application in nuclear systems and protected infra-red apertures for next-generation hardened assets.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $8.284 million. Funding decreased due to decreased emphasis on air vehicles materials technology. | | | |
| ***Title:*** High Temperature Material Technologies<br><br>***Description:*** Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for the Department of the Air Force global strike concepts.<br><br>***FY 2021 Plans:***<br>Completed transition of 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components to industry. Completed development of high performance metals for next-generation turbine disk and low cost propulsion, aerostructure and munitions components. Completed development and demonstrated advanced materials and process controls to enable complex structural components via additive manufacturing. Completed establishment of a metallic additive design center. Completed development of low cost metallic turbine engine disks made via powder processing technologies for use in high temperature, aggressive environments. Completed transition of computational and data analytics tools that enable production of affordable, complex shape metal components made via additive manufacturing. Completed work on multimaterial structures that optimally address operational temperature zones for hot structure and expendable thermal protection systems made out of advanced ceramics, ceramic matrix composites, hybrids, advanced and affordable metals, and intermetallics.<br><br>***FY 2022 Plans:***<br>Work in this effort completed in FY 2021.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding decreased compared to FY 2021 by $15.776 million. Funding decreased due to completion of effort in FY 2021. | 2.000 | 15.776 | 0.000 |
| ***Title:*** Pervasive and Affordable Metals Technologies<br><br>***Description:*** Develop and demonstrate affordable, novel high temperature powder processing materials/structures and additive metals technology concepts to enable future defense capabilities air vehicle propulsion and computational prediction models.<br><br>***FY 2021 Plans:***<br>In FY 2021, this effort moved to the Pervasive and Affordable Metals Technologies effort in PE 0602102F, Materials, Project 624347, Materials for Structures, Propulsion, and Subsystems.<br><br>***FY 2022 Plans:*** | 3.736 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633946 / *Materials Transition* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable | | | |
| ***Title:*** Transformational Technology Development | - | 0.000 | 1.860 |
| ***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: advanced materials and processing technologies for to influence design and scale-up activities. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:***<br>N/A. This effort is starting in FY 2022.<br><br>***FY 2022 Plans:***<br>Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 22 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.860 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| **Accomplishments/Planned Programs Subtotals** | 13.335 | 35.059 | 12.859 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - Metals Affordability Research<br><br>***FY 2020 Accomplishments:*** Conducted Congressional directed efforts.<br><br>***FY 2021 Plans:*** Conduct Congressional directed efforts. | 9.744 | 10.000 |
| ***Congressional Add:*** Program Increase - Composites technology | 8.770 | 6.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603112F / *Advanced Materials for Weapon Systems* | **Project (Number/Name)**<br>633946 / *Materials Transition* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| ***Congressional Add:*** Additive manufacturing for aerospace components<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 5.000 |
| ***Congressional Add:*** Advanced ballistic eyewear<br>***FY 2020 Accomplishments:*** Not Applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. These efforts will be executed in project 632100 of this program. | 0.000 | 4.000 |
| **Congressional Adds Subtotals** | 18.514 | 25.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603199F / *Sustainment Science and Technology (S&T)* | | | | | | | |
| **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 | - | 14.376 | 16.902 | 21.057 | 0.000 | 21.057 | - | - | - | - | - | - |
| 635351: *Technology Sustainment* | - | 14.376 | 16.902 | 21.057 | 0.000 | 21.057 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates mature Air Force Research Laboratory (AFRL) sustainment technologies such as: materials, corrosion, maintenance/ repair techniques, state awareness/non-destructive inspection, health management, life prediction, low observable materials and processes, composite materials and logistics for transition into fielded Department of the Air Force systems to reduce life cycle sustainment costs and increase readiness. Technologies matured and demonstrated impact affordability and availability of fielded aerospace weapon systems by reducing sustainment costs, extending service life, and maintaining mission readiness and capability. This program develops and demonstrates maintenance, life cycle management, and system/fleet decision making technologies that can be implemented to address operational sustainment issues and could influence future system sustainability decisions via risk reduction to support inclusion into new systems. Studies are conducted to analyze processes and methodologies for application of technologies to address sustainment issues across the force, identifying cross cutting applications for fielded systems, and opportunities for building in sustainability into future applications. This program also develops and demonstrates affordable advanced composites for aircraft structures of fielded and emerging systems. This includes studies, analysis, and tests for application of composites to address sustainment and affordability issues across the force. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603199F / *Sustainment Science and Technology (S&T)* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 16.249 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 14.376 | 16.902 | 21.057 | 0.000 | 21.057 |
| Total Adjustments | -1.873 | 16.902 | 21.057 | 0.000 | 21.057 |
| • Congressional General Reductions | 0.000 | -0.031 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 16.933 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.571 | 0.000 | | | |
| • Other Adjustments | -1.302 | 0.000 | 21.057 | 0.000 | 21.057 |

**Change Summary Explanation**

Increase in FY 2022 is due to increase emphasis in transformational sustainment technologies for fielded and future systems.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** System Health Management/Assessment Technologies | 4.512 | 5.510 | 0.000 |
| ***Description:*** Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future Department of the Air Force applications. The short-term tasks in this area are selected based on warfighter needs identified via a semi-annual, competitive process.<br><br>***FY 2021 Plans:***<br>Completed the development of a system to reduce maintenance requirements of carbon monoxide detection system. Completed health assessments and capability development for fielded air/space/cyber systems and components. Completed development and demonstration of diagnostic technology airframe/engine, launch vehicle, spacecraft, intercontinental ballistic missiles (ICBMs), and components.<br><br>***FY 2022 Plans:***<br>Technical work on this effort completed in FY 2021.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding decreased compared to FY 2021 by $5.510 million. Funding decreased due to completion of effort and an increased emphasis on transformational technologies. | | | |
| ***Title:*** Prevention/Enhanced Maintainability Technologies | 5.216 | 5.885 | 5.854 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603199F / *Sustainment Science and Technology (S&T)* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, replacement, and concepts for performance improvement and reduced maintenance burden for the Department of the Air Force. Short term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process.<br><br>***FY 2021 Plans:***<br>Continue rapid repair and materials development for aircraft battle damage repair of advanced fighter aircraft. Continue advanced canopy technology development. Continue total body nondestructive evaluation system for outer mold line inspection of advanced fighter aircraft. Continue development of materials and processes to reduce maintenance burden on low observable systems. Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue to develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, repair, replacement, and concepts for maintainer training, extending part life, and reduced maintenance burden spanning Air Force mission areas of Air, Space, and Cyber. Continue to develop abrasion resistance coating to protect composite material substrates for low observable systems. Continue to develop a flexible crack-blunting primer. Initiate other new efforts based on competitive selection processes in FY 2020.<br><br>***FY 2022 Plans:***<br>Continue rapid repair and materials development for aircraft battle damage repair of advanced fighter aircraft. Continue advanced canopy technology development. Continue total body nondestructive evaluation system for outer mold line inspection of advanced fighter aircraft. Continue development of materials and processes to reduce maintenance burden on low observable systems. Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue to develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, repair, replacement, and concepts for maintainer training, extending part life, and reduced maintenance burden spanning Department of the Air Force mission areas of Air, Space, and Cyber. Continue to develop abrasion resistance coating to protect composite material substrates for low observable systems. Continue to develop a flexible crack-blunting primer. Initiate other new efforts based on competitive selection processes in FY 2021.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.031 million. Funding decreased due to plans described above. | | | |
| ***Title:*** Management/Improved Reliability Technologies<br><br>***Description:*** Develop, demonstrate, and transition technologies to improve existing and new components, fleet management/ decision-making tools, and supply chain/sustainment infrastructure to decrease downtime and costs, and increase reliability. The short-term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process. | 4.648 | 5.507 | 5.477 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603199F / *Sustainment Science and Technology (S&T)* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue system development to provide prognostic capabilities for avionics components and analysis techniques to extend engine component service life. Continue efforts to develop system fleet management decision-making tools, maintenance/repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. These efforts span Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2020.<br>***FY 2022 Plans:***<br>Continue system development to provide prognostic capabilities for avionics components and analysis techniques to extend engine component service life. Continue efforts to develop system fleet management decision-making tools, maintenance/repair database technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. These efforts span Department of the Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2021.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.030 million. Funding decreased due to the plans described above. | | | |
| ***Title:*** Transformational Technology Development<br>***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: materials, corrosion, maintenance/repair techniques, state awareness/non-destructive inspection, health management, life prediction, low observable materials and processes, composite materials and logistics technologies that affect mission availability. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br>***FY 2021 Plans:***<br>Not applicable<br>***FY 2022 Plans:***<br>Fund the follow-on efforts for projects started in FY 2021. Select Transformational Technology Development efforts that support the National Defense Strategy and Department of the Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | - | 0.000 | 9.726 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603199F / *Sustainment Science and Technology (S&T)* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by 9.726 million. Funding is increased due to additional emphasis in transformational activities. | | | |
| **Accomplishments/Planned Programs Subtotals** | 14.376 | 16.902 | 21.057 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603203F / *Advanced Aerospace Sensors* | | | | | | | |
| **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 | - | 40.116 | 35.274 | 44.730 | 0.000 | 44.730 | - | - | - | - | - | - |
| 63665A: *Advanced Aerospace Sensors Technology* | - | 23.101 | 35.274 | 19.664 | 0.000 | 19.664 | - | - | - | - | - | - |
| 6369DF: *Target Attack and Recognition Technology* | - | 17.015 | 0.000 | 25.066 | 0.000 | 25.066 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

The program develops and demonstrates advanced technologies for electro-optical sensors, radar sensors and electronic counter-countermeasures, and components and algorithms. It also develops and demonstrates radio frequency (RF) and electro-optical (EO) sensors for detecting, locating, and targeting airborne, fixed, and time-critical mobile ground targets obscured by natural or man-made means. This program develops the means to find, fix, target, track, and engage air and ground targets anytime, anywhere, and in any weather. This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 42.292 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 40.116 | 35.274 | 44.730 | 0.000 | 44.730 |
| Total Adjustments | -2.176 | 35.274 | 44.730 | 0.000 | 44.730 |
| • Congressional General Reductions | 0.000 | -0.064 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 35.338 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.836 | 0.000 | | | |
| • Other Adjustments | -1.340 | 0.000 | 44.730 | 0.000 | 44.730 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 63665A: *Advanced Aerospace Sensors Technology* | | |
| Congressional Add: *Program increase - Sensor integration to support ISR operations* | 3.921 | 0.000 |
| Congressional Add Subtotals for Project: 63665A | 3.921 | 0.000 |
| Congressional Add Totals for all Projects | 3.921 | 0.000 |

**Change Summary Explanation**

FY 2020 Other Adjustments: Decrease of $1.340 million due to Air Force reprogramming.

FY 2021 and FY 2022 Congressional Directed Transfers: $35.338 million increase due to Congressional realignment.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603203F / *Advanced Aerospace Sensors* | Project (Number/Name)<br>63665A / *Advanced Aerospace Sensors Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63665A: *Advanced Aerospace Sensors Technology* | - | 23.101 | 35.274 | 19.664 | 0.000 | 19.664 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project area develops and demonstrates aerospace sensor and processing technologies for intelligence, surveillance, reconnaissance, target, and attack radar applications in both manned and unmanned platforms, including electro-optical sensors and electronic counter-countermeasures for radars. It provides aerospace platforms with the capability to precisely detect, track, and target both airborne (conventional and low radar cross-section) and ground-based, high-value, time-critical targets in adverse clutter and jamming environments. Project activities include developing multi-function radio-frequency systems including radar and electronic warfare technology and the position and timing information to enable distributed sensing. Desired warfighting capabilities include the ability to detect concealed targets in difficult background conditions.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Persistent Sensing in Contested Environment Technologies | 2.693 | 2.903 | 0.000 |
| ***Description:*** Develop active radio frequency sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced radio frequency architectures for open and reconfigurable systems. Enable persistent intelligence, surveillance and reconnaissance over wide areas, and detect advanced air and ground targets. | | | |
| ***FY 2021 Plans:***<br>Analyze results of airborne ground moving target indication data collections. Continue advanced multi-static ground moving target indication radar demonstration, increasing complexity with additional transmit degrees of freedom from multiple transmit platforms. Continue analysis of asynchronous noise waveform performance with multiple transmitters. Initiate evaluation of spacetime adaptive processing algorithm performance using synthetic and real flight data. Initiate investigation of novel algorithms with processing distributed across multiple receive platforms. Initiate system-of-systems design to optimize transmit/receive architecture. | | | |
| ***FY 2022 Plans:***<br>Not applicable | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>63665A / *Advanced Aerospace Sensors Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by 2.903 million. Funding decreased due to realignment to Project 63665A, Advanced Aerospace Sensors Technology, Passive/Multi-Mode Sensing effort and Transformational Technology Development effort. | | | |
| ***Title:*** Passive/Multi-Mode Sensing<br><br>***Description:*** Develop advanced techniques and prototype passive radio frequency sensors to intercept, collect, locate and track enemy radio frequency sensor systems for intelligence, surveillance and reconnaissance of air and ground targets.<br><br>***FY 2021 Plans:***<br>Conduct real-time passive radar illumination selection manager demonstrations using realistic operational environments. Conduct development of advanced passive radar modes and signal processing algorithms. Initiate advancement of electronic support subsystems to incorporate wide bandwidth receivers and agile emitter tracking. Initiate implementation of passive radar modes using wideband arrays with rapid digital beamforming capabilities. Initiate integration of electronic support, illumination selection manager, and passive radar subsystems to develop full passive multi-mode radar system for future ground/airborne demonstration.<br><br>***FY 2022 Plans:***<br>Continue development and ground demonstrations of illumination selection manager to address more complex signal environments and implementation in open architectures. Complete platform level modeling to evaluate key parameters for passive multi-mode radar performance. Continue mission level modeling to evaluate passive multi-mode system effectiveness for relevant scenarios. Continue implementation of electronic support, passive radar and illumination selection manager subsystems in advanced digital antenna architectures. Initiate implementation of illumination selection manager into sensor resource manager. Complete systems engineering study to identify subsystem enhancements for airborne passive multi-mode. Begin integration of illumination selection manager and/or passive multi-mode radar on existing airborne platforms. Initiate planning for airborne passive multi-mode demonstration.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.040 million. Increase is due to realignment of funding from Project 63665A, Advanced Aerospace Sensors Technology, Persistent Sensing in Contested Environment Technologies effort and Long Range Sensing Technologies effort. | 4.958 | 5.777 | 6.817 |
| ***Title:*** Long Range Sensing Technologies<br><br>***Description:*** Develop radio frequency sensor technology to detect, locate, and identify air and ground targets at long ranges, including those that are low-observable, or use deception or camouflage.<br><br>***FY 2021 Plans:*** | 2.617 | 2.785 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>63665A / *Advanced Aerospace Sensors Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Initiate analysis of over-the-horizon radar data collections to demonstrate novel algorithms for detection and high accuracy tracking of highly maneuvering targets. Conduct development of passive over-the-horizon radar systems to provide predicted performance against challenging targets including cruise missiles and hypersonic vehicles. Conduct development of low cost radio frequency payloads for small satellites. Initiate detailed component design and prototype payload fabrication.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.785 million. Funding decreased due to realignment to Project 63665A, Advanced Aerospace Sensors Technology, Passive/Multi-Mode Sensing effort and Transformational Technology Development effort. | | | |
| ***Title:*** Triple Raven Advance Technology Demonstration<br>***Description:*** Advance, demonstrate, and transition innovative imaging and non-imaging optical sensing technologies for surveillance and reconnaissance of airborne and ground-based objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities.<br>***FY 2021 Plans:***<br>Begin integration of dual-band detector system onto the new unobscured freeform afocal telescope and begin integration into a stable optical gimbal in preparation for flight testing. Perform sensor trade studies to extend dual-band extended range imaging to provide full multi-spectral imaging capabilities - equivalent to today's multi-camera systems. Develop high power agile waveform laser, processing algorithms, and photon-counting detectors. Conduct a bread-board demonstration of the laser radar system on a laboratory-class aircraft at short ranges to allow early risk-reduction of entire system.<br>***FY 2022 Plans:***<br>Continue design and development of complete surveillance demonstration system. Complete development of laser radar transmitter, receiver, and integrate with passive imaging systems and control system. Conduct lab testing of entire system. Prepare for long-range ground demonstration of system at government test range.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.166 million. Justification for this decrease is described in plans above. | 0.000 | 7.942 | 7.776 |
| ***Title:*** Passive Electro-Optical Sensing for Surveillance and Reconnaissance Technologies<br>***Description:*** Advance, demonstrate, and transition innovative imaging and non-imaging optical sensing technologies for surveillance and reconnaissance of airborne and ground-based objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities. | 5.406 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>63665A / *Advanced Aerospace Sensors Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Triple Raven Advanced Technology Demonstration effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Laser Radar for Non-Cooperative Identification<br>***Description:*** Advance, demonstrate, and transition innovative laser radar sensing technologies for non-cooperative identification of airborne and ground objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems and components necessary to yield new capabilities.<br>***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Triple Raven Advanced Technology Demonstration effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 3.506 | 0.000 | 0.000 |
| ***Title:*** Transformational Technology Development<br>***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to electro-optical and radio frequency sensors, components, and algorithms. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br>***FY 2021 Plans:*** | 0.000 | 0.000 | 5.071 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>63665A / *Advanced Aerospace Sensors Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2022 Plans:***<br>Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $5.071 million. Funding was realigned from Project 63665A, Advanced Aerospace Sensors Technology, Persistent Sensing in Contested Environment Technologies and Long Range Sensing Technologies efforts. | | | |
| ***Title:*** Multidomain Analytic Development - Evolution<br>***Description:*** Develop enabling capabilities and technical know-how required for Department of the Air Force multi-domain command and control within highly contested environments through closed-loop central and decentralized sensing for battle management, automated onboard systems that use complex reasoning for situational awareness (SA) leading "intelligent" response, executive reasoning for selectable re-planners that provide task allocation. Use of shared models with both onboard reasoners and mission simulation and evaluation. Built with government-owned scalable closed-loop algorithms.<br>***FY 2021 Plans:***<br>Develop improvements over state-of-the-art analytics with automated multi-sensor fusion and predictive analytics, Pattern of Life (PoL) modeling and persistent monitoring, and graph-based World Model representation. Mature techniques for persistent and immediate observation of anomalous behavior. Continue creation of a government owned testbed and user system with closed-loop reasoning and modular, well-characterized algorithms. Continue development of the World Model representation to improve the current intelligence data/analysis "stovepipes," for deeper analytics.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 6369DF, Target Attack and Recognition Technology, Multidomain Analytic Development - Evolution effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 15.867 million. The decrease is due to the realignment of funding to Project 6369DF, Target Attack and Recognition Technology, Multidomain Analytic Development - Evolution effort. | 0.000 | 15.867 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 19.180 | 35.274 | 19.664 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - Sensor integration to support ISR operations | 3.921 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>63665A / *Advanced Aerospace Sensors Technology* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conduct Congressional directed efforts<br>***FY 2021 Plans:*** Not applicable | | |
| **Congressional Adds Subtotals** | 3.921 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
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| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603203F / *Advanced Aerospace Sensors* | Project (Number/Name)<br>6369DF / *Target Attack and Recognition Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6369DF: *Target Attack and Recognition Technology* | - | 17.015 | 0.000 | 25.066 | 0.000 | 25.066 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project area develops and demonstrates advanced technologies for closed-loop, multi-domain, multi-intelligence sources, multi-platform, multi-sensor automation and autonomy, providing capabilities in battle management, fire control, battlespace awareness and visualization, predictive analytics, target recognition, sensor and information fusion, and sensor / platform asset tasking. This project also conducts advanced investigations to determine solution credibility, in terms of underlying technology and in terms of consistency with future Air Force missions within highly contested environments. This project includes robust techniques to support intelligence, surveillance, and reconnaissance and targeting missions within adverse weather conditions and against adversaries employing deceptive techniques. This project includes development of software-intensive solutions suitable for cloud-based integration and for development/operations-like operational environments. This project develops technology for effective management of online and offline information sources incorporating both constrained and cooperative sensing. This project has been realigned to better reflect technical areas being emphasized such as autonomy, multi-domain and multi-sensor information processing, leverage of machine learning developments and enterprise-level modeling, simulation and analysis.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Advanced Multi-Source Exploitation | 3.655 | 0.000 | 0.000 |
| ***Description:*** Demonstrate multi-source behavioral and physical knowledge generation algorithms on operational data sets for specific customers and evaluate the performance of the algorithms with respect to contested environment scenarios. Investigate methods for reducing the size, weight and power footprint of information fusion techniques to enable technology transition. Automate algorithm components to increase warfighter efficiency by reducing human-in-the-loop timeframes. Develop intelligent reasoning capabilities that inform operators with respect to information requirements to improve/enable mission success, for example, autonomously recommend additional data collection geometries/scenarios to enhance fusion for synthesis performance. | | | |
| ***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytics Development - Evolution effort. | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
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| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>6369DF / *Target Attack and Recognition Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Advanced Modeling, Simulation and Analysis for Multi-Intelligence/Domain Fusion<br>***Description:*** This advanced research will concentrate on leveraging existing modeling, simulation and analysis tactics, techniques and procedures as well as advancing the multi int/domain fusion of information to understand with greater fidelity how current and future generations of intelligence, surveillance and reconnaissance air, space and cyber sensing can be most effectively applied to the battlespace.<br>***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytics Development - Evolution effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 4.815 | 0.000 | 0.000 |
| ***Title:*** Sensing Assignments and Multisource Analytics<br>***Description:*** Develop advanced techniques for multi-domain closed-loop sensing that apply predictive analytics to available information, inferring candidate course-of-action hypotheses and recommending confirmatory/refutative sensing tasks.<br>***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytics Development - Evolution effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 8.545 | 0.000 | 0.000 |
| ***Title:*** Multidomain Analytic Development - Evolution<br>***Description:*** Develop enabling capabilities and technical know-how required for Department of the Air Force multi-domain command and control within highly contested environments through closed-loop central and decentralized sensing for battle | 0.000 | 0.000 | 16.399 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>6369DF / *Target Attack and Recognition Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| management, automated onboard systems that use complex reasoning for situational awareness (SA) leading "intelligent" response, executive reasoning for selectable re-planners that provide task allocation. Use of shared models with both onboard reasoners and mission simulation and evaluation. Built with government-owned scalable closed-loop algorithms.<br><br>***FY 2021 Plans:***<br>For FY 2021, this work is performed under Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytic Development - Evolution effort.<br><br>***FY 2022 Plans:***<br>Continue development of a prototype capability supporting the generation, evaluation, modification, and fielding of activity models for real-time use in automatically characterizing adversary behavior. Continue to demonstrate that activity modeling is a portable process, applicable to indications and warnings against a broad range of adversary activity. Continue integration of new component capabilities aimed at augmenting existing Department of the Air Force capability by developing processes used to generate adversary activity models and using those models to automatically generate indications and warnings alerts. Continue to integrate all components in an open-architecture testbed running on a cloud based environment.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $16.399 million. The increase is due to the realignment of funding from Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytic Development - Evolution effort. | | | |
| ***Title:*** Resilient & Agile Mission Systems Architecture | 0.000 | 0.000 | 4.185 |
| ***Description:*** This project performs advanced development and demonstration of methods, technologies, and tools to enable resilience and protect mission systems against threats. This involves open and adaptable architectures for rapid integration and agile systems, cyber protections and resilience technologies to protect against threats. It integrates research efforts in electronic and cyber warfare to demonstrate novel operational capabilities through laboratory, field, and flight tests and experimentation. The goal is to reduce risk for rapid transition of novel operational capabilities into Air Force mission systems.<br><br>***FY 2021 Plans:***<br>Not applicable<br><br>***FY 2022 Plans:***<br>Evolve and mature open architecture standards. Initiate development of advanced networking, processing, advanced computing paradigms, and cybersecurity technologies for next-generation avionics mission system capabilities. Apply agile software | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>6369DF / *Target Attack and Recognition Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| technologies and digital engineering techniques for rapid and affordable development, integration, and prototype capability demonstrations.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.185 million. Increase is due to realignment of funding from Project 63665A, Advanced Aerospace Sensors Technology, Multidomain Analytics Development - Evolution effort. | | | |
| ***Title:*** Transformational Technology Development<br><br>***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to closed-loop, multi-domain, multi-intelligence sources, multi-platform, multi-sensor automation and autonomy, providing capabilities in battle management, fire control, battlespace awareness and visualization, predictive analytics, target recognition, sensor and information fusion, and sensor/platform asset tasking. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:***<br>Not applicable<br><br>***FY 2022 Plans:***<br>Select new Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.482 million. Funding is increased due to Air Force reprogramming. | 0.000 | 0.000 | 4.482 |
| **Accomplishments/Planned Programs Subtotals** | 17.015 | 0.000 | 25.066 |

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

N/A

**Remarks**

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603203F / *Advanced Aerospace Sensors* | **Project (Number/Name)**<br>6369DF / *Target Attack and Recognition Technology* |

**D. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603211F / *Aerospace Technology Dev/Demo* | | | | | | | |
| **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 | - | 95.730 | 62.117 | 70.486 | 0.000 | 70.486 | - | - | - | - | - | - |
| 634094: *Next Gen Platform Dev/ Demo* | - | 0.000 | 0.000 | 17.288 | 0.000 | 17.288 | - | - | - | - | - | - |
| 634920: *Flight Vehicle Tech Integration* | - | 40.860 | 62.117 | 36.788 | 0.000 | 36.788 | - | - | - | - | - | - |
| 634926: *High Speed Systems Integ & Demo* | - | 32.849 | 0.000 | 11.058 | 0.000 | 11.058 | - | - | - | - | - | - |
| 634927: *Flight Systems Control* | - | 22.021 | 0.000 | 5.352 | 0.000 | 5.352 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program supports Department of Defense (DoD) priorities for demonstrations in hypersonics and manned/unmanned systems, respectively. This effort integrates and demonstrates advanced flight vehicle technologies that improve the performance and supportability of existing and future aerospace vehicles. System level integration brings together aerospace vehicle technologies along with avionics, propulsion, and weapon systems for demonstration in a near-realistic operational environment. Integration and technology demonstrations reduce the risk and time required to transition technologies into operational aircraft. Projects in this program have been coordinated through the DoD Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

In FY 2022, the seismic technologies efforts of PE 1206616SF, Space Advanced Technology Development/Demo, were transferred to Appropriation 3600, Research, Development, Test & Evaluation, Air Force, PE 0603211F, Aerospace Technology Dev/Demo, Project 634928, Space and Missile Propulsion & Systems, from Appropriation 3620, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603211F / *Aerospace Technology Dev/Demo* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 127.949 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 95.730 | 62.117 | 70.486 | 0.000 | 70.486 |
| Total Adjustments | -32.219 | 62.117 | 70.486 | 0.000 | 70.486 |
| • Congressional General Reductions | 0.000 | -0.113 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 25.000 | 25.000 | | | |
| • Congressional Directed Transfers | 0.000 | 37.230 | | | |
| • Reprogrammings | -24.121 | 0.000 | | | |
| • SBIR/STTR Transfer | -4.495 | 0.000 | | | |
| • Other Adjustments | -28.603 | 0.000 | 70.486 | 0.000 | 70.486 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 634920: *Flight Vehicle Tech Integration* | | |
| Congressional Add: *Program Increase - Agility Prime* | 25.000 | 25.000 |
| Congressional Add Subtotals for Project: 634920 | 25.000 | 25.000 |
| Congressional Add Totals for all Projects | 25.000 | 25.000 |

**Change Summary Explanation**

Increase in FY 2022 of 70.486 million is due to the following:

1) Congressional reversal of Program Element restructure

2) Realignment of Project 63682J, Spacecraft Vehicles, from PE 0603401F, Advanced Spacecraft Technology to Project 634094, Next Gen Platform Dev/Demo to PE 0603211F, Aerospace Technology Dev/Demo.

3) Increased emphasis in low cost attritable aircraft technologies.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603211F / *Aerospace Technology Dev /Demo* | Project (Number/Name)<br>634094 / *Next Gen Platform Dev/Demo* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634094: *Next Gen Platform Dev/ Demo* | - | 0.000 | 0.000 | 17.288 | 0.000 | 17.288 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops next-generation solid state, radiation-hardened strategic advance inertial system components for hostile environments.

This Project and associated efforts will continue to be executed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Inertial Sensor Navigation Technologies | 0.000 | 0.000 | 17.288 |
| ***Description:*** Develop next-generation solid state, radiation-hardened strategic advance inertial system components for hostile environment.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work was performed under the Inertial Sensor Navigation Technologies effort in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles.<br><br>***FY 2022 Plans:***<br>Complete gravity gradiometer testbed design. Complete design and development of second gyroscope prototype and execute environment testing; initiate nesting work with prototype. Continue design of first inertial measurement unit engineering design unit and design of radiation hardened electronics module. Continue to mature modeling, simulation, and test/validation procedures for inertial sensor systems in relevant strategic environments.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $17.288 million. Funding increased due to the transfer and realignment of the work in the inertial sensor navigation technologies effort in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles to PE 0603211F, Aerospace Technology Dev/Demo, Project 634094, Next Gen Platform Dev/Demo due to the creation of a new Appropriation for Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 0.000 | 0.000 | 17.288 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603211F / *Aerospace Technology Dev /Demo* | **Project (Number/Name)**<br>634094 / *Next Gen Platform Dev/Demo* |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603211F / *Aerospace Technology Dev /Demo* | Project (Number/Name)<br>634920 / *Flight Vehicle Tech Integration* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634920: *Flight Vehicle Tech Integration* | - | 40.860 | 62.117 | 36.788 | 0.000 | 36.788 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project demonstrates advanced aerospace vehicle technologies. Aerospace Vehicle Technology Integration efforts are accomplished through integration of various technologies to include avionics, advanced propulsion, and weapon systems for demonstration in near-realistic operational environments. Advanced Aerospace Structures Technologies are demonstrated to enhance the capability of current and future aerospace vehicles.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Aerospace Vehicle Technology Integration | 7.467 | 17.477 | 36.788 |
| ***Description:*** Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities.<br><br>***FY 2021 Plans:***<br>Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Continue the flight demonstration of a low cost unmanned aerospace systems capable of interoperations with different unmanned aerospace systems assets; completing the next sensor extension variant in FY 2021 and initiate an off-board weapons station variant. Initiate next variant of a low cost unmanned aerospace system. Complete propulsion integration component validation tests for Air Superiority 2030 requirements. Complete flight demonstrations of practical laminar flow for swept wing aircraft designs.<br><br>***FY 2022 Plans:***<br>Complete the flight demonstration of a low cost unmanned aerospace systems capable of interoperations with different unmanned aerospace systems assets. Continue next variant of a low cost unmanned aerospace system.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $19.311 million. Funding increased due to increased emphasis in Aerospace Vehicle Technology Integration including low cost attritable aircraft technology. | | | |
| ***Title:*** Advanced Aerospace Structure Technologies | 8.393 | 19.640 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603211F / *Aerospace Technology Dev /Demo* | **Project (Number/Name)**<br>634920 / *Flight Vehicle Tech Integration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems.<br><br>***FY 2021 Plans:***<br>Complete low cost airframe design and manufacturing demonstrations. Continue fully automated manufacturing demonstrations of large airframe structures. Complete structural life extension demonstration of legacy fleet metallic structures. Continue validation tests of life extension and durability methods for legacy fleet composite structures in support of aircraft Service Life Extension programs.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $19.64 million. Funding decreased due to decreased emphasis in advanced aerospace structure technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 15.860 | 37.117 | 36.788 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase - Agility Prime | 25.000 | 25.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts. | | |
| ***FY 2021 Plans:*** Conduct Congressionally directed efforts. This effort will be executed in PE 0604858F, Tech Transition Program. | | |
| **Congressional Adds Subtotals** | 25.000 | 25.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603211F / *Aerospace Technology Dev /Demo* | Project (Number/Name)<br>634926 / *High Speed Systems Integ & Demo* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634926: *High Speed Systems Integ & Demo* | - | 32.849 | 0.000 | 11.058 | 0.000 | 11.058 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, integrates and demonstrates, via simulations, ground, and flight tests, advanced flight vehicle technologies that improve the performance and supportability of future high speed/hypersonic vehicles. System level integration brings together air vehicle technologies with avionics, propulsion, warheads and other aerospace subsystems for demonstration in a near-realistic operational environment. Integration and technology demonstrations reduce the risk and time required to transition technologies into operational systems.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Speed/Hypersonic Vehicle Technologies | 32.849 | 0.000 | 11.058 |
| ***Description:*** Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems.<br><br>***FY 2021 Plans:***<br>Complete development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed. Complete some flight test activities for both Hypersonic Air-breathing Weapon Concept and Tactical Boost Glide. Initiate Advanced Airbreathing technology maturation activities to expand performance capabilities of high speed systems.<br><br>***FY 2022 Plans:***<br>Continue Multi-Mission Cruiser technology maturation activities to expand performance capabilities of high speed systems.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $11.058 million. Funding increase due to increased emphasis on high speed and hypersonic vehicle technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 32.849 | 0.000 | 11.058 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603211F / *Aerospace Technology Dev /Demo* | **Project (Number/Name)**<br>634926 / *High Speed Systems Integ & Demo* |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603211F / *Aerospace Technology Dev /Demo* | Project (Number/Name)<br>634927 / *Flight Systems Control* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634927: *Flight Systems Control* | - | 22.021 | 0.000 | 5.352 | 0.000 | 5.352 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This program integrates and demonstrates advanced control technologies that improve the performance, reliability, safety, and survivability of existing and future, manned and unmanned, aerospace systems. Enhanced capabilities are enabled by control, automation, and system level integration of subsystems and systems such as propulsion, airframes, avionics, power & thermal management, weapons, communications, and operator interfaces. Modeling and simulation, integration, and technology demonstrations in a near-operational environment reduce the risk and time required to transition technologies into existing and future aerospace systems.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Autonomous Systems Control | 22.021 | 0.000 | 5.352 |

***Description:*** Develop, simulate, and demonstrate advanced automation and control-enabled capabilities for manned or unmanned aerospace platforms. Develop, simulate, and demonstrate autonomous flight controls for safe flight and cooperative operations between manned and remotely piloted air platforms.

***FY 2021 Plans:***

Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue to incorporate autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems, airborne control of teams of unmanned aircraft, and unmanned sense-and-avoid technologies for ground and air operations to the autonomy spiral demonstrations. Continue development of technologies to reduce risk for transition of collision avoidance technologies to 4th and 5th-gen aircraft. Continue development of foundational autonomy for unmanned systems and spiral demonstrations of capability, including safe airspace interoperability and sense and avoid for air and ground operations. Continue spiral autonomy demonstration of manned-unmanned teaming capability incorporating the above technology transitions, including pilot-directed autonomous control.

***FY 2022 Plans:***

Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue research to incorporate autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems, airborne control of teams of unmanned aircraft, and unmanned sense and avoid

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603211F / *Aerospace Technology Dev /Demo* | **Project (Number/Name)**<br>634927 / *Flight Systems Control* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| technologies for ground and air operations to the autonomy spiral demonstrations. Complete development of technologies to reduce risk for transition of collision avoidance technologies to 4th and 5th-gen aircraft. Complete development of foundational autonomy for unmanned systems and spiral demonstrations of capability, including safe airspace interoperability<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $5.352 million. Funding increased due to increased emphasis on autonomous systems control. | | | |
| **Accomplishments/Planned Programs Subtotals** | 22.021 | 0.000 | 5.352 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | | | | | | | |
| **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 | - | 161.352 | 144.229 | 75.273 | 0.000 | 75.273 | - | - | - | - | - | - |
| 632480: *Aerospace Fuels* | - | 2.386 | 2.434 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 633035: *Aerospace Power Technology* | - | 39.670 | 104.795 | 18.216 | 0.000 | 18.216 | - | - | - | - | - | - |
| 634093: *Missile Rocket Propulsion Integ & Demo* | - | 0.000 | 0.000 | 7.612 | 0.000 | 7.612 | - | - | - | - | - | - |
| 634921: *Aircraft Propulsion Subsystems Int* | - | 18.016 | 0.000 | 11.610 | 0.000 | 11.610 | - | - | - | - | - | - |
| 634922: *Space & Missile Rocket Propulsion* | - | 43.635 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 635098: *Advanced Aerospace Propulsion* | - | 18.814 | 20.000 | 17.019 | 0.000 | 17.019 | - | - | - | - | - | - |
| 63681B: *Advanced Turbine Engine Gas Generator* | - | 38.831 | 17.000 | 20.816 | 0.000 | 20.816 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates technologies to achieve enabling and revolutionary advances in turbine, advanced-cycle, rocket, and space propulsion as well as electrical power, thermal management, and fuels. The program has six projects, each focusing on technologies with a high potential to enhance the performance of existing and future Air Force weapon systems. The Aerospace Fuels project develops and demonstrates improved hydrocarbon fuels and advanced propulsion systems, including those for air-breathing, high-speed/hypersonic flight. The Aerospace Power Technology project develops and demonstrates adaptive power and thermal management components, controls, and systems for high-power payloads and aircraft as part of energy-optimized aircraft development. The Aircraft Propulsion Subsystems Integration project develops demonstrator engines by integrating the engine cores demonstrated in the Advanced Turbine Engine Gas Generator project with low-pressure components. The Space and Missile Rocket Propulsion project develops and demonstrates innovative rocket propulsion technologies, propellants, and manufacturing techniques. The Advanced Aerospace Propulsion project develops the scramjet propulsion cycle to a technology readiness level appropriate for in-flight demonstration and for full integration with other engine cycles (including turbine and rocket based). The Advanced Turbine Engine Gas Generator project develops and demonstrates core turbine engine technologies for current and future aircraft propulsion systems.

All transfers detailed below are administrative realignments due to the stand up of the United States Space Force, and not new starts. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, OH, Edwards Air Force Base, CA, or Arnold Air Force Base, TN.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* |

In FY 2022, the work and funding associated with advanced space technology demonstrations in PE 0603216F, Aerospace Propulsion, Project 634922, Space & Missile Rocket Propulsion, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 634922, Space & Missile Rocket Propulsion, due to the creation of a new Appropriation for Space Force.

In FY 2022, the work and funding associated with missile rocket propulsion technologies in PE 0603216F, Aerospace Propulsion, are transferred from Project 634922, Space & Missile Rocket Propulsion, to Project 634093, Missile Rocket Propulsion Integ & Demo due to the creation of a new Appropriation for Space Force.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

Projects in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 170.973 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 161.352 | 144.229 | 75.273 | 0.000 | 75.273 |
| Total Adjustments | -9.621 | 144.229 | 75.273 | 0.000 | 75.273 |
| • Congressional General Reductions | 0.000 | -0.263 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 57.000 | 37.000 | | | |
| • Congressional Directed Transfers | 0.000 | 107.492 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -5.632 | 0.000 | | | |
| • Other Adjustments | -60.989 | 0.000 | 75.273 | 0.000 | 75.273 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 633035: *Aerospace Power Technology* | | |
| Congressional Add: *Program increase - silicon carbide research* | 10.000 | 10.000 |
| Congressional Add: *Program increase - multi-mode propulsion* | 0.000 | 5.000 |
| Congressional Add: *Program increase - low spool generator capabilites* | 5.000 | 5.000 |
| Congressional Add Subtotals for Project: 633035 | 15.000 | 20.000 |
| **Project:** 634922: *Space & Missile Rocket Propulsion* | | |
| Congressional Add: *Program increase - chemical apogee engines* | 5.000 | 0.000 |
| Congressional Add: *Program increase - upper stage engine maturation* | 18.000 | 0.000 |
| Congressional Add: *Program increase - space propulsion technologies* | 2.000 | 0.000 |
| Congressional Add: *Program increase - multi-mode propulsion* | 0.000 | 0.000 |
| Congressional Add Subtotals for Project: 634922 | 25.000 | 0.000 |
| **Project:** 63681B: *Advanced Turbine Engine Gas Generator* | | |
| Congressional Add: *Program increase - advanced turbine engine gas generator* | 17.000 | 0.000 |
| Congressional Add: *Program increase - small turbine engines for long range weapons* | 0.000 | 17.000 |
| Congressional Add Subtotals for Project: 63681B | 17.000 | 17.000 |
| Congressional Add Totals for all Projects | 57.000 | 37.000 |

**Change Summary Explanation**

Increase in FY 2022 of 75.273 million is due to the following:

1) Congressional reversal of PE restructure

2) Realignment of Project 634922, Space & Missile Rocket Propulsion to PE 1206601SF, Project 634922, Space & Missile Rocket Propulsion, due to the creation of a new Appropriation for Space Force.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>632480 / *Aerospace Fuels* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 632480: *Aerospace Fuels* | - | 2.386 | 2.434 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project evaluates and demonstrates improved hydrocarbon fuels, unique special application fuels, alternate fuels and advanced, novel aerospace propulsion technologies for Air Force applications, including high-speed and hypersonic flight and technologies to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. The advanced fuel emphasis is on demonstrating new thermally stable, high-heat sink, and controlled chemically reacting fuels for a conventional turbine engine, turbine-based combined cycle engines, and other advanced propulsion systems. The project also evaluates and demonstrates fuel system components that minimize cost, reduce maintenance, and improve performance of future aerospace systems. The advanced propulsion emphasis is on demonstrating concepts for combined cycle, ramjet, and scramjet engines. A portion of this project supports the demonstration of adaptive cycle technologies. This project develops component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Fuel-Related Thermal Management | 0.731 | 0.746 | 0.000 |
| ***Description:*** Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance.<br><br>***FY 2021 Plans:***<br>Complete investigation of fuel heat sink approaches for thermal management of adaptive engines, such as on-board fuel deoxygenation. Complete investigation of heat exchangers including additive manufactured units. Complete the development of integrated test rigs to tests these approaches and assess efficiency of these approaches.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funds decreased by 0.746 million compared to FY 2021. Justification for the decrease is described in plans above | | | |
| ***Title:*** Gas Turbine Combustion, Emissions, and Performance | 0.621 | 0.633 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>632480 / *Aerospace Fuels* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/ particulate emissions from gas turbine engines.<br><br>***FY 2021 Plans:***<br>Complete advanced development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. Complete study of fuel temperature limitations and use data to validate models.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funds decreased by 0.633 million compared to FY 2021. Justification for the decrease is described in plans above. | | | |
| ***Title:*** Fuel Logistics<br><br>***Description:*** Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force.<br><br>***FY 2021 Plans:***<br>Complete advanced development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Complete advanced development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funds decreased by 0.844 million compared to FY 2021. Justification for the decrease is described in plans above. | 0.827 | 0.844 | 0.000 |
| ***Title:*** Alternative Jet Fuels<br><br>***Description:*** Characterize and demonstrate the use of alternative hydrocarbon jet fuel to comply with Air Force certifications and standards for jet fuels.<br><br>***FY 2021 Plans:***<br>Complete development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force.<br><br>***FY 2022 Plans:***<br>Not applicable.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 0.207 | 0.211 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>632480 / *Aerospace Fuels* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 funds decreased by 0.211 million compared to FY 2021. Justification for the decrease is described in plans above. | | | |
| **Accomplishments/Planned Programs Subtotals** | 2.386 | 2.434 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>633035 / *Aerospace Power Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633035: *Aerospace Power Technology* | - | 39.670 | 104.795 | 18.216 | 0.000 | 18.216 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates system and subsystem integration to include adaptive architectures, actuation, electrical power, thermal management, and distribution for aerospace applications. This project develops and demonstrates the components, controls and systems required to satisfy the operational needs of current and future aircraft and enables the use of future high-power payloads. This technology enhances reliability and survivability, and reduces vulnerability, weight, and life cycle costs of air platforms. The electrical power system components developed are projected to provide a two-fold to five-fold improvement in aircraft reliability and maintainability, and a reduction in power system weight. This project is integrated into energy optimized aircraft efforts and power and thermal programs.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** High Power Aircraft Subsystem Technologies | 24.670 | 84.795 | 18.216 |
| ***Description:*** Develop and demonstrate integrated architecture, controls and components for power generation, conditioning, and distribution; energy storage components; and thermal management and subsystem technologies for integration into high power aircraft. | | | |
| ***FY 2021 Plans:***<br>Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue the development of hybrid-cycle power and thermal management system. Continue development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt- class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for megawatt applications. Continue development and demonstration of thermal management systems for megawatt applications. Complete development and demonstration of solid state electrical distribution technology for megawatt applications. | | | |
| ***FY 2022 Plans:***<br>Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue the development of hybrid-cycle power and thermal management system. Continue | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>633035 / *Aerospace Power Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt- class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for megawatt applications. Continue development and demonstration of thermal management systems for megawatt applications.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $66.579 million. Funding decrease due to reduced emphasis on high power aircraft subsystem technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 24.670 | 84.795 | 18.216 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - silicon carbide research<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 10.000 | 10.000 |
| ***Congressional Add:*** Program increase - multi-mode propulsion<br>***FY 2020 Accomplishments:*** N/A<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. This effort will be executed in PE 0603216F Aerospace Propulsion & Power Technology, Project 634922 Space & Missile Rocket Propulsion. | 0.000 | 5.000 |
| ***Congressional Add:*** Program increase - low spool generator capabilites<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 5.000 | 5.000 |
| **Congressional Adds Subtotals** | 15.000 | 20.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>634093 / *Missile Rocket Propulsion Integ & Demo* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634093: *Missile Rocket Propulsion Integ & Demo* | - | 0.000 | 0.000 | 7.612 | 0.000 | 7.612 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies and high-energy propellants. Aging and surveillance thrusts for solid rocket motors could reduce lifetime prediction uncertainties for individual motors by fifty percent, enabling motor replacement for cause. The efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). The efforts in this project are part of the Rocket Propulsion of the 21st Century (RP21) program. The efforts in this project are reviewed by a DoD level steering committee annually for relevance to DoD missions and achievement of technical goals defined by the RP21 program.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Ballistic Missile Technologies | - | 0.000 | 7.612 |
| ***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. | | | |
| ***FY 2021 Plans:***<br>Before FY2022, this work is performed in PE 0603216F Aerospace Propulsion and Power Technology, Project 634922 Space & Missile Rocket Propulsion, Ballistic Missile Technologies effort. | | | |
| ***FY 2022 Plans:***<br>Continue development and test of solid rocket motors relevant to defense needs such as large air-launched boosters for high speed weapon application. Continue to design and develop modeling and simulation tools that more fully describe the physical processes that occur during manufacture and/or operation, and that reduce predictive uncertainty in design and analysis. Initiate development of advanced components and manufacturing processes for solid rocket motors including inert components, energetic components, and automated assembly operations. | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $7.612 million. Funding increase is due to increased emphasis to demonstrate advanced components and manufacturing process and work transferring from PE 0603216F Aerospace Propulsion and Power | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634093 / *Missile Rocket Propulsion Integ & Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Technology, Project 634922 Space & Missile Rocket Propulsion, Ballistic Missile Technologies effort to Project 634093 Missile Rocket Propulsion Integ & Demo. | | | |
| **Accomplishments/Planned Programs Subtotals** | - | 0.000 | 7.612 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>634921 / *Aircraft Propulsion Subsystems Int* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634921: *Aircraft Propulsion Subsystems Int* | - | 18.016 | 0.000 | 11.610 | 0.000 | 11.610 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The Aircraft Propulsion Subsystems Integration (APSI) project includes demonstrator engines for manned systems and efficient small-scale propulsion for remotely piloted aircraft and cruise missile applications. The demonstrator engines integrate the core (high- pressure spool) technology developed under the Versatile Affordable Advanced Turbine Engines (VAATE) project with the engine (low-pressure spool) technology such as fans, turbines, engine controls, mechanical systems, exhaust nozzles, and augmentors. Additionally, this project includes activities to improve propulsion safety and readiness. This project also focuses on integration of inlets, nozzles, engine-to-airframe compatibility, and power and thermal management subsystems technologies. The APSI project provides aircraft with potential for longer range and higher cruise speeds with lower specific fuel consumption, surge power for successful engagements, high sortie rates with reduced maintenance, reduced life cycle cost, and improved survivability, resulting in increased mission effectiveness. Technologies developed are applicable to sustained high-speed vehicles and responsive space launch. The Aircraft Propulsion Subsystems Integration project is focused on improving propulsion capabilities while at the same time reducing the cost of ownership. Anticipated technology advances include turbine engine improvements providing approximately twice the range for a sustained supersonic combat aircraft, doubling the time on station with ten times the power output for surveillance aircraft and propulsion for a high speed supersonic missile with double the range for time sensitive targets. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, high power extraction, integrated thermal management, and durability for widely varying mission needs.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Missile/Remotely Piloted Aircraft Engine Performance | 10.674 | 0.000 | 6.878 |
| ***Description:*** Design, fabricate, and test component technologies for limited-life engines to improve the performance, durability, and affordability of missile and remotely piloted aircraft engines. | | | |
| ***FY 2021 Plans:***<br>Complete several key risk reduction testing of components for small engines. Finalize conceptual and preliminary design of small engine technology. Identify next innovative architecture, critical technologies and component designs for efficient small engines. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634921 / *Aircraft Propulsion Subsystems Int* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Finalize the assembly of advanced concept additive manufacturing heat exchanger for small core engines. Finalize fabrication of recuperator for demonstration of increased core efficiency in small core engines. Initiate operational benefits analysis for missile and UAV systems.<br>***FY 2022 Plans:***<br>Continue next innovative architecture, critical technologies and component designs for efficient small engines. Continue operational benefits analysis for missile and unmanned aerial vehicle (UAV) systems. Initiate development of pervasive, hydrocarbon pressure gained propulsion fueled technologies.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $6.878 million. Funding increase due to increased emphasis on missile and remotely piloted aircraft engine performance. | | | |
| ***Title:*** Adaptive Turbine Engine Technologies<br>***Description:*** Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies.<br>***FY 2021 Plans:***<br>Analyze and evaluate conceptual design of adaptive engine technology and continue technology rig tests to decrease risk in core technology testing. Complete component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.<br>***FY 2022 Plans:***<br>Continue analyzing and evaluating conceptual design of adaptive engine technology and continue technology rig tests to decrease risk in core technology testing. Initiate maturation and integration of key technology through component and rig testing.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $4.732 million. Funding increase due to increased emphasis on adaptive turbine engine technologies. | 7.342 | 0.000 | 4.732 |
| **Accomplishments/Planned Programs Subtotals** | 18.016 | 0.000 | 11.610 |

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

N/A

**Remarks**

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634921 / *Aircraft Propulsion Subsystems Int* |

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>634922 / *Space & Missile Rocket Propulsion* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634922: *Space & Missile Rocket Propulsion* | - | 43.635 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates advanced and innovative low-cost rocket turbo-machinery and components, and low-cost space launch propulsion technologies. Additionally, this project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy propellants. Technological advances in this project could improve the performance of expendable payload capabilities by approximately twenty to fifty percent and reduce launch, operations, and support costs by approximately thirty percent. Responsiveness and operability of propulsion systems will be enhanced for reusable launch systems. Aging and surveillance thrusts for solid rocket motors could reduce lifetime prediction uncertainties for individual motors by fifty percent, enabling motor replacement for cause. The efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD) and National Aeronautics and Space Administration (NASA). The efforts in this project are part of the Rocket Propulsion 21st Century (RP21) program. The efforts in this project are reviewed by a DoD level steering committee annually for relevance to DoD missions and achievement of technical goals defined by the RP21 program.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

In FY2022, the work and funding associated with space demonstrations in Project 634922, Space & Missile Rocket Propulsion, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Project 634922, Space & Missile Rocket Propulsion, due to the creation of a new Appropriation for Space Force.

In FY2022, the work and funding associated with missile technology demonstrations in Project 634922, Space & Missile Rocket Propulsion, are transferred to Project 634093, Missile Rocket Propulsion Integ & Demo, due to the creation of a new Appropriation for Space Force.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Liquid Rocket Propulsion Technologies | 10.063 | 0.000 | 0.000 |
| ***Description:*** Develop liquid rocket propulsion technology for current and future space launch vehicles. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634922 / *Space & Missile Rocket Propulsion* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Continue modular engine feasibility demonstration and flight experiment.<br>***FY 2022 Plans:***<br>In FY2022, the work and funding associated with space demonstrations in Project 634922, Space & Missile Rocket Propulsion, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Project 634922, Space & Missile Rocket Propulsion, due to the creation of a new Appropriation for Space Force.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | | | |
| ***Title:*** On-Orbit Propulsion Technologies<br>***Description:*** Develop solar electric, electric, and monopropellant propulsion technologies for existing and future satellites, upper stages, orbit transfer vehicles, and satellite maneuvering.<br>***FY 2021 Plans:***<br>Continue to develop and transition experimental, modeling and simulation, and theoretical efforts geared towards advanced thruster development with emphasis on understanding thrust scale-up. Continue to advance capabilities to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multi-mode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. Continue thrust scale-up effort for advanced non-toxic monopropellant thrusters. Continue electric propulsion thruster effort utilizing advanced non-toxic monopropellant.<br>***FY 2022 Plans:***<br>In FY2022, the work and funding associated with space demonstrations in Project 634922, Space & Missile Rocket Propulsion, are transferred to Appropriation 3620F, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Project 634922, Space & Missile Rocket Propulsion, due to the creation of a new Appropriation for Space Force.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | 2.236 | 0.000 | 0.000 |
| ***Title:*** Ballistic Missile Technologies<br>***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles.<br>***FY 2021 Plans:*** | 3.914 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634922 / *Space & Missile Rocket Propulsion* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Complete current technology maturation and demonstration efforts for post-boost technologies. Continue technology maturation and demonstration efforts for tactical missile technologies. Continue motor component modeling & simulation tool development, assessment, verification, and validations efforts geared towards reducing cost and schedule of new developments in an agile development landscape.<br>***FY 2022 Plans:***<br>In FY2022, the work and funding associated with missile technology demonstrations in Project 634922, Space & Missile Rocket Propulsion, are transferred to Project 634093, Missile Rocket Propulsion Integ & Demo, due to the creation of a new Appropriation for Space Force.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | | | |
| ***Title:*** Strategic System Motor Surveillance<br>***Description:*** Develop and demonstrate aging and surveillance technologies for strategic systems to reduce lifetime prediction uncertainty for individual motors, enabling motor replacement for cause.<br>***FY 2021 Plans:***<br>Not applicable.<br>***FY 2022 Plans:***<br>Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable. | 2.422 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 18.635 | 0.000 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - chemical apogee engines<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable. | 5.000 | 0.000 |
| ***Congressional Add:*** Program increase - upper stage engine maturation | 18.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>634922 / *Space & Missile Rocket Propulsion* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable. | | |
| ***Congressional Add:*** Program increase - space propulsion technologies<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable. | 2.000 | 0.000 |
| ***Congressional Add:*** Program increase - multi-mode propulsion<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 0.000 |
| **Congressional Adds Subtotals** | 25.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>635098 / *Advanced Aerospace Propulsion* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635098: *Advanced Aerospace Propulsion* | - | 18.814 | 20.000 | 17.019 | 0.000 | 17.019 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates, via ground and flight tests, the scramjet propulsion cycle to a technology readiness level appropriate for full integration with other engine cycles (including turbine and rocket-based) to provide the Air Force with transformational military capabilities. The primary focus is on the hydrocarbon-fueled, scramjet engine. Multi-cycle engines will provide the propulsion systems for possible application to support aircraft and weapon platforms operating up to Mach 7. Efforts include: scramjet flow-path optimization to enable operation over the widest possible range of Mach numbers; active combustion control to assure continuous positive thrust (even during mode transition); robust flame-holding to maintain stability through flow distortions; and maximized volume-to-surface area to minimize the thermal load imposed by the high-speed engine. Thermal management plays a vital role in scramjet and combined cycle engines, including considerations for protecting low speed propulsion systems (e.g., turbine engines) during hypersonic flight.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Scramjet Technologies | 18.814 | 20.000 | 17.019 |
| ***Description:*** Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7. | | | |
| ***FY 2021 Plans:***<br>Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically- relevant, long range, high speed strike scramjet engine designs, technologies, and components including ground and flight demonstrations needed for potential follow-on acquisition program. Initiate propulsion technology maturation activities for Multi-Mission Cruiser concept to expand performance capabilities of high speed systems. | | | |
| ***FY 2022 Plans:***<br>Continue development of scramjet technologies to enhance operability including robust operation during maneuvers and extended operating time. Continue development and demonstration of tactically-relevant, long range, high speed strike scramjet engine designs, technologies, and components including ground and flight demonstrations needed for potential follow-on acquisition | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>635098 / *Advanced Aerospace Propulsion* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| program. Continue propulsion technology maturation activities for Multi-Mission Cruiser concept to expand performance capabilities of high speed systems.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $2.981 million. Funding decreased due to reduced emphasis on scramjet technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 18.814 | 20.000 | 17.019 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | Project (Number/Name)<br>63681B / *Advanced Turbine Engine Gas Generator* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63681B: *Advanced Turbine Engine Gas Generator* | - | 38.831 | 17.000 | 20.816 | 0.000 | 20.816 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The objective is to provide continuous evolution of technologies into an advanced gas generator in which the performance, cost, durability, repairability, and maintainability can be assessed in a realistic engine environment. The gas generator, or core, is the basic building block of the engine and nominally consists of a compressor, a combustor, a high-pressure turbine, mechanical systems, and core subsystems. Experimental core engine demonstration validates engineering design tools and enhances rapid, low-risk transition of key engine technologies into engineering development, where they can be applied to derivative and/or new systems. These technologies are applicable to a wide range of military and commercial systems including aircraft, missiles, land combat vehicles, ships, and responsive space launch. Component technologies are demonstrated in a core (sub-engine). This project also assesses the impact of low spool components such as; inlet systems, fans, low pressure turbines, exhaust systems, and system level technologies such as; integrated power generators and thermal management systems on core engine performance, and durability in ground demonstrations of engine cores. The core performances of this project are validated on demonstrator engines in the Aircraft Propulsion Subsystem Integration Project of this program. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Core Engine Technologies | 9.188 | 0.000 | 8.761 |
| ***Description:*** Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines. | | | |
| ***FY 2021 Plans:***<br>Complete detailed design of medium-scale efficient core demonstrator. Complete rig testing. Continue risk reduction component tests for medium-scale engine advanced fan and core. Complete conceptual design of large-scale adaptive core concepts. Complete design of bladed disks and bearing systems components for small cruise missile size engine. Complete development | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>63681B / *Advanced Turbine Engine Gas Generator* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| of small cruise missile engine demonstrator test plans to improve life prediction capability for bladed disks and bearing systems. Initiate core tests for medium scale engines.<br>***FY 2022 Plans:***<br>Continue core tests for medium scale engines maturing key technologies. Initiate risk reduction component tests for medium-scale engine advanced fan and core.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $8.761 million. Funding increase due to increased emphasis on core engine technologies. | | | |
| ***Title:*** High Pressure Ratio Core Engine Technologies<br>***Description:*** Design, fabricate, and demonstrate high overall pressure ratio engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.<br>***FY 2021 Plans:***<br>Complete several key risk reduction testing of components for small engines (200-800 lbs class). Complete conceptual and preliminary design of small engine technology. Identify and assess innovative architecture, critical technologies and component designs for efficient, small engines. Continue assembly of advanced concept additive manufacturing heat exchanger for small core engines. Continue fabrication of recuperator for demonstration of increased core efficiency in small core engines. Continue to work medium scale core technologies.<br>***FY 2022 Plans:***<br>Continue assessing innovative architecture, critical technologies and component designs for efficient, small engines. Continue assembly of advanced concept additive manufacturing heat exchanger for small core engines. Continue fabrication of recuperator for demonstration of increased core efficiency in small core engines. Continue to work and mature medium scale core technologies.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.295 million. Funding increase due to increased emphasis on high pressure ratio core engine technologies. | 3.456 | 0.000 | 3.295 |
| ***Title:*** Adaptive Turbine Engine Core Technologies<br>***Description:*** Design, fabricate, and demonstrate adaptive turbine engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.<br>***FY 2021 Plans:*** | 9.187 | 0.000 | 8.760 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603216F / *Aerospace Propulsion and Power Technology* | **Project (Number/Name)**<br>63681B / *Advanced Turbine Engine Gas Generator* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Complete conceptual design of adaptive engine technology and initiate technology rig tests to decrease risk in core technology testing. Complete and evaluate compressor core test for large engines. Continue component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.<br>***FY 2022 Plans:***<br>Continue component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $8.760 million. Funding increase due to increased emphasis on adaptive turbine engine core technologies. | | | |
| **Accomplishments/Planned Programs Subtotals** | 21.831 | 0.000 | 20.816 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - advanced turbine engine gas generator<br>***FY 2020 Accomplishments:*** Conduct Congressionally directed efforts<br>***FY 2021 Plans:*** Not applicable. | 17.000 | 0.000 |
| ***Congressional Add:*** Program increase - small turbine engines for long range weapons<br>***FY 2020 Accomplishments:*** N/A<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts | 0.000 | 17.000 |
| **Congressional Adds Subtotals** | 17.000 | 17.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603270F / *Electronic Combat Technology* | | | | | | | |
| **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 | - | 45.882 | 35.841 | 46.591 | 0.000 | 46.591 | - | - | - | - | - | - |
| 633720: *EW Quick Reaction Capabilities* | - | 26.928 | 0.000 | 29.484 | 0.000 | 29.484 | - | - | - | - | - | - |
| 63431G: *RF Warning & Countermeasures Tech* | - | 11.691 | 31.142 | 9.255 | 0.000 | 9.255 | - | - | - | - | - | - |
| 634335: *Cyber Concepts* | - | 2.903 | 0.000 | 4.147 | 0.000 | 4.147 | - | - | - | - | - | - |
| 63691X: *EO/IR Warning & Countermeasures Tech* | - | 4.360 | 4.699 | 3.705 | 0.000 | 3.705 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates technologies to support Air Force electronic combat warfighting capabilities. The program focuses on developing components, subsystems, and technologies with potential aerospace, special operations, and airlift electronic combat applications. It develops and demonstrates technologies for integrating electronic combat sensors and systems into a fused and seamless whole. It integrates and focuses research efforts in electronic warfare and cyber warfare to rapidly demonstrate a capability for rapid fielding. It develops and demonstrates technologies for navigation and timing in radio frequency (RF) contested and denied environments. It develops and demonstrates advanced technologies for radio frequency electronic combat suites and advanced warning and countermeasure technologies to defeat electro-optical, infrared, and laser threats to aerospace platforms. It also develops and demonstrates technologies that will enable mission systems to be more resilient, agile, autonomous, and be able to operate in multiple domains. This program has been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | Date: May 2021 |
|---|---|---|---|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | | | |
| **B. Program Change Summary ($ in Millions)** | **FY 2020** | **FY 2021** | **FY 2022 Base** | **FY 2022 OCO** | **FY 2022 Total** |
| Previous President's Budget | 48.408 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 45.882 | 35.841 | 46.591 | 0.000 | 46.591 |
| Total Adjustments | -2.526 | 35.841 | 46.591 | 0.000 | 46.591 |
| • Congressional General Reductions | 0.000 | -0.065 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 35.906 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.780 | 0.000 | | | |
| • Other Adjustments | -1.746 | 0.000 | 46.591 | 0.000 | 46.591 |

**Change Summary Explanation**

FY 2020 Other Adjustments: Decrease of $1.746 million due to Air Force reprogramming.

FY 2021 and 2022: Congressional directed realignments from program element restructure.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603270F / *Electronic Combat Technology* | Project (Number/Name)<br>633720 / *EW Quick Reaction Capabilities* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633720: *EW Quick Reaction Capabilities* | - | 26.928 | 0.000 | 29.484 | 0.000 | 29.484 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project establishes a capability to rapidly assess, develop and demonstrate new electronic warfare concepts, techniques, and capabilities as well as the required position navigation and timing (PNT) technologies and capabilities in the context of systemic electronic warfare (EW) effects (electronic warfare threat interactions) in a congested/contested electromagnetic spectrum, system-of-systems (SoS) environment of the future. It develops disruptive electronic warfare and countermeasures concepts specifically selected for high-impact, game-changing effects; evaluates them in high fidelity virtual and hardware evaluation settings; and demonstrates them in an operationally relevant environment. It establishes and maintains an all-source, physics-based, threat-to-countermeasures electronic warfare systems engineering methodology. It develops a core analytic function, supported by simulation-based wargaming and interactive engineering modeling capabilities to evaluate advanced countermeasures concepts.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Radio Frequency Electronic Warfare | 10.008 | 0.000 | 3.476 |
| ***Description:*** Develop electronic warfare focused knowledge databases, engineering models, mission simulations, analysis tools and assessment environments which enable the development of multi-domain electronic warfare technologies. The primary focus is on emulating complex battlespace radio frequency environments, electronic attack effects against emerging, networked weapon systems, and assessing flexible, software-defined electronic warfare systems with non-deterministic performance (for example, utilizing cognitive algorithms). | | | |
| ***FY 2021 Plans:***<br>In FY 2021, this work was performed out of Project 63431G, RF Warning & Countermeasures Tech, Radio Frequency Electronic Warfare effort. | | | |
| ***FY 2022 Plans:***<br>Mature fidelity of simulations of advanced electronic warfare systems to emulate the complex radio frequency threats and signals environment. Continue implementation of advanced digital signal synthesis to better represent complex emitters operating in complex environments containing sophisticated background emitters. Continue the development and demonstration efforts to | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>633720 / *EW Quick Reaction Capabilities* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| prove the concepts for full spectrum countermeasures capabilities. Continue expansion of software-in-the-loop and hardware-in-the-loop environments to assess closed-loop system performance.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.476 million. Funding increased due to realignment from Project 63431G, RF Warning & Countermeasures Tech, Radio Frequency Electronic Warfare effort. | | | |
| ***Title:*** Resilient Positioning, Navigation and Timing<br><br>***Description:*** Develop and transition robust Global Navigation Satellite System capabilities; resilient complementary position, navigation and timing techniques; precise position, navigation and timing technologies for distributed sensing/effects; position, navigation and timing technology to provide position, navigation and timing electronic warfare situational awareness and training; and position, navigation and timing architectures to enable resiliency against the rapidly evolving threat. Efforts will include prototypes and relevant Open Architecture standards where applicable to enable timely technology transition.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work was performed out of Project 63431G, RF Warning & Countermeasures Tech, Position, Navigation and Timing for Contested/Denied Environments effort.<br><br>***FY 2022 Plans:***<br>Develop and demonstrate multi-ship geolocation of sources interfering with navigational satellite signals. Develop and demonstrate a transcoder that converts modernized Global Positioning System military signals into military signals useable by legacy Department of Defense Global Positioning System receivers. Continue software defined radio technology efforts to authenticate signals from foreign satellite navigation systems. Continue to define and refine navigational open architecture standards to permit integration of alternative/complementary position, navigation and timing approaches into future DoD systems including the resilient embedded Global Positioning System-inertial government reference architecture.<br><br>In FY 2022 this effort renamed from Position, Navigation and Timing for Contested/Denied Environments to Resilient Positioning, Navigation and Timing.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 14.947 million. Funding increased due to realignment from Project 63431G, RF Warning & Countermeasures Tech, Position, Navigation and Timing for Contested/Denied Environments effort. | 12.654 | 0.000 | 14.947 |
| ***Title:*** Electro-Optical/Infrared Warfare Demonstrator<br><br>***Description:*** Develop next generation countermeasure techniques to address the complete range of multispectral (for example, dual band infrared) threats including advanced techniques versus advanced man portable air defense system and air-to-air threats | 4.266 | 0.000 | 3.476 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>633720 / *EW Quick Reaction Capabilities* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| with multimode capabilities. Develop capabilities for situational awareness and countermeasure to integrated air defense systems and associated multispectral threats.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work was performed out of Project 63431G, RF Warning & Countermeasures Tech, Electro-Optical/Infrared Threat Warning and Countermeasures effort.<br><br>***FY 2022 Plans:***<br>Develop a low cost, integrated missile and laser warning capability to identify, geo-locate, and counter, using both laser and expendable countermeasure response techniques, advanced laser and EO/IR guided missile threats to aircrews. Continue to apply analysis from field test to develop requirements for proactive detection and situation awareness for multiple Air Force platforms. Continue to iterate and refresh techniques for in-house at range data collection capabilities. Continue efforts to develop multispectrum electro-optical/radio frequency countermeasures and insert capabilities into existing and developing engagement modeling and simulation tools.<br><br>In FY 2022 this effort renamed from Electro-Optical/Infrared Threat Warning and Countermeasures to Electro-Optical/Infrared Warfare Demonstrator.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 3.476 million. Funding increased due to realignment from Project 63431G, RF Warning & Countermeasures Tech, Electro-Optical/Infrared Threat Warning and Countermeasures. | | | |
| ***Title:*** Transformational Technology Development<br><br>***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to new electronic warfare concepts, techniques and capabilities as well as new positioning, navigation and timing technologies and capabilities. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:*** | 0.000 | 0.000 | 7.585 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>633720 / *EW Quick Reaction Capabilities* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2022 Plans:***<br>Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $7.585 million. Increase is due to realignment of funding from Project 63431G, RF Warning & Countermeasures Tech, Radio Frequency Electronic Warfare, Position, Navigation and Timing for Contested/Denied Environments effort and Electro-Optical/Infrared Threat Warning and Countermeasures effort. | | | |
| **Accomplishments/Planned Programs Subtotals** | 26.928 | 0.000 | 29.484 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603270F / *Electronic Combat Technology* | Project (Number/Name)<br>63431G / *RF Warning & Countermeasures Tech* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63431G: *RF Warning & Countermeasures Tech* | - | 11.691 | 31.142 | 9.255 | 0.000 | 9.255 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates advanced technologies for radio frequency electronic combat suites, including the required navigation technologies and capabilities, to enhance the survivability of aerospace vehicles and to provide crew situational awareness. The research addresses technologies for missile/threat warning, radio frequency receivers, electronic combat pre-processors, advanced sorting/pre-processing algorithms, and expert software for applications on existing and future electronic combat systems. The research also focuses on the development and demonstration of subsystems and components for generating on-board/off-board radio frequency countermeasure techniques. This includes the development of electronic countermeasures techniques, as well as advanced electronic countermeasures technologies such as antennas, power amplifiers, and preamplifiers.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Radio Frequency Electronic Warfare Demonstrator | 11.691 | 6.710 | 8.575 |
| ***Description:*** Develop aerospace platform jamming concepts, technologies and techniques to counter advanced radio frequency threats associated with current and future aerospace weapon systems. Provide position, navigation and system resilience via open architecture solutions. | | | |
| ***FY 2021 Plans:***<br>Continue research into radio frequency receiver technologies enhancing the ability to detect threats, measure increased radio frequency features with greater accuracy, identify or classify signals more reliably, track and predict signals, use reasoning algorithms to reduce ambiguities and errors, and deduce greater knowledge from the radio frequency spectrum. Conduct technology demonstrations to support transition into Department of the Air Force platforms. Continue expansion of modeling, simulation and laboratory assessment environments commensurate with technologies being researched, developed and tested including cognitive and autonomous electronic warfare technologies. Start the implementation of emerging electronic attack and electronic support capabilities into open architectures. Demonstrate the capability to rapidly respond to new and unexpected threats in realistic environments. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63431G / *RF Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Navigation Technology Satellite 3 activities are performed under the Navigation Technology Satellite 3 effort in PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguards.<br><br>***FY 2022 Plans:***<br>Continue the implementation of emerging electronic attack and electronic support capabilities into open architectures. Continue to conduct technology demonstrations to support transition into Air Force platforms. Use agile software defined process to demonstrate the capability to rapidly respond to new and unexpected complex emitters in realistic radio frequency environments. Continue expansion and maturation of modeling, simulation and laboratory assessment environments commensurate with technologies being researched, developed and tested including cognitive and autonomous electronic warfare technologies.<br><br>In FY 2022 this effort was renamed from Electronic Attack to Radio Frequency Electronic Warfare Demonstrator.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 1.865 million. Funding increased due to increased research support requirements. | | | |
| ***Title:*** Transformational Technology Development<br><br>***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to the development and demonstration of advanced technologies for radio frequency electronic combat suites. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:***<br>Not applicable<br><br>***FY 2022 Plans:***<br>Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.680 million. Justification for the increase is described in the plans above. | 0.000 | 0.000 | 0.680 |
| ***Title:*** Radio Frequency Electronic Warfare | 0.000 | 5.800 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63431G / *RF Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop electronic warfare focused knowledge databases, engineering models, mission simulations, analysis tools and assessment environments which enable the development of multi-domain electronic warfare technologies. The primary focus is on emulating complex battlespace radio frequency environments, electronic attack effects against emerging, networked weapon systems, and assessing flexible, software-defined electronic warfare systems with non-deterministic performance (for example, utilizing cognitive algorithms).<br><br>***FY 2021 Plans:***<br>Continue expansion of simulations to accommodate advanced electronic warfare systems and emulate the complex radio frequency threats and signals environment. Begin implementation of advanced digital signal synthesis to better represent complex emitters operating in complex environments containing sophisticated background emitters. Continue development of higher fidelity threat system and signal propagation models. Continue developing the tools, methods and demonstrations to assess both the performance of future electronic warfare systems as well as their effectiveness including cognitive and autonomous technologies. Continue the development and demonstration efforts to prove the concepts for full spectrum countermeasures capabilities. Continue expansion of software-in-the-loop and hardware-in-the-loop environments to achieve closed-loop system performance.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 633720, EW Quick Reaction Capabilities, Radio Frequency Electronic Warfare effort and Transformational Technology Development effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 5.800 million. The decrease is due to the realignment of funding to Project 633720, EW Quick Reaction Capabilities, Radio Frequency Electronic Warfare effort and Transformational Technology Development effort. | | | |
| ***Title:*** Position, Navigation and Timing for Contested/Denied Environments<br><br>***Description:*** Develop and transition robust Global Navigation Satellite System capabilities; resilient complementary position, navigation and timing techniques; precise position, navigation and timing technologies for distributed sensing/effects; position, navigation and timing technology to provide position, navigation and timing electronic warfare situational awareness and training; and position, navigation and timing architectures to enable resiliency against the rapidly evolving threat. Efforts will include prototypes and relevant Open Architecture standards where applicable to enable timely technology transition.<br><br>***FY 2021 Plans:***<br>Continue to further research techniques to securely certify Global Navigation Satellite System software defined radio technology and methods to trust Global Navigation Satellite Systems. Complete advanced reconfigurable software defined radio navigation receivers to enable spectrum agile systems and integration as the user equipment component to the Navigation Technology Satellite-3 flight experimentation. Continue to develop alternative/complementary position, navigation and timing techniques which | 0.000 | 8.899 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63431G / *RF Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| increase the availability of the position, navigation and timing solution and support creation of an integrated position, navigation and timing solution focused on increasing the precision needed to support novel radio frequency coherent sensing and electronic warfare techniques. Continue to define and refine navigational open architecture standards to allow for integration of Global Navigation Satellite System and alternative/complementary position, navigation and timing approaches into future systems. Demonstrate integration of improved Global Navigation Satellite System position, navigation and timing and alternative position, navigation and timing solutions into an advanced resilient embedded Global Positioning System-inertial government reference architecture.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 633720, EW Quick Reaction Capabilities, Resilient Positioning, Navigation and Timing effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $8.899 million. The decrease is due to the realignment of funding to Project 633720, EW Quick Reaction Capabilities, Resilient Positioning, Navigation and Timing effort. | | | |
| ***Title:*** Electro-Optical/Infrared Threat Warning and Countermeasures | 0.000 | 5.034 | 0.000 |
| ***Description:*** Develop next generation countermeasure techniques to address the complete range of multispectral (for example, dual band infrared) threats including advanced techniques versus advanced man portable air defense system and air-to-air threats with multimode capabilities. Develop capabilities for situational awareness and countermeasure to integrated air defense systems and associated multispectral threats.<br>***FY 2021 Plans:***<br>Apply analysis from field test to develop requirements for proactive detection and situation awareness for multiple Department of the Air Force platforms. Iterate and refresh techniques for in-house at range data collection capabilities. Perform test against real threats at significant range. Continue to evaluate acquisition alternatives for a proactive advanced technology demonstration. Continue efforts to develop multispectrum electro-optical/radio frequency countermeasures and insert capabilities into existing engagement modeling and simulation tools.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 633720, EW Quick Reaction Capabilities, Electro-Optical/Infrared Warfare Demonstrator effort and Transformational Technology Development effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63431G / *RF Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by 5.034 million. The decrease is due to the realignment of funding to Project 633720, EW Quick Reaction Capabilities, Electro-Optical/Infrared Warfare Demonstrator effort and Transformational Technology Development effort. | | | |
| ***Title:*** Avionics Cyber Vulnerabilities<br><br>***Description:*** Develop and demonstrate methods, techniques, and technical tools to enable, assist, and improve the vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components. Investigate techniques to mitigate discovered vulnerabilities. Develop and demonstrate mitigation and protection technologies on future concept platforms for adaptability and resilience.<br><br>***FY 2021 Plans:***<br>Complete transition of vulnerability mitigation technologies to legacy weapon systems. Begin demonstrations of agile, resilient and lethal capabilities of next-generation architecture. Provide integration support for emerging technologies such as autonomy, alternative-navigation technologies, open system architecture standards and approaches, multispectral and distributed intelligence surveillance and reconnaissance, and electromagnetic spectrum warfare. Continue to transition next-generation architectures to adopting programs/platforms, and open architecture approaches to rapidly integrate advanced mission system capability for next generation architectures.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 634335, Cyber Concepts, Resilient and Agile Mission Systems Architecture effort and Transformational Technology Development effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 1.500 million. The decrease is due to the realignment of funding to Project 634335, Cyber Concepts, Resilient and Agile Mission Systems Architecture effort and Transformational Technology Development effort. | 0.000 | 1.500 | 0.000 |
| ***Title:*** Avionics Cyber Protections<br><br>***Description:*** Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software.<br><br>***FY 2021 Plans:***<br>Continue to enhance and extend cyber protection tools, techniques and test beds for manned and unmanned air vehicles, mission and support equipment. Complete development of system integration laboratories to test resilient and agile mission system architecture concepts on avionics; intelligence, surveillance, and reconnaissance; positioning, navigation, and timing systems. Continue to flight test and demonstrate advanced cyber protection capabilities on mission systems. Continue to collaborate with | 0.000 | 3.199 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63431G / *RF Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| program offices and end-users to transition resilient and agile technologies. Leverage open system architecture standards and approaches to demonstrate agile, resilient and autonomous capabilities for current and next-generation architectures.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work is performed under Project 634335, Cyber Concepts, Resilient and Agile Mission Systems Architecture effort and Transformational Technology Development effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 3.199 million. The decrease is due to the realignment of funding to Project 634335, Cyber Concepts, Resilient and Agile Mission Systems Architecture effort and Transformational Technology Development effort. | | | |
| **Accomplishments/Planned Programs Subtotals** | 11.691 | 31.142 | 9.255 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603270F / *Electronic Combat Technology* | Project (Number/Name)<br>634335 / *Cyber Concepts* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634335: *Cyber Concepts* | - | 2.903 | 0.000 | 4.147 | 0.000 | 4.147 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates methods to discover cyber susceptibilities, assess avionics systems, formulate mitigation strategies, and investigate use of tools and technologies to automate this process. It is designed to apply developed vulnerability discovery, vulnerability mitigation, and cyber protection technology to avionics systems and components and embedded systems. This involves technologies for trusted sensors and trusted systems that deter exploitation of our critical hardware and software. This project aims to develop cyber resilience and protect systems through adaptation of the system to the threat. It demonstrates these technologies in open and adaptable architectures for system integration in field demonstrations and proves out the technologies through rapid integration of sensors and architectures for technology transition. It integrates research efforts in electronic and cyber warfare to rapidly demonstrate a capability for rapid fielding.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Avionics Cyber Vulnerabilities | 1.613 | 0.000 | 0.000 |
| ***Description:*** Develop and demonstrate methods, techniques, and technical tools to enable, assist, and improve the vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components. Investigate techniques to mitigate discovered vulnerabilities. Develop and demonstrate mitigation and protection technologies on future concept platforms for adaptability and resilience.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under Project 63431G, RF Warning & Countermeasures Tech, Avionics Cyber Vulnerabilities effort.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Avionics Cyber Protections | 1.290 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>634335 / *Cyber Concepts* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under Project 63431G, RF Warning & Countermeasures Tech, Avionics Cyber Protections effort.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Resilient and Agile Mission Systems Architecture<br><br>***Description:*** This effort performs advanced development and demonstration of methods, technologies, and tools to enable resilience and protect mission systems against threats. This involves open and adaptable architectures for rapid integration and agile systems, cyber protections and resilience technologies to protect against threats. It integrates research efforts in electronic and cyber warfare to demonstrate novel operational capabilities through laboratory, field, and flight tests and experimentation. The goal is to reduce risk for rapid transition of novel operational capabilities into Department of the Air Force mission systems.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work was performed under Project 63431G, RF Warning & Countermeasures Tech, Avionics Cyber Vulnerabilities effort and Avionics Cyber Protections effort.<br><br>***FY 2022 Plans:***<br>Continue ongoing investigations to evolve and mature open architecture standards. Initiate development of advanced networking, processing, advanced computing paradigms, and cybersecurity technologies for next-generation avionics mission system capabilities. Apply agile software technologies and digital engineering techniques for rapid and affordable development, integration, and prototype capability demonstrations.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.260 million. Increase is due to realignment of funding from Project 63431G, RF Warning & Countermeasures Tech, Avionics Cyber Vulnerabilities effort and Avionics Cyber Protections effort. | 0.000 | 0.000 | 3.260 |
| ***Title:*** Transformational Technology Development | 0.000 | 0.000 | 0.887 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>634335 / *Cyber Concepts* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to the development and demonstration of methods to discover cyber susceptibilities, assess avionics systems, formulate mitigation strategies and investigate use of tools and technologies to automate this process. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br><br>***FY 2021 Plans:***<br>Not applicable<br><br>***FY 2022 Plans:***<br>Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.887 million. Justification for this increase is described in the plans above. | | | |
| **Accomplishments/Planned Programs Subtotals** | 2.903 | 0.000 | 4.147 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603270F / *Electronic Combat Technology* | Project (Number/Name)<br>63691X / *EO/IR Warning & Countermeasures Tech* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63691X: *EO/IR Warning & Countermeasures Tech* | - | 4.360 | 4.699 | 3.705 | 0.000 | 3.705 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates the advanced warning and countermeasure technologies required to negate electro-optical/infrared and laser threats to aerospace platforms. Develops off-board (decoys and expendables) and on-board countermeasure technologies for aircraft self-protection to provide robust, affordable solutions for protection against infrared missiles with autonomous seekers, multi-spectral threats, laser-guided weapons, and electro-optical/infrared tracking systems used to direct electro-optical/infrared and radar-guided missiles.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies | 4.360 | 4.699 | 2.791 |
| ***Description:*** Analyze the vulnerabilities of current infrared missile systems and future imaging infrared sensors. Develop advanced countermeasure system techniques to exploit vulnerabilities for use against infrared and electro-optical guided missile threats. Develop advanced optical and infrared sensor systems for airborne and space situational awareness and threat warning. | | | |
| ***FY 2021 Plans:***<br>Continue threat characterization and countermeasures development and field testing of new advanced threats to include laser jam codes and techniques. Continue the incorporation of air to air threat radio frequency data links into validated engagement models and examine the combination of the infrared models with equivalent radio frequency models into the overarching Advanced Framework for Simulation, Integration and Modeling software environment to address multispectrum threats. Continue assessment of missile warning technologies and techniques for a variety of Department of the Air Force platforms. Develop the requirements for next generation laser threat sensors for combat aircraft and space situation awareness. Start the integration of the testbed supporting development of space sensors. | | | |
| ***FY 2022 Plans:***<br>Continue to mature the process for threat characterization and countermeasures development and field testing of new advanced threats to include laser jam codes and techniques. Mature the incorporation of air to air threat radio frequency data links into validated engagement models and examine the combination of the infrared models with equivalent radio frequency models into | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603270F / *Electronic Combat Technology* | **Project (Number/Name)**<br>63691X / *EO/IR Warning & Countermeasures Tech* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| the overarching Advanced Framework for Simulation, Integration and Modeling software environment to address multispectrum threats. Continue effectiveness assessment of laser and missile warning technologies and techniques for a variety of Air Force platforms.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $1.908 million. Decrease is a result of Air Force reprogramming. | | | |
| ***Title:*** Transformational Technology Development<br>***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to the development and demonstration of advanced warning and countermeasure technologies required to negate electro-optical/infrared and laser threats to aerospace platforms. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made.<br>***FY 2021 Plans:***<br>Not applicable<br>***FY 2022 Plans:***<br>Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.914 million. Justification for the increase is described in the plans above. | 0.000 | 0.000 | 0.914 |
| **Accomplishments/Planned Programs Subtotals** | 4.360 | 4.699 | 3.705 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | | | | | | | |
| **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 | - | 75.405 | 87.608 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 632181: *Spacecraft Payloads* | - | 23.176 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 633834: *Integrated Space Technology Demonstrations* | - | 18.856 | 57.268 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 634400: *Space Systems Protection* | - | 7.708 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 635021: *Space Systems Survivability* | - | 1.581 | 6.500 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 63682J: *Spacecraft Vehicles* | - | 24.084 | 23.840 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops, integrates, and demonstrates space technologies in the areas of spacecraft payloads, spacecraft protection, spacecraft vehicles, and space systems survivability. The integrated space technologies are demonstrated by component or system level tests on the ground or in flight. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2022, PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 633834, Integrated Space Technology Demonstrations, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.

In FY 2022, the space communications technologies efforts of PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 63682J, Spacecraft Vehicles, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 80.525 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 75.405 | 87.608 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | -5.120 | 87.608 | 0.000 | 0.000 | 0.000 |
| • Congressional General Reductions | 0.000 | -0.160 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 30.500 | | | |
| • Congressional Directed Transfers | 0.000 | 57.268 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -2.652 | 0.000 | | | |
| • Other Adjustments | -2.468 | 0.000 | 0.000 | 0.000 | 0.000 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 632181: *Spacecraft Payloads* | | |
| Congressional Add: *Congressional Add: Program increase - radiation hardened memory* | 10.000 | 0.000 |
| Congressional Add Subtotals for Project: 632181 | 10.000 | 0.000 |
| **Project:** 633834: *Integrated Space Technology Demonstrations* | | |
| Congressional Add: *Congressional Add: Program increase - modular satellite power systems* | 0.000 | 4.000 |
| Congressional Add: *Congressional Add: Program increase - upper stage engine technology* | 0.000 | 20.000 |
| Congressional Add Subtotals for Project: 633834 | 0.000 | 24.000 |
| **Project:** 635021: *Space Systems Survivability* | | |
| Congressional Add: *Congressional Add: Program increase - ground-based interferometry* | 0.000 | 6.500 |
| Congressional Add Subtotals for Project: 635021 | 0.000 | 6.500 |
| Congressional Add Totals for all Projects | 10.000 | 30.500 |

**Change Summary Explanation**

Decrease in FY 2022 due to efforts of PE 0603401F, Advanced Spacecraft Technology, being transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | Project (Number/Name)<br>632181 / *Spacecraft Payloads* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 632181: *Spacecraft Payloads* | - | 23.176 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project funds the development, demonstration, and evaluation of radiation-hardened space electronic hardware, satellite control hardware, and software for advanced satellite surveillance operations. Future improved space-qualifiable electronics and software for data and signal processing will be more interchangeable, interoperable, and standardized. In the near-term, this project's work concentrates on converting (for example, radiation-hardening) commercial data and signal processor technologies for use in Air Force space systems. For mid-term applications, this project merges advanced, radiation-hardened space processor, memory, and interconnect technologies with commercially-derived, open system architectures to develop and demonstrate robust, on-board processing capabilities for 21st century Department of Defense satellites. In the long-term, this project area focuses on developing low-cost, easily modifiable software and hardware architectures for fully autonomous constellations of intelligent satellites capable of performing all mission related functions without operator intervention.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Advanced Space Electronics<br><br>***Description:*** Develop microelectronic devices, including radiation-hardened data processors and high-density hardened memories, advanced packaging technologies, and micro-electro-mechanical system components and applications.<br><br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 3.197 | 0.000 | 0.000 |
| ***Title:*** Advanced Space Modeling and Simulation Tools<br><br>***Description:*** Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments.<br><br>***FY 2021 Plans:*** | 0.749 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>632181 / *Spacecraft Payloads* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Advanced Space Sensors<br>***Description:*** Develop space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well as "cold body" objects.<br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 2.070 | 0.000 | 0.000 |
| ***Title:*** Positioning, Navigation, and Timing Space Payload Technologies<br>***Description:*** Develop, validate, and transition technologies that: enable new, or enhance existing, United States positioning, navigation, and timing satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop, validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs.<br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 7.160 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>632181 / *Spacecraft Payloads* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 13.176 | 0.000 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Congressional Add: Program increase - radiation hardened memory | 10.000 | 0.000 |
| ***FY 2020 Accomplishments:*** Conduct Congressionally directed effort | | |
| ***FY 2021 Plans:*** N/A. | | |
| **Congressional Adds Subtotals** | 10.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | Project (Number/Name)<br>633834 / *Integrated Space Technology Demonstrations* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633834: *Integrated Space Technology Demonstrations* | - | 18.856 | 57.268 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project is a series of advanced technology demonstrations designed to address mission needs by applying emerging technologies from the Air Force Research Laboratory, other United States government laboratories, and industry. These technologies are integrated into system-level demonstrations that are used to test, evaluate, and validate the technologies in a relevant environment.

In FY 2021, PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrate Space Technology Demonstrations, Navigation Technology Satellite-3 (NTS-3) Vanguard efforts were transferred to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards, in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Integrated Satellite Demonstrations | 18.856 | 33.268 | 0.000 |
| ***Description:*** Develop satellite technologies for integrated, robust, and flexible satellite demonstrations building on previous work and leveraging investments by other organizations. | | | |
| ***FY 2021 Plans:***<br>In FY 2021, Navigation Technology Satellite-3 Vanguard activities will be performed under the Navigation Technology Satellite-3 effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.<br>Continue on-orbit demonstrations of multiple formation flying satellites for near autonomous formation control leveraging opportunities to fly demonstrations and prototypes, where successes can identify quick transition to next generation technology needs. Continue coordination of a manifest timeline for critical space projects prioritizing Air Force Space Command technical, security, and operational development requirements. Continue to utilize the Long Duration Propulsive Evolved Expendable Launch Vehicle Secondary Payload Adaptor launch schedule and other prospects to quickly fly demonstrations and prototypes. Continue payloads maturation tasks from concept proposal to leveraging commercial Low Earth orbit constellations. | | | |
| ***FY 2022 Plans:***<br>In FY 2022, PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>633834 / *Integrated Space Technology Demonstrations* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Advanced Technology Development/Demo, Project 633834, Integrated Space Technology Demonstrations, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $33.268 million. Funding decreased due to the transfer and realignment of the work in the Integrated Satellite Demonstrations effort in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations, to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 633834, Integrated Space Technology Demonstrations due to the creation of a new Appropriation for Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 18.856 | 33.268 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Congressional Add: Program increase - modular satellite power systems<br><br>***FY 2020 Accomplishments:*** Not applicable<br><br>***FY 2021 Plans:*** Conduct Congressionally directed effort. | 0.000 | 4.000 |
| ***Congressional Add:*** Congressional Add: Program increase - upper stage engine technology<br><br>***FY 2020 Accomplishments:*** Not applicable<br><br>***FY 2021 Plans:*** Conduct Congressionally directed effort. Per Congressional Committee direction, this effort will be executed in PE 0603216F, Aerospace Propulsion and Power Technology, Project 634922, Space & Missile Rocket Propulsion. | 0.000 | 20.000 |
| **Congressional Adds Subtotals** | 0.000 | 24.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | Project (Number/Name)<br>634400 / *Space Systems Protection* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 634400: *Space Systems Protection* | - | 7.708 | 0.000 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates tools, instruments, and mitigation techniques required to assure operation of United States space assets in hostile warfighting environments. The project performs assessments of critical components and subsystems, and evaluates susceptibility and vulnerability to radio frequency and laser threats. This project also develops technologies that mitigate identified vulnerabilities. These technologies support balanced satellite protection strategies for detecting and avoiding threats in a hostile space environment.

In FY 2021 and future years, the efforts and activities under Project 634400, Space Systems Protection, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Space Situational Awareness Capability Development | 1.409 | 0.000 | 0.000 |
| ***Description:*** Develop tools and technologies that advance space-based proximity awareness capabilities and enable protection and countermeasure courses of action. Efforts will assess a variety of phenomenologies and concepts in response to multiple threat classes and scenarios.<br><br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Space Indicators and Warning Research | 2.182 | 0.000 | 0.000 |
| ***Description:*** Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>634400 / *Space Systems Protection* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Spacecraft Threat Detection<br>***Description:*** Develop active satellite local space awareness technologies and exploitation tools for satellite systems.<br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 4.117 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 7.708 | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | Project (Number/Name)<br>635021 / *Space Systems Survivability* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635021: *Space Systems Survivability* | - | 1.581 | 6.500 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates technologies to improve space system survivability and reliability of current and future Department of Defense space systems that must continue operation despite natural space hazards. It develops and demonstrates cost-effective solutions to mitigate hazardous space environmental interactions including electrical charge buildup and electronics failures due to both single radiation events and long-term radiation doses.

In FY 2021 and future years, the efforts and activities under Project 635021, Space Systems Survivability, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Spacecraft Survivability/Reliability | 1.581 | 0.000 | 0.000 |
| ***Description:*** Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting.<br><br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 1.581 | 0.000 | 0.000 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Congressional Add: Program increase - ground-based interferometry | 0.000 | 6.500 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>635021 / *Space Systems Survivability* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed effort. This effort will be executed in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations. | | |
| **Congressional Adds Subtotals** | 0.000 | 6.500 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603401F / *Advanced Spacecraft Technology* | Project (Number/Name)<br>63682J / *Spacecraft Vehicles* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63682J: *Spacecraft Vehicles* | - | 24.084 | 23.840 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates compact, low-cost, spacecraft power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. This project also develops composites for spacecraft structures and technologies for spacecraft control and mechanisms.

In FY 2022, the space communications technology development efforts of PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 63682J, Spacecraft Vehicles, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.

In FY 2022, strategic deterrence ground technology development efforts of PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, were transferred to PE 0603211F, Aerospace Technology Dev/Demo, Project 634094, Next Gen Platform Dev/Demo, to better align DAF technology development.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Space Power Technologies | 1.065 | 0.000 | 0.000 |
| ***Description:*** Develop power generation space technologies such as multi-junction solar cells, thin-film solar cells, lightweight solar cell arrays, and radiation resistant solar cell modules and arrays.<br><br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Spacecraft Structures Technologies | 1.415 | 0.000 | 0.000 |
| ***Description:*** Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing.<br><br>***FY 2021 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>63682J / *Spacecraft Vehicles* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** On-Orbit Satellite Controls<br>***Description:*** Develop technologies for spacecraft controls and mechanisms for on-orbit applications.<br>***FY 2021 Plans:***<br>In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 0.416 | 0.000 | 0.000 |
| ***Title:*** Space Communication Technologies<br>***Description:*** Develop technologies for next-generation space communications terminals and equipment, along with methods/techniques to enable future space system operational command and control concepts.<br>***FY 2021 Plans:***<br>Continue support of planned five-year W/V-band propagation experiment. Support ground terminal operations, maintenance, and re-deployments. Collect and analyze data to statistically characterize atmospheric propagation effects and correlate to meteorological parameters. Continue research and development to address future military satellite communications capability and technology needs. Continue development of space-qualified V-band high power amplifier technology. Initiate development of W/V-band satellite transponder for on-orbit experiment and demonstration coupled with crosslinks. Continue systems engineering and technology risk-reduction for W/V-band ground terminals.<br>***FY 2022 Plans:***<br>In FY 2022, the space communications technology development efforts of PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, were transferred to Appropriation 3620, Research, Development, Test & Evaluation, | 9.744 | 9.317 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603401F / *Advanced Spacecraft Technology* | **Project (Number/Name)**<br>63682J / *Spacecraft Vehicles* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 63682J, Spacecraft Vehicles, from Appropriation 3600, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $9.317 million. Funding decreased due to transfer of space communications technology development efforts in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Space Advanced Technology Development/Demo, Project 63682J, Spacecraft Vehicles, due to the creation of a new Appropriation for Space Force. | | | |
| ***Title:*** Inertial Sensor Navigation Technologies<br><br>***Description:*** Develop next-generation solid state, radiation-hardened strategic advance inertial system components for hostile environments.<br><br>***FY 2021 Plans:***<br>Continued development of sensor and strategic grade components required for next generation systems.<br><br>***FY 2022 Plans:***<br>In FY 2022, strategic deterrence ground technology development efforts of PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, were transferred to PE 0603211F, Aerospace Technology Dev/Demo, Project 634094, Next Gen Platform Dev/Demo, to better align DAF technology development.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $14.523 million. Funding decreased due to transfer of strategic deterrence ground technology development efforts in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, to PE 0603211F, Aerospace Technology Dev/Demo, Project 634094, Next Gen Platform Dev/Demo, to better align DAF technology development. | 11.444 | 14.523 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 24.084 | 23.840 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603444F / *Maui Space Surveillance System (MSSS)* |

| 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 | - | 11.343 | 12.068 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| 634868: *Maui Space Surveillance System* | - | 11.343 | 12.068 | 0.000 | 0.000 | 0.000 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This program funds ground-based optical space situational awareness (SSA) technology development and demonstration at the Maui Space Surveillance System (MSSS) in Hawaii, as well as the operation and upgrade of the facility. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2022, the entirety of PE 0603444, Project 634868, Maui Space Surveillance System, is transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Project 634868, Maui Space Surveillance System, due to the creation of a new Appropriation for Space Force.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603444F / *Maui Space Surveillance System (MSSS)* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 11.878 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 11.343 | 12.068 | 0.000 | 0.000 | 0.000 |
| Total Adjustments | -0.535 | 12.068 | 0.000 | 0.000 | 0.000 |
| • Congressional General Reductions | 0.000 | -0.022 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 12.090 | | | |
| • Reprogrammings | -0.023 | 0.000 | | | |
| • SBIR/STTR Transfer | -0.096 | 0.000 | | | |
| • Other Adjustments | -0.416 | 0.000 | 0.000 | 0.000 | 0.000 |

**Change Summary Explanation**

FY 2022 decrease is due to the entirety of PE 0603444, Project 634868, Maui Space Surveillance System, is transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, Project 634868, Maui Space Surveillance System, due to the creation of a new Appropriation for Space Force.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Operate and Upgrade Maui Space Surveillance System | 11.343 | 12.068 | 0.000 |

***Description:*** Operate and upgrade the Maui Space Surveillance System to support development, demonstration, and integration of ground-based optical space situational awareness technologies.

***FY 2021 Plans:***

Continue to maintain Maui Space Surveillance System facility and experimental equipment in a mission-ready state. Perform needed upgrades and modernization to keep facilities and equipment in good working order and allow Maui Space Surveillance System to perform efficiently and reliably. Continue to operate Maui Space Surveillance System facility for development and demonstration of ground based optical space situational awareness capabilities in conjunction with customer programs and an operational Space Situational Awareness mission. Continue to accept control of geosynchronous satellite imaging capability, collecting images as requested by mission partners. Transition of dynamic telescope system operations into Maui Space Surveillance System capability baseline will be complete.

***FY 2022 Plans:***

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603444F / *Maui Space Surveillance System (MSSS)* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| In FY 2022, work formerly performed under this effort was transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, USSF S&T 6.3, Project 634868, Maui Space Surveillance System, from Appropriation 3620, Budget Activity (BA) 03 due to the creation of a new Appropriation for Space Force.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 12.068 million. Funding decreased due to the transfer and realignment of the work in the Operate and Upgrade Maui Space Surveillance System effort in PE 0603444F, Maui Space Surveillance Sys, Project 634868, Maui Space Surveillance System, to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206616SF, USSF S&T 6.3, Project 634868, Maui Space Surveillance System due to the creation of a new Appropriation for Space Force. | | | |
| **Accomplishments/Planned Programs Subtotals** | 11.343 | 12.068 | 0.000 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

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| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | | | | | | | |
| **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 | - | 32.827 | 31.667 | 24.589 | 0.000 | 24.589 | - | - | - | - | - | - |
| 635323: *Directed Energy Bioeffects Parameters* | - | 5.154 | 0.000 | 5.847 | 0.000 | 5.847 | - | - | - | - | - | - |
| 635324: *Human Dynamics and Terrain Demonstration* | - | 5.886 | 10.777 | 5.959 | 0.000 | 5.959 | - | - | - | - | - | - |
| 635325: *Mission Effective Performance* | - | 6.930 | 20.890 | 7.133 | 0.000 | 7.133 | - | - | - | - | - | - |
| 635327: *Warfighter Interfaces* | - | 14.857 | 0.000 | 5.650 | 0.000 | 5.650 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates technologies to enhance Airman performance and effectiveness in the aerospace force. State-of-the-science advances are made in warfighter training, warfighter system interfaces, directed energy bioeffects, deployment and sustainment of warfighters in extreme environments, and understanding and shaping adversarial behavior. The Directed Energy Bioeffects Parameters project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. The Human Dynamics and Terrain Demonstration develops, demonstrates, and transitions technologies to sustain airman performance in adverse operational and/or training environments, monitor and mitigate in-flight unexplained physiological events, and prevent human performance related mishaps through real-time monitoring and mitigation—particularly through highly automated or autonomous systems. The Mission Effective Performance project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. The Warfighter Interfaces project develops, demonstrates, and transitions technologies to revolutionize the way airmen synergistically use Air Force systems, including autonomous machines and adaptive teams of airmen and machines. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* |

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 37.542 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 32.827 | 31.667 | 24.589 | 0.000 | 24.589 |
| Total Adjustments | -4.715 | 31.667 | 24.589 | 0.000 | 24.589 |
| • Congressional General Reductions | 0.000 | -0.058 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 31.725 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -1.168 | 0.000 | | | |
| • Other Adjustments | -3.547 | 0.000 | 24.589 | 0.000 | 24.589 |

**Change Summary Explanation**

FY 2021 and FY 2022: Congressional directed realignments from program element restructure.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | Project (Number/Name)<br>635323 / *Directed Energy Bioeffects Parameters* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635323: *Directed Energy Bioeffects Parameters* | - | 5.154 | 0.000 | 5.847 | 0.000 | 5.847 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. This project develops the human components of the guidelines for testing, deployment, and protection from high-power microwave and high-energy laser systems and uses this information to enhance the effectiveness of these weapon systems in air, space, and cyber operations. This project develops tools and plug-ins that enhance mission and engagement models, provide predictive risk analysis for deployment of Directed Energy systems, and analyzes systems for use in the Department of Defense. This project develops tools and analysis techniques to model and demonstrate the use of fielded protection on Airman performance, and informs developers of design specifications to optimize design of novel weapon systems.

This project includes the initiation and development of programs addressing Department of the Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to Department of Air Force design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | 0.000 | 0.000 | 1.198 |
| ***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |
| ***FY 2021 Plans:***<br>Not applicable. This effort is starting in FY 2022. | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635323 / *Directed Energy Bioeffects Parameters* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.198 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| ***Title:*** Directed Energy Bioeffects<br><br>***Description:*** This project combined two efforts into a single effort to better align the directed energy modeling simulation and analysis supporting both radio-frequency and laser (optical) bioeffects advanced demonstration. Develop and demonstrate modeling capabilities to assess collateral hazards from high power directed energy laser and radio frequency (RF) systems, including the use of probabilistic risk assessment techniques and analysis of system level effects on the Airman. Develop and demonstrate optical protective technologies for aircrew and ground personnel to provide protection against directed energy threats.<br><br>***FY 2021 Plans:***<br>Provide hazard analysis for High Energy Laser flight safety reports. Readdress safety analysis for advancing Department of Defense directed energy concepts for safety review and technical review boards. Continue development of high peak power assessment models and tools to address real world concerns. Conclude evaluation of next generation of nuclear flash-blindness technologies and the impact on mission performance. Continue integration of radio frequency hazard, optical radiation hazard, and vision analysis and tools into Advanced Framework for Simulation, Integration and Modeling (AFSIM) architecture and the Endgame Framework architecture for future transitions in Joint weaponeering and targeteering tool suites. Begin development of Integrated Vision Modeling libraries to inform display design and advance protection technologies.<br><br>***FY 2022 Plans:***<br>Provide hazard analysis for directed energy systems under development for Department of Defense. Continue maturation of high peak power assessment models and tools to address real world concerns. Provide human response analysis to use of nuclear flash-blindness protection technologies and the impact on mission performance. Continue integration of radio frequency hazard, optical radiation hazard, and vision analysis and tools into Advanced Framework for Simulation, Integration and Modeling (AFSIM) architecture and the Endgame Framework architecture for future transitions in Joint weaponeering and targeteering tool suites and to support formal studies and analyses. Continue development of Integrated Vision Modeling libraries to inform display design and advanced protection technologies.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 0.000 | 0.000 | 4.649 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635323 / *Directed Energy Bioeffects Parameters* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $4.649 million. Funding increase due to added emphasis on Directed Energy Bioeffects efforts. | | | |
| ***Title:*** Optical Radiation Bioeffects<br>***Description:*** Develop and demonstrate optical protective technologies for aircrew and ground personnel to provide protection against directed energy threats. Develop modeling capabilities to assess collateral hazards from high-power directed energy laser systems.<br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Directed Energy Bioeffects effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 4.169 | 0.000 | 0.000 |
| ***Title:*** Radio Frequency Bioeffects<br>***Description:*** Develop and demonstrate technologies to assess radio frequency (RF) bioeffects and collateral hazards from high-power RF directed energy systems.<br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Directed Energy Bioeffects effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 0.985 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 5.154 | 0.000 | 5.847 |

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

N/A

**Remarks**

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635323 / *Directed Energy Bioeffects Parameters* |

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | Project (Number/Name)<br>635324 / *Human Dynamics and Terrain Demonstration* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635324: *Human Dynamics and Terrain Demonstration* | - | 5.886 | 10.777 | 5.959 | 0.000 | 5.959 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

Project objective is to develop, demonstrate, and transition products that provide Airman-integrated capabilities to sustain, enhance, and augment airmen physical and cognitive performance under challenging and adverse operational and training mission environments. Integrate technical advances in molecular and synthetic biology, multi-omics, cognitive performance optimization, brain-machine interface, and application of non-invasive physiological and cognitive performance monitoring devices. Develop solutions to sense, assess, and mitigate impacts to airmen performance degradation including, but not limited to, unexplained physiological events (UPE), fatigue, injury, stressors (environmental, occupational, personal), and cognitive overload. Develop technologies to enhance and accelerate individual physical and cognitive ability to rapidly learn and acquire new mission skills and maintain proficiency of acquired skills. Develop technologies providing commanders real time status monitoring and assessment of individual's mission ready status and intervention protocols to accelerate restoral to combat readiness.

This project includes the initiation and development of programs addressing Department of Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to Department of Air Force design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | 0.000 | 0.000 | 1.540 |
| ***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: unexplained physiological events (UPE), fatigue, injury, stressors (environmental, occupational, personal), and cognitive overload. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |
| ***FY 2021 Plans:***<br>Not Applicable | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635324 / *Human Dynamics and Terrain Demonstration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.540 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| ***Title:*** Sensing and Assessment<br><br>***Description:*** This project combined two efforts into a single effort to better align product development. Develop products that integrate biological, physiological, neural, environmental, and behavioral sensing capabilities with validated analytics and assessments to sustain and enhance airman performance in adverse operational and/or training environments.<br><br>***FY 2021 Plans:***<br>Initiate Integrated Cockpit Sensing effort to develop validated sensor suite providing real-time pilot alerting and data storage for unexplained physiological event root cause analysis. Perform sensor component down select following laboratory environmental (altitude chamber, centrifuge) testing. Conduct sensor component flight demonstrations in T-6 and F-16. Conduct ground-based demonstration of prototype integrated capability in F-35 simulation and simulator-based training exercises.<br><br>***FY 2022 Plans:***<br>Continue to develop, validate, and demonstrate the Integrated Cockpit Sensing technology. Start demonstration effort of a fatigue management system that incorporates self-contained sensing capabilities with validated models of cognitive performance under fatigue to guide targeted intervention. Begin integration of component sensors, models, and intervention protocols/methods into an advanced prototype fatigue management system. Develop models for use in wargaming simulations to assess impact of fatigue on operation effectiveness efficacy of fatigue management technologies. Demonstrates mobile decision-support technologies and software solutions improving situation awareness and enhancing communication effectiveness for dismounted operators. Demonstrate technologies enabling remote monitoring of airman physical and cognitive state. Demonstrate wearable interfaces lessening cognitive demands and increasing sensor interoperability.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $6.358 million. Funding decrease due to a reduced emphasis in sensing and assessment efforts. | 0.000 | 10.777 | 4.419 |
| ***Title:*** Human Analyst Augmentation<br><br>***Description:*** Develop and demonstrate human-centered design processes and operational tools that optimize Intelligence, Surveillance and Reconnaissance information exploitation and analysis. | 4.104 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635324 / *Human Dynamics and Terrain Demonstration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Sensing and Assessment effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Human Trust and Interaction<br>***Description:*** Develop and demonstrate machine translation and speech-to-text tools to support the span of Air Force mission areas including intelligence, surveillance, and reconnaissance and cyber operations.<br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Sensing and Assessment effort.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 1.782 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 5.886 | 10.777 | 5.959 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | Project (Number/Name)<br>635325 / *Mission Effective Performance* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635325: *Mission Effective Performance* | - | 6.930 | 20.890 | 7.133 | 0.000 | 7.133 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. This project also develops advanced methods and technologies to enable interactive live, virtual, and constructive (LVC) environments for performance-aiding methods and technologies. Focus areas include integrated high-fidelity weapon systems training technologies for air, space, and cyber; tailored immersive simulation environments for airmen at the tactical and operational levels; and incorporation of performance assessment and feedback tools. These methods and technologies facilitate the development of mission-essential competencies.

This project includes the initiation and development of programs addressing Department of Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to Department of Air Force design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | 0.000 | 0.000 | 2.054 |
| ***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |
| ***FY 2021 Plans:***<br>Not Applicable | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635325 / *Mission Effective Performance* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $2.054 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| ***Title:*** Readiness<br><br>***Description:*** Develop and demonstrate secure, persistent, and standardized live, virtual, and constructive training enterprise. Utilize modeling capabilities for technology demonstration efforts focused on developing software-based tools for training that would replace human instructors.<br><br>***FY 2021 Plans:***<br>Complete initial development of proficiency-based training metrics and assessments in operational contexts. Continue multidomain operations training development and demonstration. Continue field evaluations for performance-based after action review visualization tools in unit-level and Red Flag-Level training and rehearsal. Continue assessments and evaluations of common range and simulation architecture technologies for Live, Virtual, and Constructive training capabilities. Complete portfolio migration focused on advanced research and transitions under a Readiness product line construct with emphases on standards for training and operational data, tools for rapid development of mission-focused software agent applications. Continue to develop realistic in contested degraded operations environment multi- domain operations training and rehearsal.<br><br>***FY 2022 Plans:***<br>Continue transition of readiness and proficiency tracking tools into tactical operations. Continue development and evaluation of technologies to permit routine tracking of mission performance and readiness across virtual and live training environments. Complete data specifications for encrypted data retrieval from operational aircraft and instrumented ranges and conduct field demonstrations of seamless, integrated readiness tracking. Begin alignment of augmented and virtual reality training with readiness and proficiency tracking tools. Begin field testing of software agent models inside Government and Commercial training and rehearsal systems and on instrumented ranges.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by 15.811 million. Funding decrease due to reduced emphasis in readiness efforts. | 0.000 | 20.890 | 5.079 |
| ***Title:*** Continuous Learning | 6.930 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635325 / *Mission Effective Performance* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate secure, persistent, and standardized LVC training enterprise. Utilize modeling capabilities for technology demonstration efforts focused on developing software-based tools for training that would replace human instructors.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Readiness effort.<br><br>***FY 2022 Plans:***<br>Not applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| **Accomplishments/Planned Programs Subtotals** | 6.930 | 20.890 | 7.133 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | Project (Number/Name)<br>635327 / *Warfighter Interfaces* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635327: *Warfighter Interfaces* | - | 14.857 | 0.000 | 5.650 | 0.000 | 5.650 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, demonstrates, and readies the transition of technologies to revolutionize the way airmen optimize the capabilities of Air Force systems, including autonomous machines and adaptive teams of Airmen and machines. Improvements in the presentation of operational information to the community of users, from the system operator to the commander, must be developed in step with advancements in the acquisition, storage, and retrieval of information. This project provides the advances in understanding of human cognitive abilities, as well as the utilization of human interfaces, multisensory fusion, high-resolution image displays, and three-dimensional (3D) audio to customize communications and enhance shared understanding across a diverse user community in air, space, and cyber for maximum situational awareness.

This project includes the initiation and development of programs addressing Department of Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to Department of Air Force design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | 0.000 | 0.000 | 0.856 |
| ***Description:*** Continually funded effort. This funding allocation is to provide funding to start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: autonomous machines and adaptive teams of Airmen and machines. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |
| ***FY 2021 Plans:***<br>Not Applicable | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635327 / *Warfighter Interfaces* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Fund the follow-on efforts for Transformational Technology Development projects selected in prior FYs. Select Transformational Technology Development efforts starting in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.856 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | | | |
| ***Title:*** Airman Machine Interfaces<br><br>***Description:*** Develops and demonstrates wearable technologies and operator-centric interfaces that increase the Airman's combat capabilities. This is accomplished through integrated solutions that develop synergies, maximize battlespace interoperability, and increase combat power while decreasing Airman physical and cognitive workloads.<br><br>***FY 2021 Plans:***<br>In FY 2021, prepare for transition of advanced wearable technologies improving situation awareness and enhancing communication effectiveness for dismounted operators. Develop and demonstrate manned-unmanned pilot vehicle interface mission intents and team concepts for tactical environments. Develop team collaborative interfaces focusing on cognitive workload reduction. Prototype innovative man-wearable interfaces tailored to Special Warfare operations.<br><br>***FY 2022 Plans:***<br>Prepare for transition of advanced command and control technologies for operators in multiple domains operating in both the air and ground. Develop and demonstrate manned-unmanned teaming interfaces with intents and concepts embedded within the strategic, operational and tactical environments. Continue development of collaborative interfaces for cognitive workload reduction. Establish online repositories for open and interoperable software development. Prototype operational human-machine interfaces via dismounted/mounted hardware. Develop and transition interface technologies to satisfy user requirements by controlling the tactical airspace inhabited by small unmanned aerial systems.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $1.678 million. Funding increase due to added emphasis in airman-machine interface efforts. | 0.000 | 0.000 | 1.678 |
| ***Title:*** Analytic Tools<br><br>***Description:*** Develops, demonstrates, and matures software solutions for Command and Control, Intelligence Surveillance & Reconnaissance, Space, and Cyber customers for improved system performance (operator/analyst and software). Software ranges from simplistic decision support systems to sophisticated artificial intelligence and machine learning algorithms designed to handle data at the scale of operations. Heavy emphasis is placed on human-machine teaming including workflow design and | 0.000 | 0.000 | 3.116 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635327 / *Warfighter Interfaces* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| integration of both automated and human-generated results. Effort leverages significant infrastructure in big-data design and capture, allowing for rapid prototyping of capabilities directly to web-based platforms on classified environments. Program directly supports contested-denied operations in a multi-domain environment.<br><br>***FY 2021 Plans:***<br>In FY 2021, prepare to transition speech-to-text technologies for military intelligence producing systems. Enhance and prepare for transition Electronic Order of Battle tools for multiple theaters of operation. Test and host open source speech-to-text methods on multiple networks. Enhance automated speed of detections for national imagery exploitation. Perform technical demonstrations at exercises supporting United States Pacific Command and United States European Command.<br><br>***FY 2022 Plans:***<br>Perform integration and transition of speech-to-text technologies with military intelligence systems. Enhance electronic, air, and air defense order of battle visualization, analysis, and dissemination to multiple theaters of operation. Enhance threat detection, decision making, and intelligence, surveillance and reconnaissance (ISR) planning and collection decision aides. Prepare for Department of the Air Force certification and transition of technology solutions to strategic partners. Conduct research to speed up access to the relevance of auto-detections of vital data. Timeliness of detection will continue to improve warfighter decision making. Research and document detections via several methods of automation and deliver concepts of operation (CONOPS) and tactics, techniques and procedures (TTPs) for tactical use of national exploitation systems, with characterizations of denied weapons systems. Perform evaluations of automation methods for new systems, not typically used for algorithm detections.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.116 million. Funding increased due to added emphasis analytic tools efforts. | | | |
| ***Title:*** Battlespace Acoustics<br><br>***Description:*** Develops and demonstrates wearable technologies and operator-centric interfaces that increase the Airman's combat capabilities. This is accomplished through integrated solutions that develop synergies, maximize battlespace interoperability, and increase combat power while decreasing Airman physical and cognitive workloads.<br><br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Airman Machine Interfaces effort, with the exception of funding associated with the Skyborg Vanguard demonstration which is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguards.<br><br>***FY 2022 Plans:*** | 3.714 | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603456F / *Human Effectiveness Advanced Technology Development* | **Project (Number/Name)**<br>635327 / *Warfighter Interfaces* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | | | |
| ***Title:*** Human Role in Semiautonomous Systems<br>***Description:*** Develops, demonstrates, and matures software solutions for Command and Control, Intelligence Surveillance & Reconnaissance, Space, and Cyber customers for improved system performance (operator/analyst and software). Software ranges from simplistic decision support systems to sophisticated artificial intelligence and machine learning algorithms designed to handle data at the scale of operations. Heavy emphasis is placed on human-machine teaming including workflow design and integration of both automated and human-generated results. Effort leverages significant infrastructure in big-data design and capture, allowing for rapid prototyping of capabilities directly to web-based platforms on classified environments. Program directly supports contested-denied operations in a multi-domain environment.<br>***FY 2021 Plans:***<br>In FY 2021, this work is performed under the Analytic Tools effort, with the exception of funding associated with the Skyborg Vanguard demonstration which is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguards.<br>***FY 2022 Plans:***<br>Not applicable<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not applicable | 11.143 | 0.000 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 14.857 | 0.000 | 5.650 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not applicable

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603601F / *Conventional Weapons Technology* | | | | | | | |
| **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 | - | 202.048 | 133.900 | 157.423 | 0.000 | 157.423 | - | - | - | - | - | - |
| 63670A: *Weapon Technology Development* | - | 57.895 | 0.000 | 55.278 | 0.000 | 55.278 | - | - | - | - | - | - |
| 63670B: *Weapon Concept Development* | - | 144.153 | 133.900 | 102.145 | 0.000 | 102.145 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This project develops, integrates, and demonstrates advanced ordnance and guidance technologies for air-launched conventional weapons. The effort focuses on conventional ordnance component technologies such as warheads, fuzes, and explosives, as well as munition guidance component technologies such as navigation and control systems and seekers. Technologies to be developed, demonstrated, and integrated into system concepts will address blast, fragmentation, penetration, low collateral damage, variable depth/location fuzing, precise guidance, and high-performance and insensitive explosives. Efforts in this project have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | Date: May 2021 |
|---|---|---|---|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | **R-1 Program Element (Number/Name)**<br>PE 0603601F / *Conventional Weapons Technology* | | |
| **B. Program Change Summary ($ in Millions)** | **FY 2020** | **FY 2021** | **FY 2022 Base** | **FY 2022 OCO** | **FY 2022 Total** |
| Previous President's Budget | 225.817 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 202.048 | 133.900 | 157.423 | 0.000 | 157.423 |
| Total Adjustments | -23.769 | 133.900 | 157.423 | 0.000 | 157.423 |
| • Congressional General Reductions | 0.000 | -0.245 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | 0.000 | 134.145 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -7.604 | 0.000 | | | |
| • Other Adjustments | -16.165 | 0.000 | 157.423 | 0.000 | 157.423 |

**Change Summary Explanation**

FY 2021 and 2022: Congressional directed realignment due to reversal of program element restructure.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603601F / *Conventional Weapons Technology* | Project (Number/Name)<br>63670A / *Weapon Technology Development* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63670A: *Weapon Technology Development* | - | 57.895 | 0.000 | 55.278 | 0.000 | 55.278 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, matures, assesses, and demonstrates advanced/innovative ordnance and guidance component and subsystem technologies for air-launched conventional weapons. The project focuses on maturation of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Ordnance Technologies | 29.582 | 0.000 | 27.082 |

***Description:*** Develop and demonstrate integrated ordnance technologies to improve conventional air-delivered munitions. Specific technical areas of focus include energetic materials, fuze technology, warhead sciences, and modeling and simulation tools.

***FY 2021 Plans:***

Complete joint technology demonstration for dialable effects technologies. Continue to demonstrate distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications such as layer counting at high speed, including assessing long-term safety, survivability, and functionality. Continue development of ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Continue to mature ordnance technologies for rapid transition into high-speed strike weapon concepts, collecting complex arena test data for implementation into lethality modeling and simulation tools. Continue to develop test capabilities and high-fidelity analysis tools to generate more accurate, faster-running weaponeering data. Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research into armament systems for Special Operations applications. Continue to conduct lethality analyses for weapons and improve lethality and survivability tools at the meso-scale and micro-scale. Continue to mature research on distributed, collaborative, cooperative effects munition technologies. Continue the development of high-fidelity test capabilities and analysis tools to evaluate ordnance technologies in relevant environments. Continue incorporation of previously developed material models and improve/advance additional joint kinetic/directed energy common target models. Continue synthesis and incorporation of warhead models for progressive collapse, multiple point initiation, secondary debris and others.

***FY 2022 Plans:***

Continue to demonstrate distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications such as layer counting at high-speed, including assessing long-term safety, survivability, and functionality. Continue

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603601F / *Conventional Weapons Technology* | **Project (Number/Name)**<br>63670A / *Weapon Technology Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| development of ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Continue to mature ordnance technologies for rapid transition into high-speed strike weapon concepts, collecting complex arena test data for implementation into lethality modeling and simulation tools. Continue to develop test capabilities and high-fidelity analysis tools to generate more accurate, faster-running weaponeering data. Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research into armament systems for Special Operations applications. Continue to conduct lethality analyses for weapons and improve lethality and survivability tools at the meso-scale and micro-scale. Continue to mature research on distributed, collaborative and cooperative effects munition technologies. Continue the development of high-fidelity test capabilities and analysis tools to evaluate ordnance technologies in relevant environments. Continue incorporation of previously developed material models and improve/advance additional joint kinetic/directed energy common target models. Continue synthesis and incorporation of warhead models for progressive collapse, multiple point initiation, secondary debris and other models.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $27.082 million. Funding increased in FY 2022 due to the Weapon Technology Development Project funding being inadvertently recorded in the Weapon Concept Development Project in FY 2021. | | | |
| ***Title:*** Guidance Technologies | 28.313 | 0.000 | 28.196 |
| ***Description:*** Develop guidance technologies to improve the precision, controlled lethality, and flexibility of conventional, air-delivered munitions. Specific technical areas include precision navigation and terminal seekers.<br><br>***FY 2021 Plans:***<br>Continue integration of hardware-in-the-loop, software-in-the-loop, and other Modeling and Simulation technologies for the demonstration of open architecture, high-speed, cooperative, and modular munition concepts. Continue the design and development of seeker subsystem prototypes for platform self-defense. Continue development of advanced, high-resolution infrared scene projectors, distributed simulation concepts, software defined radio frequency test chamber, scene generation, mission, engagement, campaign level simulations, and panoramic infrared dome technologies. Continue to develop technologies for precision navigation of weapons in Global Positioning System-denied scenarios. Continue to mature and integrate advanced carriage and release concepts and sub-systems. Continue providing multi-security level, cross-domain distributed Modeling and Simulation support for munition research using distributed connectivity between multiple Eglin Air Force Base facilities. Begin integration of lethality models into guidance and control simulation to enhance weapon integrated performance. Begin development of sensor test technologies to enable verification of autonomous munition concepts. Initiate the integration of higher fidelity constructive analysis tools with engagement and mission level Modeling and Simulation.<br>***FY 2022 Plans:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603601F / *Conventional Weapons Technology* | **Project (Number/Name)**<br>63670A / *Weapon Technology Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue integration of hardware-in-the-loop, software-in-the-loop, and other modeling and simulation technologies for the demonstration of open architecture, high-speed, networked, collaborative and autonomous, and modular munition concepts. Continue the design and development of seeker sub-system prototypes for platform self-defense. Continue development of advanced, high-resolution infrared scene projectors, distributed simulation concepts, software-defined radio frequency test chamber, scene generation, mission, engagement, campaign level simulations, and panoramic infrared dome technologies. Continue to develop technologies for precision navigation of weapons in Global Positioning System-denied scenarios. Continue to mature and integrate advanced carriage and release concepts and sub-systems. Continue providing multi-security level, cross-domain distributed modeling and simulation support for munition research using distributed connectivity between Eglin Air Force Base facilities and other geographic locations. Continue integrating lethality models into guidance and control simulations to enhance weapon integrated performance. Continue development of sensor test technologies to enable verification of autonomous munition concepts. Continue integrating higher fidelity constructive analysis tools with engagement and mission level modeling and simulation. Initiate miniature munition technology integration for ground launch demonstration.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $28.196 million. Funding increased in FY 2022 due to the Weapon Technology Development Project funding being inadvertently recorded in the Weapon Concept Development Project in FY 2021. | | | |
| **Accomplishments/Planned Programs Subtotals** | 57.895 | 0.000 | 55.278 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603601F / *Conventional Weapons Technology* | Project (Number/Name)<br>63670B / *Weapon Concept Development* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63670B: *Weapon Concept Development* | - | 144.153 | 133.900 | 102.145 | 0.000 | 102.145 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops, refines, integrates, demonstrates, and assesses ordnance and guidance technologies to reduce risk for potential air-launched conventional weapons acquisitions. The project concentrates in two effort areas, Air-to-Air Concept Development and Air-to-Ground Concept Development. The project focuses on risk reduction of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Air-to-Air Concept Development | 69.707 | 64.968 | 43.790 |
| ***Description:*** Mature, integrate, and demonstrate air-to-air weapon components and systems to include ordnance, guidance, and carriage and release technologies to demonstrate war-fighter capability. | | | |
| ***FY 2021 Plans:***<br>Continue developing the technology trade space to enable air-to-air weapons with robust capability in the future threat environment, including technologies for efficient propulsion, high lethality, efficient flight / high agility, miniaturization, and cost and risk reduction for both offensive and defensive purposes. Continue to develop and test prototype propulsion systems with flexibility to enable more adaptable next generation air-to-air weapons. Continue to conduct lethality studies to enable design of small form factor warheads lethal against the 2030 plus target set. Transition advanced target models to other AF and DoD offices. Continue to develop preliminary design of air-to-air weapon concepts for sixth generation platforms. Continue to document missile flight dynamics trade space and conduct wind-tunnel experiments to characterize airframes and validate aerodynamic codes leading to development of highly maneuverable and efficient missiles to counter advanced targets, and improve persistence and survivability of future platforms. Continue to conduct ground and arena tests of advanced weapons experimental carriages for sixth generation weapon concept and prepare for flight worthiness testing. Continue to mature simulation architectures to assess the trade and synergies between kinetic and directed energy weapons. Continue to perform experiments with small warheads to obtain data for lethality analysis to validate and improve designs. Continue to plan and execute integrated subsystem | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603601F / *Conventional Weapons Technology* | **Project (Number/Name)**<br>63670B / *Weapon Concept Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| experiments. Complete self defense munition maturation of hardware and software elements, integrate, assemble and test the complete munition.<br><br>***FY 2022 Plans:***<br>Continue developing the technology trade space to enable air-to-air weapons with robust capability in the future threat environment, including technologies for efficient propulsion, high lethality, efficient flight, high agility, miniaturization, as well as cost and risk reduction for both offensive and defensive purposes. Continue to develop and test prototype propulsion systems with flexibility to enable more adaptable next generation air-to-air weapons. Continue to conduct lethality studies to enable design of small form factor warheads lethal against the 2030 plus target set. Transition advanced target models to other AF and DoD offices. Continue to develop preliminary design of air-to-air weapon concepts for sixth generation platforms. Continue to document missile flight dynamics trade space. Continue to conduct wind-tunnel experiments to characterize airframes and validate aerodynamic codes leading to development of highly maneuverable and efficient missiles to counter advanced targets, and improve persistence and survivability of future platforms. Continue to conduct ground and arena tests of advanced weapons experimental carriages for sixth generation weapon concept and prepare for flight worthiness testing. Continue to mature simulation architectures to assess the trade and synergies between kinetic and directed energy weapons. Continue to perform experiments with small warheads to obtain data for lethality analysis to validate and improve designs. Continue to plan and execute integrated sub-system experiments. Initiate miniature munition ground launch demonstration. Initiate modeling, simulation, analysis, and digital engineering in support of air-to-air advanced weapon technologies.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $21.178 million. Funding decreased in FY 2022 due to the Weapon Technology Development Project funding being inadvertently recorded in the Weapon Concept Development Project in FY 2021. | | | |
| ***Title:*** Air-to-Ground Concept Development<br><br>***Description:*** Mature, integrate, and demonstrate air-to-ground weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate war-fighter capability.<br><br>***FY 2021 Plans:***<br>Complete hypersonic boost glide testing. Initiate expanded integration of collaborative weapon technology onto additional weapon systems. Continue system integration of algorithms and software defined radios onto pathfinder weapon system to enable synchronized collaborative weapon effects. Continue planning and technology risk reduction including demonstration and flight testing for weapons concepts responsive to the future threat environment (including hypersonic and cooperative/collaborative concepts). Continue to mature simulation architectures to assess the trades and synergies between kinetic and directed energy weapons. Continue to develop kinetic/non-kinetic payloads, seeker, and fuze technology for hypersonic applications.<br><br>***FY 2022 Plans:*** | 74.446 | 68.932 | 47.768 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603601F / *Conventional Weapons Technology* | **Project (Number/Name)**<br>63670B / *Weapon Concept Development* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue expanded integration of collaborative weapon technology onto additional weapon systems. Complete exploring the algorithms and software defined radios for networked, collaborative, and autonomous weapon effects. Continue planning efforts for technology risk reduction including demonstration and flight testing for weapons concepts responsive to the future threat environment (including hypersonic and cooperative/collaborative concepts). Continue to mature simulation architectures to assess the trades and synergies between kinetic and directed energy weapons. Continue to develop kinetic/non-kinetic payloads, seeker, and fuze technology for hypersonic applications. Initiate modeling, simulation, analysis, and digital engineering in support of air-to-ground advanced weapon technologies.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $21.164 million. Funding decreased in FY 2022 due to the Weapon Technology Development Project funding being inadvertently recorded in the Weapon Concept Development Project in FY 2021. | | | |
| ***Title:*** Transformational Component<br>***Description:*** This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority<br>***FY 2021 Plans:***<br>Not Applicable.<br>***FY 2022 Plans:***<br>Initiate transformational efforts to address weapons capability gaps.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY22 increased compared to FY21 by $10.587 million. Funding is increased due to initiation of this effort to increased emphasis in Transformational Technology Development projects. | 0.000 | 0.000 | 10.587 |
| **Accomplishments/Planned Programs Subtotals** | 144.153 | 133.900 | 102.145 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | Date: May 2021 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603605F / *Advanced Weapons Technology* | | | | | | | |
| **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 | - | 32.578 | 31.388 | 28.258 | 0.000 | 28.258 | - | - | - | - | - | - |
| 633151: *High Power Solid State Laser Technology* | - | 14.418 | 31.388 | 18.359 | 0.000 | 18.359 | - | - | - | - | - | - |
| 633152: *High Power Microwave Development and Integration* | - | 18.160 | 0.000 | 9.899 | 0.000 | 9.899 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program provides for the development, integration, demonstration, and detailed assessment of directed energy (DE) weapon technologies for potential application on Air Force platforms. These include high energy laser (HEL), high power microwaves (HPM), and other unconventional weapon generation and transmission technologies, which can support a wide range of Air Force applications. The program develops a corresponding susceptibility, vulnerability, and lethality database for directed energy weapons. This program also develops laser-enabled atmospheric-compensated optical imaging for space situational awareness (SSA). Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this program element would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | Date: May 2021 |
|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | R-1 Program Element (Number/Name)<br>PE 0603605F / *Advanced Weapons Technology* | | |
| **B. Program Change Summary ($ in Millions)** | **FY 2020** | **FY 2021** | **FY 2022 Base** | **FY 2022 OCO** | **FY 2022 Total** |
| Previous President's Budget | 37.404 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 32.578 | 31.388 | 28.258 | 0.000 | 28.258 |
| Total Adjustments | -4.826 | 31.388 | 28.258 | 0.000 | 28.258 |
| • Congressional General Reductions | 0.000 | -0.057 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 0.000 | | | |
| • Congressional Directed Transfers | -0.060 | 31.445 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -1.232 | 0.000 | | | |
| • Other Adjustments | -3.534 | 0.000 | 28.258 | 0.000 | 28.258 |

**Change Summary Explanation**

Air Force activities supporting Directed Energy advanced technology development in FY 2022 decreased compared to FY 2021 by 0.690 Million. Funding decreased in order to implement the Department of the Air Force Science and Technology 2030 Strategy for transformational capabilities.

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603605F / *Advanced Weapons Technology* | Project (Number/Name)<br>633151 / *High Power Solid State Laser Technology* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633151: *High Power Solid State Laser Technology* | - | 14.418 | 31.388 | 18.359 | 0.000 | 18.359 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project provides for the development, integration, demonstration, and detailed technical assessment of high energy laser devices, advanced imaging and beam control technologies needed for applications such as force protection, force application, precision engagement, and aircraft self-protection. Laser system concept assessments to include vulnerability assessments and target effect testing are performed.

This project includes the initiation and development of programs addressing Department of the Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| ***Title:*** High Energy Laser/Beam Control | 14.418 | 31.388 | 17.418 | 0.000 | 17.418 |
| ***Description:*** Develop and demonstrate advanced beam control technologies, integrated laser systems, and aircraft self-protection laser technologies. Demonstrate beam control components integrated with high energy lasers for the Department of the Air Force utility. | | | | | |
| ***FY 2021 Plans:***<br>Complete system integration of 50 kilo-Watt high power podded laser system for flight demonstration. Complete high power ground test for podded 50 kilo-Watt laser system. Begin preparations for high power flight test. | | | | | |
| ***FY 2022 Base Plans:***<br>Continue SHiELD (Self-Protect High Energy Laser Demonstrator) system development and integration for technical demonstration. Continue planning for flight testing. | | | | | |
| ***FY 2022 OCO Plans:***<br>Not applicable. | | | | | |
| ***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603605F / *Advanced Weapons Technology* | **Project (Number/Name)**<br>633151 / *High Power Solid State Laser Technology* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $13.970 million. Funding decreased in order to implement the Department of the Air Force Science and Technology 2030 Strategy for transformational capabilities. FY 2022 funding levels consistent with planed investments for Directed Energy advance technology development. | | | | | |
| ***Title:*** Transformational Technology Development<br><br>***Description:*** This effort includes the initiation and development of programs addressing Department of the Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.<br><br>***FY 2021 Plans:***<br>Select Transformational Technology Development efforts in FY 2021 that support the National Defense Strategy and Department of Air Force priorities.<br><br>***FY 2022 Base Plans:***<br>Fund the follow-on efforts for projects started in FY 2021. Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities<br><br>***FY 2022 OCO Plans:***<br>N/A<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 0.941 million. Funding is increased due to additional emphasis in the development of high energy laser weapon systems. | 0.000 | 0.000 | 0.941 | 0.000 | 0.941 |
| **Accomplishments/Planned Programs Subtotals** | 14.418 | 31.388 | 18.359 | 0.000 | 18.359 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603605F / *Advanced Weapons Technology* | Project (Number/Name)<br>633152 / *High Power Microwave Development and Integration* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 633152: *High Power Microwave Development and Integration* | - | 18.160 | 0.000 | 9.899 | 0.000 | 9.899 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This project develops and demonstrates high power microwave and other unconventional electromagnetic field generation and transmission technologies that can be integrated into future weapon systems to support a wide range of the Department of the Air Force missions such as air base defense or the damage/destruction of an adversary's electronic infrastructure. It also provides inputs to the susceptibility, vulnerability, and lethality databases used across the Department of Defense to understand thresholds for scalable effects of directed energy weapons.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| ***Title:*** High Power Microwave Technologies | 18.160 | 0.000 | 3.826 | 0.000 | 3.826 |
| ***Description:*** Develop and evaluate high power microwave and other unconventional weapon technologies for various platforms, including aerial, for applications such as counter-electronics. Develop and evaluate high power microwave technologies for non-kinetic and counter-electronic weapon applications.<br><br>***FY 2021 Plans:***<br>Down-select to an advance reusable platform. Initiate high power microwave payload integration. Continue to characterize, model, test and evaluate current and projected blue directed energy threats on current red assets. Integrate the high power microwave payload into the aerial platform for the joint flight demonstration with the Navy. Design agile waveform high power sources.<br><br>***FY 2022 Base Plans:***<br>Initiate high power microwave payload integration into an advanced, reusable, aerial platform. Continue to characterize, model, test and evaluate current and projected blue Directed Energy weapons against relevant red assets. Conduct the joint static technology demonstration of a compact High Power Microwave weapon with the Navy. Design next generation High Power Microwave sources.<br><br>***FY 2022 OCO Plans:*** | | | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603605F / *Advanced Weapons Technology* | **Project (Number/Name)**<br>633152 / *High Power Microwave Development and Integration* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Not applicable.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $3.826 million. FY 2022 funding levels are below originally planed investments for high power microwave advanced technology development. Funding decreased in order to implement the Department of the Air Force Science and Technology 2030 Strategy for transformational future force capabilities. | | | | | |
| ***Title:*** Transformational Technology Development<br>***Description:*** This effort includes the initiation and development of programs addressing Department of the Air Force capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.<br>***FY 2021 Plans:***<br>Select Transformational Technology Development efforts in FY 2021 that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2022 Base Plans:***<br>Fund the follow-on efforts for projects started in FY 2021. Select Transformational Technology Development efforts in FY 2022 that support the National Defense Strategy and Department of the Air Force priorities<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 6.073 million. Funding is increased due to additional emphasis in the development of transformational capabilities. | 0.000 | 0.000 | 6.073 | - | 6.073 |
| **Accomplishments/Planned Programs Subtotals** | 18.160 | 0.000 | 9.899 | 0.000 | 9.899 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603680F / *Manufacturing Technology Program* | | | | | | | |
| **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 | - | 133.059 | 138.748 | 45.259 | 0.000 | 45.259 | - | - | - | - | - | - |
| 635280: *Manufacturing Technologies* | - | 133.059 | 138.748 | 45.259 | 0.000 | 45.259 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

This program executes technical efforts to develop and maintain an affordable and reliable industrial base and manufacturing capability responsive to Department of the Air Force warfighter needs. The program develops and improves manufacturing technologies and processes to reduce transition risk, enable cost reduction, improve component and system quality, increase readiness and affordable mission availability, enhance industrial capability and promote transformation through the industrial base. Value stream modifications and manufacturing throughput improvements are implemented to shorten weapon system cycle times during design, development, production and sustainment. Cost savings are realized through early engagement with stakeholders to promote producible designs, ensuring the industrial base will be ready to manufacture at the needed quantities. Manufacturing technologies objectives are conducted through industrial partnerships that enable targeted investment of manufacturing technologies and reduce risk in the industrial supply chain for existing weapon system upgrades and new warfighter systems. Efforts in the program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* |

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 130.916 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 133.059 | 138.748 | 45.259 | 0.000 | 45.259 |
| Total Adjustments | 2.143 | 138.748 | 45.259 | 0.000 | 45.259 |
| • Congressional General Reductions | 0.000 | -0.253 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 98.600 | | | |
| • Congressional Directed Transfers | 0.000 | 40.401 | | | |
| • Reprogrammings | -0.003 | 0.000 | | | |
| • SBIR/STTR Transfer | -3.256 | 0.000 | | | |
| • Other Adjustments | 5.402 | 0.000 | 45.259 | 0.000 | 45.259 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 635280: *Manufacturing Technologies* | | |
| Congressional Add: *Program increase - F-35 Battery Technology* | 9.549 | 9.600 |
| Congressional Add: *Program increase - Thermal protection for hypersonic vehicles* | 9.744 | 0.000 |
| Congressional Add: *Program increase - Materials Development Research* | 4.872 | 0.000 |
| Congressional Add: *Program Increase - Modeling Technology for Small Turbine Engines* | 4.872 | 7.000 |
| Congressional Add: *Program increase - Low cost manufacturing methods for hypersonic vehicle components* | 7.795 | 8.000 |
| Congressional Add: *Program increase - Flexible hybrid electronics* | 4.872 | 0.000 |
| Congressional Add: *Program increase - Aerospace composite structures* | 4.872 | 0.000 |
| Congressional Add: *Program increase - Certification of bonded aircraft structures* | 4.872 | 0.000 |
| Congressional Add: *Program increase - Industrialization of ceramic matrix composites for hypersonic weapons* | 9.744 | 0.000 |
| Congressional Add: *Program increase - Thermal batteries* | 1.949 | 0.000 |
| Congressional Add: *Program increase - Technologies to repair fastener holes* | 4.872 | 5.000 |
| Congressional Add: *Program increase - Manufacturing technology for reverse engineering* | 4.872 | 5.000 |
| Congressional Add: *Program increase - Solid state battery research* | 2.923 | 0.000 |
| Congressional Add: *Program increase - Agile manufacturing initiatives* | 9.744 | 0.000 |
| Congressional Add: *Program increase - Hybrid manufacturing for rapid tooling and repair* | 0.000 | 5.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add: *Program increase - cost reduction for aerospace composite structures* | 0.000 | 10.000 |
| Congressional Add: *Program increase - flexible thermal protection systems for hypersonics* | 0.000 | 10.000 |
| Congressional Add: *Program increase - alternative domestic rubber production* | 0.000 | 5.000 |
| Congressional Add: *Program increase - large scale additive manufacturing for hypersonics* | 0.000 | 6.000 |
| Congressional Add: *Program increase - manufacturing readiness for hypersonic propulsion systems* | 0.000 | 10.000 |
| Congressional Add: *Program increase - thermoplastic material systems* | 0.000 | 7.000 |
| Congressional Add: *Program increase - automated fiber placement for composite structures* | 0.000 | 5.000 |
| Congressional Add: *Program increase - hypersonic manufacturing capability and supply* | 0.000 | 6.000 |
| Congressional Add Subtotals for Project: 635280 | 85.552 | 98.600 |
| Congressional Add Totals for all Projects | 85.552 | 98.600 |

**Change Summary Explanation**

Increase in FY 2022 is due to realigning the manufacturing efforts to this program.
FY 2020 Other Adjustments due to Civilian pay adjustment.

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Affordable Mission Availability | 13.302 | 11.241 | 13.578 |
| ***Description:*** Develop and transition pervasive manufacturing technologies for affordable mission availability of Department of the Air Force components and systems. The name of this effort changed from Sustainment Manufacturing Technologies to Affordable Mission Availability to better reflect the technical objectives. | | | |
| ***FY 2021 Plans:***<br>Continue to advance high demand specialized manufacturing technologies to develop cost effective conventional production, overhaul, and specialty material repair technologies to enable affordable sustainment of aircraft systems. Continue to develop cost-effective manufacturing and repair processes to meet specific needs of Programs of Record and depots. Continue to develop manufacturing methods to meet the needs of the next generation hypersonic platforms. Continue to develop and demonstrate the manufacturability of materials, processes and devices for command and control communication technologies, intelligence, surveillance and reconnaissance systems, and RF, digital and power management components. | | | |
| ***FY 2022 Plans:*** | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Continue to advance high demand specialized manufacturing technologies to develop cost effective conventional production, overhaul, and specialty material repair technologies to enable affordable sustainment of aircraft systems. Continue to develop cost-effective manufacturing and repair processes to meet specific needs of Programs of Record and depots. Continue to develop manufacturing methods to meet the needs of the next generation hypersonic platforms. Continue to develop and demonstrate the manufacturability of materials, processes and devices for command and control communication technologies, intelligence, surveillance and reconnaissance systems, and RF, digital and power management components. Initiate manufacturing repair technologies for turbine engine components.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding increased compared to FY 2021 by $2.337 million. Funding increased due to increased emphasis on manufacturing technologies for weapon system readiness. | | | |
| ***Title:*** Advanced Manufacturing Technologies | 34.205 | 28.907 | 22.630 |
| ***Description:*** Develop and transition affordable advanced manufacturing for Department of the Air Force fielded and future platforms.<br>***FY 2021 Plans:***<br>Continue to enable and promote advanced manufacturing processes, techniques, and equipment availability for reducing materiel acquisition, maintenance and repair costs. Continue to develop, demonstrate and introduce intelligent robotics and digital engineering concepts into manufacturing processes. Continue to develop, demonstrate and evaluate additively manufactured aerospace components and subcomponents. Continue to develop and demonstrate technologies enabling factory of the future, digital supply chain management, industrial internet of things to provide improvements in production, delivery and support of warfighter capabilities.<br>***FY 2022 Plans:***<br>Continue to enable and promote advanced manufacturing processes, techniques, and equipment availability for reducing materiel acquisition, maintenance and repair costs. Continue to develop and demonstrate intelligent robotics and digital engineering concepts into manufacturing processes. Continue to develop, demonstrate and evaluate additively manufactured aerospace components and subcomponents. Continue to develop and demonstrate technologies enabling factory of the future, digital supply chain management, industrial internet of things to provide improvements in production, delivery and support of warfighter capabilities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* |

| C. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 funding decreased compared to FY 2021 by $6.277 million. Funding decreased due to increased emphasis in other higher demand manufacturing technologies. | | | |
| ***Title:*** Manufacturing for Transformational Technologies<br>***Description:*** Develop and transition manufacturing technologies that enable advanced technology solutions that will shape the future force across the air, space and cyberspace domains.<br>***FY 2021 Plans:***<br>Not applicable since this effort will begin in FY 2022.<br>***FY 2022 Plans:***<br>Refine development of high demand manufacturing technologies including low cost and attritable systems, thermal protection materials for high temperature applications and other manufacturing technologies geared toward realizing the future force and to provide a cost-imposing strategy against adversarial forces.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 funding increased compared to FY 2021 by $9.051 million. Funding increased due to increased emphasis on manufacturing for attritable systems and other transformational manufacturing efforts. | 0.000 | 0.000 | 9.051 |
| **Accomplishments/Planned Programs Subtotals** | 47.507 | 40.148 | 45.259 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program increase - F-35 Battery Technology<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 9.549 | 9.600 |
| ***Congressional Add:*** Program increase - Thermal protection for hypersonic vehicles<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 9.744 | 0.000 |
| ***Congressional Add:*** Program increase - Materials Development Research<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 4.872 | 0.000 |
| ***Congressional Add:*** Program Increase - Modeling Technology for Small Turbine Engines | 4.872 | 7.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* | |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| ***Congressional Add:*** Program increase - Low cost manufacturing methods for hypersonic vehicle components<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 7.795 | 8.000 |
| ***Congressional Add:*** Program increase - Flexible hybrid electronics<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 4.872 | 0.000 |
| ***Congressional Add:*** Program increase - Aerospace composite structures<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 4.872 | 0.000 |
| ***Congressional Add:*** Program increase - Certification of bonded aircraft structures<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 4.872 | 0.000 |
| ***Congressional Add:*** Program increase - Industrialization of ceramic matrix composites for hypersonic weapons<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 9.744 | 0.000 |
| ***Congressional Add:*** Program increase - Thermal batteries<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 1.949 | 0.000 |
| ***Congressional Add:*** Program increase - Technologies to repair fastener holes<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 4.872 | 5.000 |
| ***Congressional Add:*** Program increase - Manufacturing technology for reverse engineering | 4.872 | 5.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* | |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| ***Congressional Add:*** Program increase - Solid state battery research<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 2.923 | 0.000 |
| ***Congressional Add:*** Program increase - Agile manufacturing initiatives<br>***FY 2020 Accomplishments:*** Conducted Congressionally directed efforts.<br>***FY 2021 Plans:*** Not applicable | 9.744 | 0.000 |
| ***Congressional Add:*** Program increase - Hybrid manufacturing for rapid tooling and repair<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 5.000 |
| ***Congressional Add:*** Program increase - cost reduction for aerospace composite structures<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 10.000 |
| ***Congressional Add:*** Program increase - flexible thermal protection systems for hypersonics<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 10.000 |
| ***Congressional Add:*** Program increase - alternative domestic rubber production<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 5.000 |
| ***Congressional Add:*** Program increase - large scale additive manufacturing for hypersonics<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 6.000 |
| ***Congressional Add:*** Program increase - manufacturing readiness for hypersonic propulsion systems | 0.000 | 10.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603680F / *Manufacturing Technology Program* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | | |
| ***Congressional Add:*** Program increase - thermoplastic material systems<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 7.000 |
| ***Congressional Add:*** Program increase - automated fiber placement for composite structures<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 5.000 |
| ***Congressional Add:*** Program increase - hypersonic manufacturing capability and supply<br>***FY 2020 Accomplishments:*** Not applicable<br>***FY 2021 Plans:*** Conduct Congressionally directed efforts. | 0.000 | 6.000 |
| **Congressional Adds Subtotals** | 85.552 | 98.600 |

**D. Other Program Funding Summary ($ in Millions)**

N/A

**Remarks**

**E. Acquisition Strategy**

N/A

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | | | | | | | | | | | | Date: May 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | | | | | R-1 Program Element (Number/Name)<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | | | | | | | |
| **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 | - | 53.036 | 63.106 | 56.772 | 0.000 | 56.772 | - | - | - | - | - | - |
| 635321: *C4I Battlespace Dev and Demo* | - | 32.925 | 29.086 | 36.177 | 0.000 | 36.177 | - | - | - | - | - | - |
| 635329: *Cyber Battlespace Dev & Demo* | - | 20.111 | 34.020 | 20.595 | 0.000 | 20.595 | - | - | - | - | - | - |

**A. Mission Description and Budget Item Justification**

This program develops and demonstrates Air Force enterprise-centric information technologies for the warfighter. The Anticipatory Operations Intent and Response project develops the technologies for dynamic planning and execution with the accuracy, fidelity, and timeliness needed to dominate the battlespace. The Assured Worldwide Connectivity project provides advanced net-enabled architectures and communications technologies in support of global military operations, including a secure information grid for worldwide information exchange of near-real-time multimedia (i.e., voice, data, video, and imagery) information. In addition, this project develops and demonstrates advanced optical networking and communications for Air Force air and space-based information exchange on and between platforms. These optical networks will be rapidly deployable, mobile, interoperable, and seamless between Air and Space Operations Centers (AOCs) and air and space-based platforms either en route or in theater. This project also provides tools and applications leading to the development and integration of cyber deterrence technologies resulting in a strategic capability of cyber dominance within the secure information grid. The Global Battlespace Awareness project develops, integrates, and demonstrates advanced technologies to achieve comprehensive net-centric operations and total battlespace awareness by using and exploiting information from all sources. The Knowledge Management and Computing project develops the technology applications that will provide for a secure, tailored, seamless exchange of information among producers, consumers, and managers of information relevant to a particular community of interest (COI). The project also provides the development of interactive and real-time computing technologies that greatly improve the usability of high-performance computing for the exchange, utilization, and management of information in the enterprise. The Cyber Battlespace Development and Demonstration project develops the ability to deliver sovereign options in cyberspace through the development and integration of cyber attack, cyber defense, and cyber support technologies for a strategic capability of cyber dominance.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. Operational agility will require flexibility (manifested as multi-domain operations), speed (manifested as superior decision speed), coordination (manifested as dynamic command and control), balance (manifested as presenting a balanced capability mix), and strength (manifested as performance-optimized teams). In order to enable operational agility, this program will begin to shape future research and development (R&D) to focus on technologies in support of operational agility through multi-domain command and control (MDC2) capabilities.

This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* |

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

The Department of the Air Force technologies in this program are both enabling and enduring as we invest in maturing emerging technologies that address established mission gaps, and transformational technologies that address integrated enterprise capabilities intended to reshape the future force across air, space, and cyber warfighting domains. Development of transformational operational capabilities through advanced technology solutions focuses on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

| B. Program Change Summary ($ in Millions) | FY 2020 | FY 2021 | FY 2022 Base | FY 2022 OCO | FY 2022 Total |
|---|---|---|---|---|---|
| Previous President's Budget | 56.414 | 0.000 | 0.000 | 0.000 | 0.000 |
| Current President's Budget | 53.036 | 63.106 | 56.772 | 0.000 | 56.772 |
| Total Adjustments | -3.378 | 63.106 | 56.772 | 0.000 | 56.772 |
| • Congressional General Reductions | 0.000 | -0.115 | | | |
| • Congressional Directed Reductions | 0.000 | 0.000 | | | |
| • Congressional Rescissions | 0.000 | 0.000 | | | |
| • Congressional Adds | 0.000 | 15.000 | | | |
| • Congressional Directed Transfers | 0.000 | 48.221 | | | |
| • Reprogrammings | 0.000 | 0.000 | | | |
| • SBIR/STTR Transfer | -1.404 | 0.000 | | | |
| • Other Adjustments | -1.974 | 0.000 | 56.772 | 0.000 | 56.772 |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| **Project:** 635321: *C4I Battlespace Dev and Demo* | | |
| Congressional Add: *Program Increase- Assured Communication and Networks* | 0.000 | 0.000 |
| Congressional Add: *Program Increase- Command and Control Capability Development* | 0.000 | 0.000 |
| Congressional Add Subtotals for Project: 635321 | 0.000 | 0.000 |
| **Project:** 635329: *Cyber Battlespace Dev & Demo* | | |
| Congressional Add: *Program Increase- assured communication and networks* | 0.000 | 10.000 |

| Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Air Force | Date: May 2021 |
|---|---|
| **Appropriation/Budget Activity**<br>3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)* | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* |

| Congressional Add Details ($ in Millions, and Includes General Reductions) | FY 2020 | FY 2021 |
|---|---|---|
| Congressional Add: *Program Increase- command and control capability development* | 0.000 | 5.000 |
| Congressional Add Subtotals for Project: 635329 | 0.000 | 15.000 |
| Congressional Add Totals for all Projects | 0.000 | 15.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | Project (Number/Name)<br>635321 / *C4I Battlespace Dev and Demo* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635321: *C4I Battlespace Dev and Demo* | - | 32.925 | 29.086 | 36.177 | 0.000 | 36.177 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on technologies in support of multi-domain command and control.

In order to achieve operational agility, the Air Force must be able (a) to monitor, assess, plan, and execute missions rapidly across the full spectrum of operations at all levels of war and during all phases of conflict; (b) to field advanced, secure, net-enabled architectures and communications/network technologies in support of persistent, global, and survivable kinetic and non-kinetic military operations; (c) to process and exploit data and information from a variety of sources and domains to create a common operating picture of the battlespace; and (d) to provide the decision maker and staff with seamless access to tailored information within a mobile, dynamic, and scalable, globally distributed Air Operations Center, as well as among other producers, consumers, and managers of information relevant to other particular Communities of Interest (COI).

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority."

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | - | 0.000 | 10.053 |
| ***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: Command and Control capabilities, satellite communication, assured communication, and information processing. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635321 / *C4I Battlespace Dev and Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Select Transformational Technology Development efforts that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2022 Plans:***<br>Fund the follow-on efforts for projects started in FY 2021. Select Transformational Technology Development efforts that support the National Defense Strategy and Department of the Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by 10.053 million. Funding is increased due increased emphasis in transformational activities. | | | |
| ***Title:*** Multi-Domain Command and Control<br>***Description:*** Perform research and development (R&D) that will advance existing, or discover new, command and control capabilities to support multi-domain operations (MDO) for air, space, cyberspace, land, sea, and undersea.<br>***FY 2021 Plans:***<br>Continue to execute experiments, based on operational scenarios, which incorporate process management execution into the extensible Space command and control framework, and which integrate disparate data and applications, providing a pedigree for proposed tasking options to decision makers. Continue to develop software capabilities that employ cyber, directed energy, and electronic warfare weaponry. Continue to provide on-the-fly valuable quantitative evaluations of cyber assets to cyber operators, enabling them to present viable cyber options to commanders in multi-domain settings. Develop tools, technology, and framework for execution management of operational center process workflows and applications.<br>***FY 2022 Plans:***<br>Continue demonstration of communication, information management, and replication capabilities for intra base distribution of one C2 operational echelon function. Continue to execute experiments, based on operational scenarios, which incorporate process management execution into the extensible Space command and control framework, and which integrate disparate data and applications, providing a pedigree for proposed tasking options to decision makers. Continue to develop software capabilities that employ cyber, directed energy, and electronic warfare weaponry. Continue to provide on-the-fly valuable quantitative evaluations of cyber assets to cyber operators, enabling them to present viable cyber options to commanders in multi-domain settings. Continue development of tools, technology, and framework for execution management of operational center process workflows and applications.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 7.635 | 6.919 | 6.975 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635321 / *C4I Battlespace Dev and Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $.056 million. Justification for increase is described in the plans above. | | | |
| ***Title:*** Nuclear C3 Modernization | 4.357 | 3.308 | 0.000 |
| ***Description:*** Develop and demonstrate the advancement of existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.<br><br>***FY 2021 Plans:***<br>Continue to perform real-time monitoring of ionospheric conditions over the Continental United States (CONUS). Continue testing of very-low-frequency (VLF) stubb antenna for reachback. Continue testing of prototype compact high-frequency (HF) antennas. Enhance communication link availability prediction for better Command, Control, and Communications (C3) planning and simulation. Develop visualization tool for providing common operation picture (COP) to commanders and Nuclear C3 (NC3) operators.<br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed in PE 0603788F, Battlespace Knowledge, Development, and Demonstration, Project 635321, C4I Battlespace Dev and Demo, Assured Communications & Networks effort.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $3.308 million. Starting in FY 2022, this work will be performed in PE 0603788F, Battlespace Knowledge, Development, and Demonstration, Project 635321, C4I Battlespace Dev and Demo, Assured Communications & Networks effort. | | | |
| ***Title:*** Artificial Intelligence/Autonomy/Machine Learning | 4.802 | 2.597 | 3.274 |
| ***Description:*** Develop and demonstrate to harness the speed and scale of computers and machines to address problems of complexity.<br><br>***FY 2021 Plans:***<br>Continue to operationalize and implement state of the art learning models. Continue to integrate within the StreamlinedML framework. Continue development of model recommendation & user workflow capabilities.<br>***FY 2022 Plans:***<br>Continue development of robust artificial intelligence/machine learning (AI/ML) for targeted transition capabilities. Continue to operationalize and implement state of the art learning models. Continue to integrate within the StreamlinedML framework. Continue development of secure diode for cross-domain embedded solution.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635321 / *C4I Battlespace Dev and Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 increased compared to FY 2021 by $.677 million. Justification for increase is described in the plans above. | | | |
| ***Title:*** Data to Decisions<br>***Description:*** Develop and demonstrate the collection, management, analysis, and exploitation of complex data for availability to Air Force and other stakeholders.<br>***FY 2021 Plans:***<br>Continue to refine and test technologies for ultra-wideband electronics intelligence signal detection and prosecution. Continue development and demonstration of intelligence analysis capabilities from multiple intelligence sources for both near-real time and post mission. Continue research and development in data analytics and strategic indications and warnings. Continue to perform service-based capability development. Complete work for object based production optimized processing and automated-association capability.<br>***FY 2022 Plans:***<br>Continue development and demonstration of intelligence analysis capabilities from multiple intelligence sources for both near-real time and post mission. Continue research and development in data analytics and strategic indications and warnings. Continue to perform service-based capability development. Conduct a demonstration of additional government fusion techniques applied to combined commercial/commodity hardware and existing military hardware within a trusted wrapper. Conduct an integrated demonstration of data flow into intelligence production environment. Continue to advance the prototype to deliver multi-INT exploitation on-board and in real-time.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.734 million. Funding decrease is described in plans above and moving to transformational future force capabilities. | 6.579 | 4.543 | 3.809 |
| ***Title:*** Game Changing Computing Power<br>***Description:*** Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime.<br>***FY 2021 Plans:***<br>Continue work to improve software specifications using evolutionary approaches to optimize computer processing. Continue work in the areas of nanotechnology for autonomous systems. Continue work in the area of neuromorphic intelligent computing systems.<br>***FY 2022 Plans:*** | 0.000 | 3.449 | 3.099 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635321 / *C4I Battlespace Dev and Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Demonstrating secure, on-board, simultaneous processing of multi-INT data to correlate and identify surface targets.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $0.350 million. Funding decrease is described in plans above and moving to transformational future force capabilities. | | | |
| ***Title:*** Assured Communications & Networks<br><br>***Description:*** Develop and demonstrate secure and reliable communications to ensure the delivery of timely, reliable, and actionable information to warfighters and systems.<br><br>***FY 2021 Plans:***<br>Continue development and demonstration for rapid waveform development of multi-mission software defined radio frequency capability. Continue wideband high frequency waveform development and testing. Continue ionospheric research, propagation modeling and simulation. Continue beacon data collection on both the V and W frequency bands along with waveform development and simulation. Continue development of test platform for Common Very Low Frequency Receiver Increment Two.<br><br>***FY 2022 Plans:***<br>Continue development and demonstration for rapid waveform development of multi-mission software defined radio frequency capability. Continue wideband high frequency waveform development and testing. Continue ionospheric research, propagation modeling and simulation. Continue beacon data collection on both the V and W frequency bands along with waveform development and simulation. Develop robust mesh networking capability with both Line-of-Sight and Beyond Line-of-Sight communication links. Continue to add SATCOM links to multi-spectral capability. Continue to demonstrate a protected, single security domain commercial off-the-shelf (COTS) device hosting user and asset tracking, machine learning architecture provisioning and innovative aerial port (AMC) solutions for mobile situational awareness (SA) and decision making. Continue to enhance communication link availability prediction for better Command, Control, and Communications (C3) planning and simulation.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $0.697 million. Justification for increase is described in the plans above. | 9.552 | 8.270 | 8.967 |
| **Accomplishments/Planned Programs Subtotals** | 32.925 | 29.086 | 36.177 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase- Assured Communication and Networks | 0.000 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635321 / *C4I Battlespace Dev and Demo* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed effort. | | |
| ***Congressional Add:*** Program Increase- Command and Control Capability Development<br>***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed effort. | 0.000 | 0.000 |
| **Congressional Adds Subtotals** | 0.000 | 0.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | | Date: May 2021 |
|---|---|---|---|
| Appropriation/Budget Activity<br>3600 / 3 | R-1 Program Element (Number/Name)<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | Project (Number/Name)<br>635329 / *Cyber Battlespace Dev & Demo* | |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 635329: *Cyber Battlespace Dev & Demo* | - | 20.111 | 34.020 | 20.595 | 0.000 | 20.595 | - | - | - | - | - | - |
| Quantity of RDT&E Articles | - | - | - | - | - | - | - | - | - | - | | |

**A. Mission Description and Budget Item Justification**

The Air Force requires the ability to deliver sovereign options in cyberspace through the development and integration of cyber-attack, cyber defense, and cyber support technologies for a strategic capability of cyber dominance. This project develops the ability to deliver cyber-attack capabilities (access, stealth, persistence, intelligence, and weapons delivery), cyber defense capabilities (attack detection, attack attribution, and response automation) and cyber support capabilities (situation awareness and war gaming). This project will also develop 1) a science and engineering capability demonstrating new models of computation, 2) novel approaches for high performance, interactive, net-centric, distributed and embedded computing systems, and 3) the technological tools enabling affordable, large-scale, and complex software-intensive systems.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on cyber technologies in support of multi-domain command and control.

This project includes the initiation and development of programs addressing DAF capability gaps and provides technologies for transformational future force capabilities. Transformational efforts will be identified through a competitive process and be responsive to DAF design priorities. Selected efforts will be designated as transformational, indicating enterprise-level priority.

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Title:*** Transformational Technology Development | - | 0.000 | 4.064 |
| ***Description:*** Continually funded effort. This funding allocation will start new and continue Transformational Technology Developments. The Transformational Technology Development program will select new projects, in alignment with mission focused areas which include, but are not limited to: Intelligent Planning and Wargaming; Battlespace Awareness; Integrated Base Defense; and Hypersonic Multi-Mission Aircraft. Investments focus on technology development efforts including, but are not limited to: offensive and defensive cyber warfare capabilities, and cyber system and network resiliency. This investment is overseen by senior representatives from Air and Space Forces who participate in the submission, initial review, and down-selection of Transformational Technology Development proposed efforts. Final selections will be reviewed by the Air Force Deputy Assistant Secretary for Science, Technology, and Engineering before a final recommendation for Congressional approval is made. | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635329 / *Cyber Battlespace Dev & Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***FY 2021 Plans:***<br>Select Transformational Technology Development efforts in FY 2021 that support the National Defense Strategy and Department of Air Force priorities.<br>***FY 2022 Plans:***<br>Fund the follow-on efforts for projects started in FY 2021. Select Transformational Technology Development efforts that support the National Defense Strategy and Department of the Air Force priorities.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY21 by 4.064 million. Funding is increased due increased emphasis in transformational activities. | | | |
| ***Title:*** Cyber Defense Technologies<br>***Description:*** Develop and demonstrate defensive cyber operations capabilities in a series of experimental technology demonstrations.<br>***FY 2021 Plans:***<br>Not applicable.<br>***FY 2022 Plans:***<br>Continue development of software capabilities and concept of operations for active guidance and automated processes addressing cyber defense. Continue to demonstrate automated cyber survivability using integrated cyber technologies within the operational system laboratory in the context of risk management framework requirements. Continue development of an advanced secure processor hardware capability. Develop processor-agnostic sub-system for golden-image storage, verification, and re-flashing. Continue development and integration of polyglot file identification filters to mitigate data exfiltration risks. Continue to sustain development of a modularized filter store to maximize filter re-usability and increase the agility of cross-domain solutions to support new file types. Continue development and demonstration of Air, Space, Cyber tasking order interoperability and ingestion by IKE Cyber system. Demonstrate additional government fusion techniques applied to combined commercial/ commodity hardware and existing military hardware within a trusted wrapper. Demonstrate data flow into the intelligence production environment.<br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $7.416 million. Funding increased due to increased emphasis in Cyber Defense Technologies effort and $4.064 million moving to transformational future force capabilities. | - | 0.000 | 7.416 |
| ***Title:*** Cyber Offense Technologies | - | 0.000 | 9.115 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635329 / *Cyber Battlespace Dev & Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| ***Description:*** Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.<br><br>***FY 2021 Plans:***<br>Not applicable.<br><br>***FY 2022 Plans:***<br>Continue the development of a counter small unmanned aerial system open architecture specification to enable interoperability between disparate protection systems. Develop a base-threat awareness toolkit. Develop a framework for quickly adapting new features to allow for increased efficiency in updating cyber offense capabilities. Continue development of processor-agnostic sub-system for golden-image storage, verification, and re-flashing. Continue to integrate and transition multiple Air Force Research Laboratory and Air Force Lifecycle Management Center counter small unmanned aerial system capabilities. Continue the development of a capability to enable the warfighter access into congested environments as directed by warfighter requirements. Continue development of cellular testbed with 5G and Internet of Things representative technologies. Demonstrate an initial SIGINT hardware prototype.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 increased compared to FY 2021 by $9.115 million. Starting in FY 2022, this work will be performed within this PE, under Project 635329, Cyber Battlespace Dev & Demo, in the Cyber Offense Technologies effort. | | | |
| ***Title:*** Resiliency<br><br>***Description:*** Integrate and demonstrate a resilient and self-generating information enterprise that dynamically recognizes, characterizes, and understands novel cyber attacks, and then reconfigures and self-optimizes itself to resist new attacks.<br><br>***FY 2021 Plans:***<br>Continue to develop and evolve software capabilities and concept of operations for active guidance and automated processes addressing cyber resiliency and survivability. Continue to advance capability migration to form factors which more readily align with operational systems. Continue to demonstrate automated cyber survivability using integrated cyber technologies within the operational system laboratory in the context of risk management framework requirements. Continue development of an advanced secure processor hardware capability. Develop processor-agnostic sub-system for golden-image storage, verification, and re-flashing.<br><br>***FY 2022 Plans:*** | 7.339 | 7.485 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635329 / *Cyber Battlespace Dev & Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| Starting in FY 2022, this work will be performed within this PE, under Project 635329, Cyber Battlespace Dev & Demo, in the Cyber Defense Technologies effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $7.485 million. Starting in FY 2022, this work will be performed within this PE, under Project 625329, Cyber Battlespace Dev & Demo, in the Cyber Defense Technologies effort. | | | |
| ***Title:*** Game Changing Computing Power<br><br>***Description:*** Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime.<br><br>***FY 2021 Plans:***<br>In FY 2021, the cyber component of this work is completed and the non-cyber component of this work is performed under the Game Changing Computing Power effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.<br><br>***FY 2022 Plans:***<br>Not Applicable<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>Not Applicable | 4.962 | 0.000 | 0.000 |
| ***Title:*** Autonomous, Multi-level Access and Transfer<br><br>***Description:*** Develop autonomous, secure information access and sharing capabilities required by the Air Force net-centric information enterprise.<br><br>***FY 2021 Plans:***<br>Continue to develop and integrate polyglot file identification filters to mitigate data exfiltration risks. Continue to sustain development of a modularized filter store to maximize filter re-usability and increase the agility of cross-domain solutions to support new file types.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed within this PE, under Project 635329, Cyber Battlespace Dev & Demo, in the Cyber Defense Technologies effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:*** | 1.422 | 1.042 | 0.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635329 / *Cyber Battlespace Dev & Demo* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2020 | FY 2021 | FY 2022 |
|---|---|---|---|
| FY 2022 decreased compared to FY 2021 by $1.042 million. Starting in FY 2022, this work will be performed within this PE, under Project 625329, Cyber Battlespace Dev & Demo, in the Cyber Defense Technologies effort. | | | |
| ***Title:*** Cyber Power Projection<br>***Description:*** Develop and demonstrate offensive cyber capabilities in contested environments through a series of experiments and exercises.<br><br>***FY 2021 Plans:***<br>Continue the development of systems to identify items of interest associated with the Internet of Things. Continue to advance the development of a counter small unmanned aerial system open architecture specification to enable interoperability between disparate protection systems. Develop processor-agnostic sub-system for golden-image storage, verification, and re-flashing. Continue to integrate and transition multiple Air Force Research Laboratory and Air Force Lifecycle Management Center counter small unmanned aerial system capabilities. Continue to develop a capability to enable the warfighter access into congested environments as directed by warfighter requirements. Research multiple-input, multiple-output state matrices to detect physical changes in base electromagnetic environments to monitor large areas using passive techniques for detection of commercial-off-the-shelf small unmanned aerial systems.<br><br>***FY 2022 Plans:***<br>Starting in FY 2022, this work will be performed within this PE, under Project 635329, Cyber Battlespace Dev & Demo, in the Cyber Offense Technologies effort.<br><br>***FY 2021 to FY 2022 Increase/Decrease Statement:***<br>FY 2022 decreased compared to FY 2021 by $10.493 million. Starting in FY 2022, this work will be performed within this PE, under Project 625329, Cyber Battlespace Dev & Demo, in the Cyber Offense Technologies effort. | 6.388 | 10.493 | 0.000 |
| **Accomplishments/Planned Programs Subtotals** | 20.111 | 19.020 | 20.595 |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***Congressional Add:*** Program Increase- assured communication and networks<br><br>***FY 2020 Accomplishments:*** Not applicable.<br><br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 635321, C4I Battlespace Dev and Demo. | 0.000 | 10.000 |
| ***Congressional Add:*** Program Increase- command and control capability development | 0.000 | 5.000 |

| Exhibit R-2A, RDT&E Project Justification: PB 2022 Air Force | | Date: May 2021 |
|---|---|---|
| **Appropriation/Budget Activity**<br>3600 / 3 | **R-1 Program Element (Number/Name)**<br>PE 0603788F / *Battlespace Knowledge Development and Demonstration* | **Project (Number/Name)**<br>635329 / *Cyber Battlespace Dev & Demo* |

| | FY 2020 | FY 2021 |
|---|---|---|
| ***FY 2020 Accomplishments:*** Not applicable.<br>***FY 2021 Plans:*** Conduct congressionally directed efforts. To be executed from Project 635321, C4I Battlespace Dev and Demo. | | |
| **Congressional Adds Subtotals** | 0.000 | 15.000 |

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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