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Air Force T-7A Red Hawk Trainer

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Summary

NOTE: This report was originally written by Ceir Coral while he was an Air Force Fellow at the Congressional Research Service. Since his departure, it has been maintained by Jeremiah Gertler of CRS.

On September 27, 2018, the United States Air Force (USAF) awarded The Boeing Company a contract, worth up to $9.2 billion, to procure 351 Advanced Pilot Training (APT T-X) aircraft and 46 Ground-Based Training Systems (GBTS) to replace the existing fleet of T-38C jet trainers. The Air Force had originally valued the contract at roughly $19.7 billion. Information on the value of other competitors' bids was not available.

On September 16, 2019, Acting Secretary of the Air Force Matthew Donovan announced that in service, the T-X aircraft would be known as the T-7A Red Hawk. In this report, "APT T-X" will be used to identify the entire training system, while "T-7A" will refer to the aircraft portion of that system.

The FY2020 Administration budget request included $348.473 million for the APT T-X.

According to the USAF, the current T-38C trainer fleet is old, costly, and outdated, and lacks the technology to train future pilots for fifth-generation fighter and bomber operations. Based on Air Education Training Command's evaluation of the required capabilities to train future pilots for fifth-generation fighters and bombers, the T-38C falls short in 12 of 18 capabilities, forcing the USAF to train for those capabilities in operational units where flying hours are costly and can affect fleet readiness.

Based on the requirements set forth in the USAF's RFP, the T-7A may shift training from Field Training Units, where expensive fifth-generation aircraft are used, to less expensive trainer aircraft. Also, the higher fidelity GBTS could improve training for student pilots and move many tasks from aerial flight training into simulators.

The T-7A acquisition strategy poses potential oversight issues for Congress, including the following: Is the number of planned aircraft purchases sufficient? Given the reported Air Force pilot shortage, should the procurement be accelerated? What effects do increased F-35A and KC-46 purchases, along with development of the new Long Range Strike Bomber, B-21, have on the USAF budget and the feasibility of an additional Major Defense Acquisition Program? Given that the winning bid was roughly half the expected cost, can the contract be carried out on time and on budget?

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Introduction

On September 27, 2018, the United States Air Force (USAF) awarded the Boeing Company a contract, worth up to $9.2 billion, to procure 351 Advanced Pilot Training (APT T-X) aircraft and 46 Ground-Based Training Systems (GBTS) to replace the existing fleet of T-38C jet trainers. The Air Force had originally valued the contract at roughly $19.7 billion. Information on the value of other competitors' bids was not available.

On September 16, 2019, Acting Secretary of the Air Force Matthew Donovan announced that in service, the T-X aircraft would be known as the T-7A Red Hawk. In this report, "APT T-X" will be used to identify the entire training system, while "T-7A" will refer to the aircraft portion of that system.

The FY2020 Administration budget request included $348.473 million for the APT T-X.

The APT T-X acquisition strategy poses potential oversight issues for Congress. The addition of a new Major Defense Acquisition Program as the Air Force continues to purchase F-35As and KC-46s and develop the new Long Range Strike Bomber, B-21, will affect the USAF budget requests going forward, and the T-X contract award was delayed several times in light of budget issues. Specific to the T-7A acquisition, Congress may wish to consider the correct number of trainer aircraft and ground-based training systems along with timing of their procurement and fielding.

Background

U.S. Air Force Trainer Aircraft

For the purpose of this report, a trainer is defined as an aircraft primarily designed to facilitate aircrew or pilot flight training. Trainer aircraft features include tandem flight controls, simplified cockpit arrangements, and other elements that allow student pilots to operate the aircraft safely. U.S. Air Force trainer aircraft are assigned under the Air Education and Training Command's (AETC's) 19th Air Force, which includes 19 training locations, 10 regular Air Force wings supported by 6 Guard and Reserve wings, approximately 32,000 personnel, and more than 1,350 aircraft of 29 different models.[1] Currently, the trainer fleet is in use at Joint Base San Antonio-Randolph, Texas; Laughlin Air Force Base (AFB), Texas; Vance AFB, Oklahoma; Columbus AFB, Mississippi; and Sheppard AFB, Texas.

The current U.S. Air Force (USAF) pilot trainer aircraft fleet consists mainly of the T-6 Texan II, T-1A Jayhawk, and the T-38 Talon. Pilot candidates will generally begin in the T-6, moving to the other aircraft depending on the type of aircraft (fighter, cargo, etc.) to which they will ultimately be assigned.

[1] U.S. Air Force, "19th AF activates under AETC," September 29, 2014, at http://www.af.mil/News/ArticleDisplay/tabid/223/Article/502946/19th-af-activates-under-aetc.aspx.

Current USAF Trainer Fleet

Table 1. AETC Main Trainer Fleet

	T-1A Jayhawk	T-6 Texan II	T-38 Talon	Total
Numbers of Aircraft	178	444	430	1,049

Source: HQ AETC/A5RX Email dated December 6, 2016.

Note: AETC maintains other trainer aircraft in addition to T-1, T-6, and T-38; however, these three models comprise almost 80% of the trainer fleet.

T-6 Texan II

The T-6 Texan II trainer aircraft is a single-engine, two-seat, turboprop aircraft designed to train student pilots in basic flying skills common to both USAF and U.S. Navy (USN) pilots in Joint Primary Pilot Training. A military version of the Beech/Pilatus PC-9 Mk II, the T-6 was originally manufactured by Raytheon Aircraft, later Beechcraft. The USAF acquired the T-6 in May 2000 and began training with it that same year. In 2001, the USAF and USN began using the T-6 as the primary trainer in the Joint Primary Pilot Training program at Moody AFB, GA. The aircraft has tandem seating (one pilot behind the other) with interchangeable instructor/student seating. The aircraft features a pressurized cockpit, an anti-G force system, an advanced avionics package, ejection seats, and fully aerobatic flight controls.[2] The T-6A is the aircraft portion of the Joint Primary Aircraft Training System (JPATS), and is currently in use at Columbus AFB, Mississippi; Vance AFB, Oklahoma; and Laughlin AFB and Sheppard AFB in Texas.

Joint Primary Aircraft Training System (JPATS)

The JPATS acquisition program is a system-of-systems for primary flight-training devices to meet USAF and USN initial pilot training requirements. The principle JPATS mission is to train entry-level student pilots in primary flying skills to a proficiency level that will allow them to transition to advanced pilot training tracks. The program was initiated in 1994 and designed to replace the USAF T-37B and USN T-34C aircraft and associated ground-based training systems. The JPATS program consisted of the T-6 Texan II aircraft, simulators, ground-based training devices, a Training Integration Management System, instructional courseware, and contractor logistics support. The original JPATS program called for production of 452 T-6A aircraft for the USAF and 249 for the USN. Raytheon was awarded the acquisition and support contract in 1996.

The Training Integration Management System is a computer-driven system used to manage student progress through the Joint Primary Pilot Training program. It contains all the academic modules, tracks student events and grades, performs aircraft scheduling, and assists in overall training management.

Source: http://www.dote.osd.mil/pub/reports/FY1999/pdf/af/99jpats.pdf, http://www.dote.osd.mil/pub/reports/FY2007/pdf/navy/2007jpats.pdf, and http://slideplayer.com/slide/9358758/.

[2] U.S. Air Force, "T-6A Texan II," March 28, 2003, at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104548/t-6a-texan-ii.aspx.

Figure 1. T-6A Texan II

Source: http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104548/t-6a-texan-ii.aspx.

T-1A Jayhawk

The T-1A Jayhawk is a medium-range, twin-engine jet used in the advanced phases of Specialized Undergraduate Pilot Training (SUPT). Students selected to become airlift or tanker aircraft pilots will train in the T-1A after completing Undergraduate Pilot Training. The T-1A was manufactured by Raytheon, later Hawker Beechcraft, and derived from the commercial Beechjet 400A aircraft.[3] The USAF first acquired the jet in 1992 and students began using the aircraft for training in 1993.[4] The main differences between the military aircraft and civilian version are structural enhancements for bird strike resistance and an additional fuel tank. The cockpit is configured to support an instructor pilot and two student pilots. The T-1A is currently used for pilot training at Columbus AFB, Mississippi; Laughlin AFB, Texas; Vance AFB, Oklahoma; and Randolph AFB, Texas; and for combat systems officer training at Naval Air Station Pensacola, FL.

[3] Airforce-Technology.com, "T-1 Jayhawk Trainer Aircraft, United States of America," at http://www.airforce-technology.com/projects/t1-jayhawk/.

[4] U.S. Air Force, "T-1A Jayhawk," September 14, 2005, at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104542/t-1a-jayhawk.aspx.

Figure 2. T-1A Jayhawk

Source: http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104542/t-1a-jayhawk.aspx.

T-38C Talon

The T-38C Talon is a twin-engine, high-altitude, supersonic jet trainer used for Joint Specialized Undergraduate Pilot Training (JSUPT). It is used to train pilots selected to fly fighter and bomber aircraft. Other versions of the T-38 are assigned to Air Combat Command, Air Force Materiel Command, and the National Aeronautics and Space Administration (NASA) in various roles. The T-38 has a history of economy of operations, ease of maintenance, high performance, and exceptional safety.[5] The T-38 was manufactured by Northrop Grumman Corporation and first flew in 1959. Over 1,100 T-38s were delivered to the USAF between 1961 and 1972. The aircraft has swept wings, tricycle landing gear, and a steerable nose wheel. It incorporates a glass cockpit[6] and integrated avionics displays and tandem seating similar to the T-6A. More than 60,000 USAF pilots have trained in the T-38 since entering service.[7] In addition to U.S. forces, the T-38 is in service in Germany, South Korea, Taiwan, and Turkey.[8]

Numerous design improvements have been retrofitted into operational T-38s. In 2007, Boeing completed a major avionics suite upgrade to the T-38A/B models, converting 463 T-38s to T-38Cs. Also, Northrop Grumman developed and delivered replacement wing sets to extend the life of the T-38C. In 2015, the USAF embarked on a structural modernization program known as

[5] U.S. Air Force, "T-38 Talon," September 23, 2005, at http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104569/t-38-talon.aspx.

[6] A "glass cockpit" replaces traditional dials and gauges that display aircraft information with screens that replicate such gauges and can be reprogrammed to simulate various aircraft's cockpits.

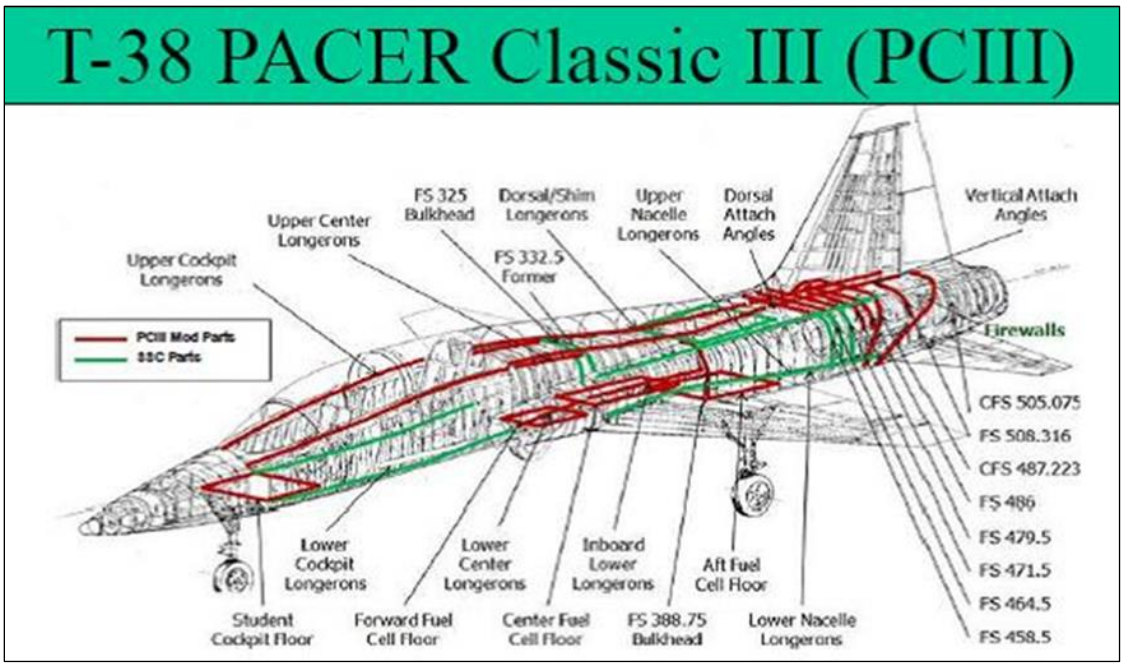
[7] Air Force-Technology.com, "T-38 Talon Twin-Jet Trainer Aircraft, United States of America," at http://www.airforce-technology.com/projects/t-38/.

[8] Ibid.

PACER CLASSIC III (see **Figure 3**). The program procures 180 structural upgrade modification kits to ensure the structural integrity of the T-38C aircraft that were at high risk of grounding. The structural work includes replacement of the ejection seat, longerons, landing gear, brakes, flight controls, and canopy, among other structural work. USAF maintainers perform the modifications, extending the aircraft's life to 2029.[9] The USAF's Ogden Air Logistics Complex at Hill AFB, Utah, is charged with executing the modification program. However, the actual modification of the aircraft takes place at Randolph AFB, Texas.[10]

Figure 3. PACER CLASSIC III Program

Structural Modifications to T-38C



Source: http://defenseinnovationmarketplace.dtic.mil/resources/T-38_Pacer_ClassicIII.pdf.

The T-38C is used to train USAF, USN, and North Atlantic Treaty Organization (NATO) pilots. In addition, USAF and USN test pilots and flight test engineers are trained in the T-38A. The T-38C is the current trainer used to prepare front-line fighter and bomber pilots to operate all USAF fighters except the F-35. In addition, NASA uses the T-38C to train future astronauts.[11]

[9] Flightglobal, "Boeing wins 10-year T-38C contract as USAF looks to T-X," January 5, 2016, at https://www.flightglobal.com/news/articles/boeing-wins-10-year-t-38c-contract-as-usaf-looks-to-420533/.

[10] Email communication with Maj. Joseph Clapsaddle, Trainer Program Element Monitor, Global Reach Directorate, Secretary of the Air Force for Acquisition, March 7, 2017.

[11] U.S. Air Force, "T-38 Talon Fact Sheet," May, 2, 2008 at https://web.archive.org/web/20130801121407/http:/www.af.mil/information/factsheets/factsheet.asp?id=126.

Figure 4. T-38C Talon

Source: http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104569/t-38-talon.asp.

Advanced Pilot Training (APT T-X) Program Basics

The USAF identified and documented gaps in its ability to meet advanced pilot training requirements in 2018 and beyond in an October 2009 initial capabilities document (ICD). Within the ICD, the USAF identified 12 shortfalls, out of 18 mission tasks set forth in SUPT and IFF courses, of the T-38C Talon aircraft. (See **Appendix C**.[12]) Based on the ICD, the USAF commissioned an analysis of alternatives (AOA) in 2011 to determine potential solutions to meet the identified shortfalls in training. In 2014, as a result of a change in the initial operational capability (IOC) date from 2017 to 2023, the USAF published an update to the original 2011 AOA document. The results of the AOA recommended a materiel solution to the issue, and the USAF developed a capabilities development document (CDD) to describe the requirements of the materiel solution, then known as the APT T-X program. The Joint Requirements Oversight Council approved the CDD in October 2015. According to the USAF, the current planned IOC for the APT T-X is 2024 and full operational capability (FOC) in 2034.[13]

What Are Capability Requirement Documents?

Capability requirement documents are used to articulate deliberate or urgent capability requirements and associated information to support review and validation through the Joint Capabilities Integration and Development System (JCIDS). Review and validation through the JCIDS process assures compliance with Title 10, U.S.C. Section 181, "Joint Requirements Oversight Council" statutory requirements.[14]

Initial Capabilities Document (ICD)—Capability requirements, with significant capability gaps, documented in an ICD can lead to development of capability solutions. These solutions can be materiel, nonmateriel, or a combination of both.

Capability Development Document (CDD)—Capability requirement document that is tailored toward a particular materiel solution to capability gaps.

[12] Air Education and Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations," at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

[13] Ibid.

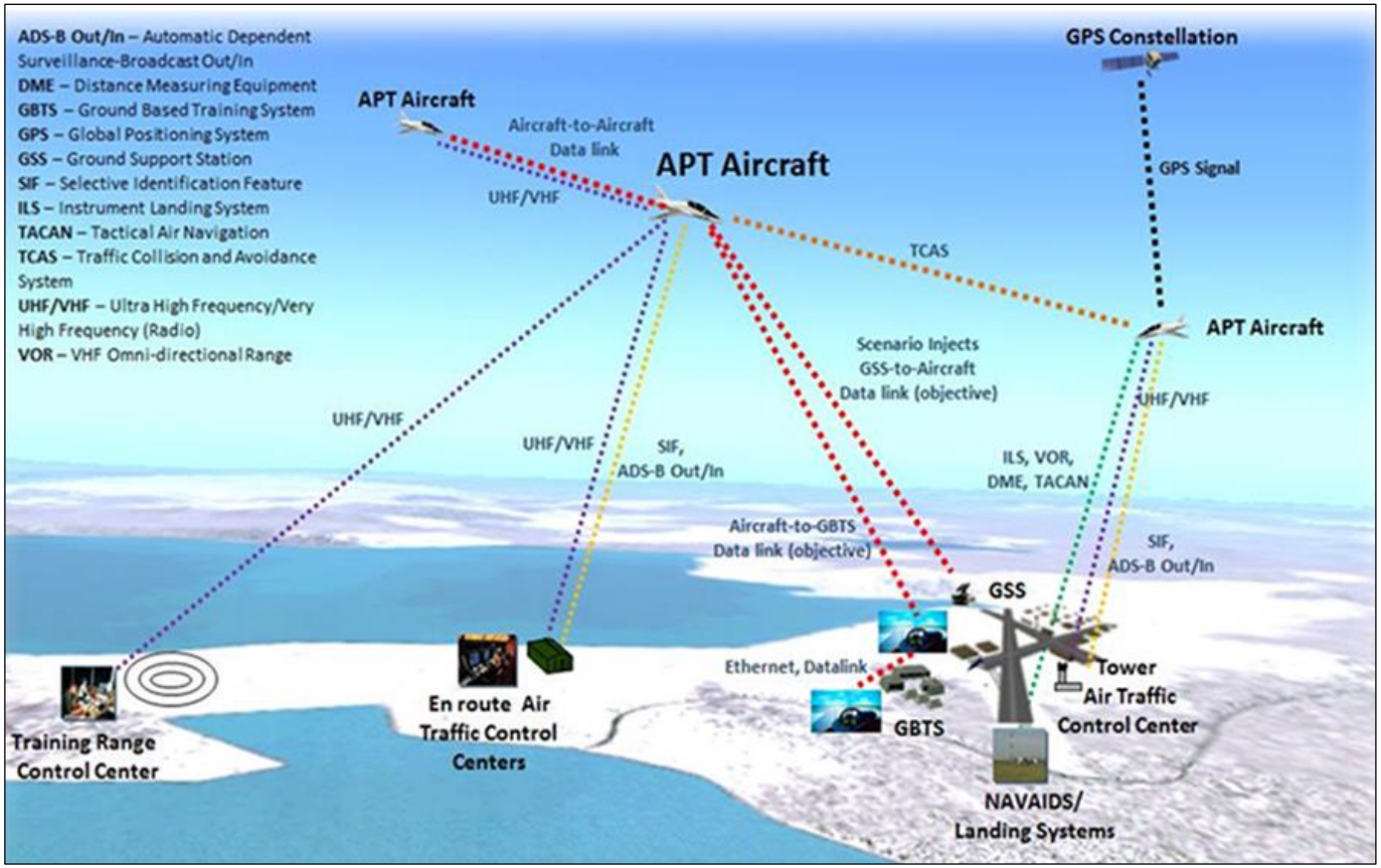
[14] CJCSI 3170.01, January, 23, 2015, at https://dap.dau.mil/policy/Documents/2015/CJCSI_3170_01I.pdf.

The stated mission of the APT T-X system is to prepare student pilots to operate fourth- and fifth-generation fighters and bombers. The USAF plans to integrate the APT T-X within the advanced phase of the fighter/bomber track of SUPT as well as IFF. The scope of the acquisition program is to acquire an advanced trainer aircraft and ground-based training system to be used by the Air Education and Training Command (AETC) in the pilot training pipeline.[15] The purpose of the trainer aircraft is to bridge the UPT primary phase in the T-6 Texan and fifth-generation Formal Training Unit (FTU) aircraft.

The APT T-X is comprised of multiple systems working together to enable advanced pilot training. The major components include the aircraft, ground-based training systems, virtual training systems, electronic classrooms, aircraft maintainers (personnel), maintenance training systems, and support infrastructure. **Figure 5** provides a high-level graphical view of the APT mission and associated architecture capabilities.

[15] Air Education and Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations," at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

Figure 5. APT T-X Operational View



Source: Advanced Pilot Training (APT T-X) Concept of Operations, Air Education and Training Command, Directorate of Plans, Programs, Requirements and Assessments.

Note: The Operational View shows the interdependencies with support services such as air traffic control, as well as the interoperability between the ground-based training systems.

According to the USAF, the APT T-X system will close the 12 capability gaps identified in the ICD and better prepare student pilots for operations in fifth-generation fighters and bombers. Based on the stated requirements found within the CDD, the T-7A will provide more effective high-G and high-angle-of-attack training than the T-38C and will more closely resemble fifth-generation operational environments.[16] AETC leaders believe the improved fidelity and aerodynamic modeling required in the Ground-Based Training System (GBTS) will enable better training and allow some tasks to be moved from flight training to the simulators. Also, the more capable aircraft will provide better opportunity to move training from the FTUs into SUPT and IFF, thereby reducing the high cost of flight hours in fifth-generation aircraft normally required to develop experienced pilots.[17]

In addition to the operational training gains projected with the APT T-X system, the planned sustainment concept envisioned by the USAF seeks to reduce ownership, operation, and system support costs, while increasing system readiness and operational capability. According to the USAF, the current T-38C fleet has an operational availability of 60%, which continues to fall yearly while maintenance costs continue to rise.[18] The USAF requirement for the T-7A is an operational availability of 80% or greater.[19]

Trainer Aircraft System Requirements

The USAF contends that by 2031, 60% of all combat air forces will be fifth-generation aircraft and therefore the force will require a modern aircraft to train future fighter and bomber pilots.[20] The USAF's 2009 ICD showed that the current T-38C fleet cannot accomplish 12 of the 18 mission tasks required for advanced pilot training. These tasks include high-G training, advanced air-to-air skill sets, and advanced cockpit/crew resource-management tasks such as data fusion using modern sensors.[21] Currently, FTUs fulfill the 12 tasks; student pilots train using actual fourth- and fifth-generation fighters and bombers at a higher operating cost. Before 2014, the F-16 bridge course mitigated the risk of sending student pilots directly into the cockpit of an F-22 with students operating a fourth-generation fighter under instructor pilot tutelage before moving to the fifth-generation fighter. However, AETC deemed the bridge course inefficient and ended the course.[22]

Beginning in the 1950s, the original mission of the T-38 fleet was to serve as the advanced pilot trainer for the Century Series fighters (F-100, F-104, etc.). Based on USAF projections, the 430 T-38C aircraft remaining in active inventory have a projected service life through 2034, when the T-7A reaches FOC.[23]

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[16] Angle of attack is defined by Britannica as the angle of the aircraft wings relative to the wind or oncoming flow. According to NASA analysts, modern fighter aircraft that can maintain controlled flight at high angles of attack provide the fighter pilot the ability to turn rapidly and enhance his or her nose-pointing capability, forming the basis for superior handling qualities. For more detailed information see NASA Technical Memorandum 104322 at https://www.nasa.gov/centers/dryden/pdf/88437main_H-2128.pdf.

[17] Air Education and Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations," at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276. CRS has been unable to find views dissenting from AETC assertions.

[18] Ibid.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Ibid.

The APT T-X System Specifications (see **Appendix D**) detail the specific system requirements for the new trainer aircraft to meet the USAF's 18 identified mission tasks. The USAF's December 30, 2016, final RFP solicitation included the system specification document.

The current USAF plan is to recapitalize five existing T-38C bases with APT

- Columbus AFB, Mississippi (SUPT/IFF)
- Laughlin AFB, Texas (SUPT)
- Vance AFB, Oklahoma (SUPT)
- Sheppard AFB, Texas (ENJJPT/IFF/Pilot Instructor Training)
- Joint Base San Antonio-Randolph, Texas (IFF/Pilot Instructor Training).

Ground-Based Training System Requirements

The Ground-Based Training System (GBTS) includes simulators, training devices, computer-based training systems, and academics. The largest portion of the GBTS is the simulator and is referred to as Aircrew Training Devices (ATDs). The ATDs are further broken down into three categories: Unit Training Devices (UTDs), Operational Flight Trainers (OFTs), and Weapons Systems Trainers (WSTs).[24]

The most basic ATD is the UTD. It provides training in normal procedures, instruments, and emergency procedures. Its primary use is to train basic flying tasks such as instrument and navigation training, ground and systems procedures, and emergency procedures.[25]

OFTs provide a networked simulator capability to train more advanced flight profiles and IFF course tasks. The OFT provides a greater training capability than the UTD, enabling visual flight patterns and landings, basic formation flying, and low-level operations.[26] The ability to link the OFT simulators provides the capability to train formation flying in a virtual battlespace.

The WST is also a linked simulator network similar to the OFT. In addition to OFT capabilities, the WST's greater field-of-view capability allows students to train in basic fighter maneuvers. WSTs are critical to training fighter formation flight and tactical maneuvering.

The GBTS will include all Interactive Multimedia Instruction (IMI) to include instructor-based training and computer-based training. Also, the USAF requires that all aspects of aircraft maintenance training be integrated into IMI. The IMI system must be web-based and provide seamless communication with student management systems.[27]

According to the USAF, a high-fidelity GBTS that can replicate advanced sensors as well as actual aircraft handling characteristics will enable more accurate simulated flying training to facilitate more *offloaded* training (training moved from an aircraft into a simulator). The desire to evolve simulator training from traditional stick-and-throttle flying to sensor-driven tactics is a direct result of fifth-generation fighter capabilities such as advanced data links, multispectral sensor fusion, and Advanced Cockpit/Crew Resource Management.[28] The level of performance

[24] Ibid.

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid. Advanced Cockpit/Crew Resource Management means the ability to prioritize mission tasks and operate on-board sensors and systems to maximize situational awareness and mission effectiveness.

provided by the GBTS will be a driving factor in determining how much training can be *offloaded* into the simulator.

The current inventory of T-38C ATDs is 36 total systems. The USAF's ATD requirement for T-X is 46 total systems.[29]

Acquisition Strategy

Request for Proposal (RFP)

In March 2015, the USAF began its pursuit of the APT family of systems through release of a request for information (RFI) to industry. The RFI focused on soliciting industry comments and questions on the draft requirements.[30] In addition to the industry comments, the USAF announced a presolicitation conference at Wright-Patterson AFB, Ohio, home of the APT System Program Office. The conference was an opportunity for prospective offerors to engage with the system program office and discuss early requirements in relation to the upcoming APT source selection. During the following year, numerous engagements between the government and industry occurred to ensure clear communication and transparency throughout the solicitation process. All written communication was initiated through the FedBizOpps.gov internet-based e-business tool.[31]

In July 2016, the USAF issued a draft request for proposal (RFP) and encouraged prospective industry bidders to provide comments, questions, concerns, and requests for clarification in preparation for a final RFP release in 2016.[32] Interactive dialogue continued after release of the draft RFP to improve the clarity of the system specifications, program schedules, and contract documentation and eventually update the complete draft RFP in September 2016.[33] Following the release of that updated draft RFP, the USAF made minor corrections to solicitation documents and responded to industry questions. The USAF proceeded through final reviews and approvals of the RFP, culminating in the release of the final solicitation RFP on December 30, 2016.[34]

Contracting Plan

The statement of work (SOW) associated with the APT solicitation includes all engineering and manufacturing development (EMD), production, and sustainment activities. In addition, the SOW calls for Field Service Representatives and Interim Contractor Support for the APT aircraft in

[29] Ibid.

[30] FedBizOpps.gov, "Request For Information FBO Notice," March 17, 2015, at https://www.fbo.gov/utils/view?id=1d96db580a132adaaed1961d2f64dcf3.

[31] FedBizOpps.gov is a single government point of entry for Federal government procurement opportunities that exceed $25,000. Government buying agents can publicize their business opportunities by posting information directly on the site. Vendors seeking Federal markets for their products and services can search for opportunities solicited by Federal contracting agencies. The portal can provide transparency when communicating with potential vendors and ensure all interested parties have access to the same information.

[32] FedBizOpps.gov, "Draft RFP," July 2016, at https://www.fbo.gov/?tab=documents&tabmode=form&subtab=core&tabid=9143b12ef30590a154ed155e427fe784.

[33] FedBizOpps.gov, "Updated Draft RFP," September 2016, at https://www.fbo.gov/?tab=documents&tabmode=form&subtab=core&tabid=73ec7b43fdfb914eed96078b65d1150a.

[34] FedBizOpps.gov, "Final Solicitation RFP," December 2016, at https://www.fbo.gov/?tab=documents&tabmode=form&subtab=core&tabid=ce37a15c1aa4f8d81a60ea2e88ed63d9.

support of transitioning to a government organic supply chain management and maintenance concept. The GBTS devices will be supported by a contractor logistics support contract.

The USAF awarded a 16-year Indefinite Delivery/Indefinite Quantity contract as allowed by the Federal Acquisition Regulation (48 C.F.R. 16.504) for up to 475 T-7As. Air Force plans expected the award to also include up to 120 GBTS. The minimum quantity of aircraft the government will order is 5 (test articles) and the minimum quantity of GBTS is 7.[35] The contract types include both fixed-price incentive firm and firm fixed-price.[36]

The acquisition strategy calls for mature, demonstrated technologies as opposed to a new, developmental system, although it should be noted that the winning Boeing design falls into the latter category. The EMD portion of the contract will be limited and focused on developmental work to incorporate capabilities to meet the system specifications. The current program schedule projects initial operational capability in FY2024.

Some analysts argued that the fixed-price elements of the contract placed new designs at a disadvantage compared with vendors offering a modified existing platform.[37] This is based on the fact that the vendor offering a new design must invest corporate funds to cover design costs. Other analysts argued that the decision to offer a new design is a corporate business decision and not a requirement; therefore, the risk and investment was purely a business consideration when deciding to compete for the contract award.

Source Selection Evaluation Plan

According to the USAF APT solicitation, the competition was a best value source selection conducted in accordance with Federal Acquisition Regulation Part 15, *Contracting by Negotiation,*[38] with the contract awarded to the offeror whose proposal is determined to offer the best *value* to the government based on an assessment of evaluation factors and subfactors identified in the solicitation's Section M—Evaluation Factors for Award. According to the USAF, lessons learned from the KC-X source selection were incorporated into the source selection strategy employed for the APT competition.[39] **Figure 6** represents the evaluation factors and subfactors that were to be used to evaluate offeror proposals.

Under the evaluation plan, only proposals less than $16.3 billion would be eligible to proceed. According to the USAF solicitation, in order for a proposal to be considered awardable, offerors must meet that *affordability gate*,[40] and receive a *Low* or *Moderate* technical risk rating for Subfactors 1.1-1.5, as well as an *Acceptable* rating for Subfactors 1.6-1.7. Also, if any nonprice factor or subfactor was evaluated as *High* or *Unacceptable*, the entire proposal would be

[35] FedBizOpps.gov, "RFP Model Contract Sections A-M," December 30, 2016, at https://www.fbo.gov/utils/view?id=c9c098127f89fa2e70a83d6a88bbaf27.

[36] For further details on contract specifics see the RFP Model Contract at https://www.fbo.gov/utils/view?id=c9c098127f89fa2e70a83d6a88bbaf27.

[37] Schweizer, Roman, *Competition Catalysts: T-X Field Tightens Ahead of March Bid Due Date*, Cowen Washington Research Group Policy Note, January 30, 2017, at https://cowen.bluematrix.com/sellside/EmailDocViewer?encrypt=74e303fc-95ae-4476-98be-4d9656d89b8b&mime=pdf&co=cowen&id=lmwilliams@crs.loc.gov&source=mail.

[38] FedBizOpps.gov, "Solicitation FA8617-17-6219, Section J – Attachment 18, Section M – Evaluation Factors for Award," December 30, 2016, at https://www.fbo.gov/utils/view?id=d90ec3750a14ef0886e67ec289f84095.

[39] For additional information on the KC-X program, see CRS Report RL34398, *Air Force KC-46A Tanker Aircraft Program*, by Jeremiah Gertler.

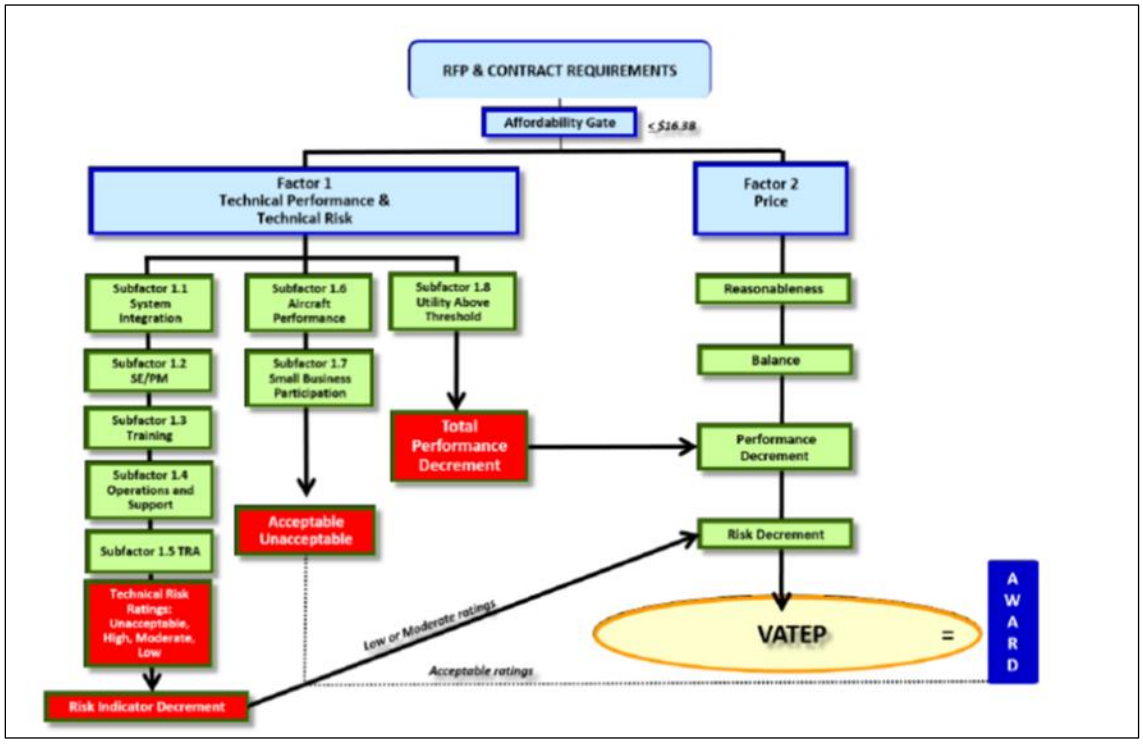
[40] The *Affordability Gate* is a cost cap on the total contract value of the vendor's offer. In order to be considered as an awardable offer the contract value must be less than or equal to $16.3B.

ineligible for award.[41] The offerors were to meet all standard government solicitation requirements (e.g., compliance with terms and conditions, intellectual property assertions, cost and data requirements, and security compliance). Each subfactor was to be evaluated individually and assessed based on detailed criteria found in Section M of the solicitation.

Proposals from prospective offerors were submitted by the March 30, 2017 deadline, and the USAF planned to award the contract in December 2017.[42] Subsequently, the Administration's FY2019 budget submission projected contract award sometime in FY2018. The contract was awarded on September 27, 2018.[43]

Figure 6. APT Source Selection Strategy

Evaluation Factors and Subfactors



Source: Solicitation FA8617-17-6219, Section J – Attachment 18, Section M – Evaluation Factors for Award.

Notes: Value Adjusted Total Evaluated Price (VATEP). For a greater explanation of each subfactor and evaluation criteria see Solicitation FA8617-17-6219, Section J–Attachment 18, Section M–Evaluation Factors for Award.

Prospective Offerors

Five aerospace company partnerships voiced intent to compete for the APT contract. Details of each partnership's offering are limited due to the nature of contract competitions; however, some

[41] Ibid.

[42] FedBizOpps.gov, "Solicitation FA8617-17-6219, Section J–Attachment 17, Section L–Instructions, Conditions, and Notices to Offerors," December 30, 2016, at https://www.fbo.gov/utils/view?id=ce217c3f392a69eac7c0d7b7d16ac2dc.

[43] Air Force News Service, *Air Force awards next-generation fighter and bomber trainer*, Arlington, VA, September 27, 2018, https://www.af.mil/News/Article-Display/Article/1647147/air-force-awards-next-generation-fighter-and-bomber-trainer/.

marketing information surfaced in anticipation of the APT solicitation. The following section will identify the prospective offerors and their intended product offerings.

Boeing-Saab T-X

In December 2013, Boeing and Saab formed a partnership to develop a purpose-built trainer in anticipation of the USAF APT program. The single-engine, twin-tail, stadium seating trainer was unveiled on September 13, 2016, at Boeing's St. Louis, MO, facility. According to Boeing, the T-X (see **Figure 7**) is a production aircraft and not a prototype. As of December 2016, two T-X aircraft had already flown maiden flights.[44] Boeing claims the purpose-built trainer was designed from the ground up to include the Ground-Based Training System and support. Parts of the aircraft were manufactured in Sweden and final assembly took place in St. Louis, MO.[45]

Figure 7. Boeing-Saab T-X

Source: http://www.boeing.com/defense/t-x/#/gallery.

Note: According to the Boeing website, this picture was taken during T-X's second flight.

Northrop Grumman-BAE-L-3 Model 400

In late 2011, Northrop Grumman and BAE Systems announced they would offer the single-engine BAE Hawk as the replacement bid for the T-38C. However, in 2014 the companies announced that they would offer a new purpose-built jet trainer system.[46] According to Northrop

[44] Weisgerber, Marcus, *A New Military Jet Flies Just One Year After It Was Designed*, Defense One, December 20, 2016, at http://www.defenseone.com/business/2016/12/new-military-jet-flies-just-one-year-after-it-was-designed/134065/?oref=gbb-newsletter.

[45] Ibid.

[46] Weisgerber, Marcus, *Northrop Secretly Building Jet for Air Force Trainer Competition*, Defense One, February 6, 2015, at http://www.defenseone.com/technology/2015/02/northrop-secretly-building-jet-air-force-trainer-competition/

executives, the new design would better meet the USAF requirements than the Hawk offering. The partnership with BAE Systems and L-3 would combine ground-based training systems and training devices to form a complete training system.

In August 2016, a single-engine, single-tail, two-seat T-X prototype was seen performing high-speed taxi tests at the Mojave Air and Space Port in California (see **Figure 8**).[47] The aircraft bore the logos of Northrop Grumman and its subsidiary, Scaled Composites; it was subsequently known to have the designation Model 400 Swift.[48] According to aerospace analysts, the design resembled the Northrop T-38C it was intended to replace.[49] On February 1, 2017, *Defense News* reported that Northrop Grumman-BAE-L3 had decided not to enter the competition for the T-X contract "as it would not be in the best interest of the companies and their shareholders."[50]

Figure 8. Northrop Grumman/BAE/L-3 T-X Prototype (Model 400)

Source: http://www.janes.com/article/63129/northrop-grumman-s-t-x-design-breaks-cover.

Lockheed Martin-Korean Aerospace Industries T-50A

Lockheed Martin (LM) and Korean Aerospace Industries (KAI) jointly developed the T-50A (see **Figure 9**), a modernized T-50 aircraft, as the APT contender. According to company officials, the block upgrade to the T-50 aircraft includes the addition of air refueling capability, embedded

104739/.

[47] Jennings, Gareth, *Northrop Grumman's T-X Design Breaks Cover*, IHS Jane's Defence Weekly, August 22, 2016, at http://www.janes.com/article/63129/northrop-grumman-s-t-x-design-breaks-cover.

[48] Jon Lake, "Swift: Looking Back on the Forgotten T-X Contender," *AINOnline*, January 25, 2019, https://www.ainonline.com/aviation-news/defense/2019-01-25/swift-looking-back-forgotten-t-x-contender.

[49] Jennings, Gareth, *Northrop Grumman's T-X Design Breaks Cover*, IHS Jane's Defence Weekly, August 22, 2016, at http://www.janes.com/article/63129/northrop-grumman-s-t-x-design-breaks-cover.

[50] Insinna, Valerie and Mehta, Aaron, *Northrop Grumman Drops Out of T-X Trainer Competition,* Defense News, February 1, 2017, http://www.defensenews.com/articles/northrop-grumman-drops-out-of-t-x-trainer-competition.

training, open system architecture, and a fifth-generation cockpit.[51] The T-50 aircraft was designed by KAI and LM in 2002 and is used as a trainer in Korea, Indonesia, Thailand, the Philippines, and Iraq.[52]

Figure 9. Lockheed Martin-KAI T-50A

Source: Lockheed Martin from *Janes Defence Weekly* article.

Notes: First flight of the T-50A by Lockheed Martin.

Leonardo T-100

The T-100 (see **Figure 10**) is a variant of the M-346 trainer currently in use in Italy, Israel, Poland, and Singapore.[53] Leonardo said the T-100 would be built at a new facility in Tuskegee, AL. Leonardo had originally partnered with General Dynamics and then with Raytheon to offer the T-100.[54] In February, 2017, Leonardo announced plans to enter the competition on its own with its U.S. subsidiary DRS as the prime contractor.

[51] Malenic, Maria, *Lockheed Martin flies first T-50A aimed at USAF T-X competition,* IHS Jane's Defence Weekly, June 3, 2016, at http://www.janes.com/article/60936/lockheed-martin-flies-first-t-50a-aimed-at-usaf-t-x-competition.

[52] Ryall, Julian, *South Korea's T-50 clocks up 5,000 test flights*, IHS Jane's Defence Weekly, November 28, 2016, at http://www.janes.com/article/65793/south-korea-s-t-50-clocks-up-5-000-test-flights.

[53] Ibid.

[54] Insinna, Valeria and Mehta Aaron, *Raytheon, Leonardo End partnership for T-X Trainer Program,* Defense News, January 25, 2017, http://www.defensenews.com/articles/raytheon-leonardo-end-partnership-for-t-x-trainer-program.

Figure 10. Leonardo T-100

Source: https://milaviate.files.wordpress.com/2013/08/t-100-alenia-aermacchi.jpg.

Notes: The T-100 is a variant of the Leonardo M-346. Leonardo has been previously known as Finmeccanica and Alenia Aermacchi.

Sierra Nevada Corp.-Turkish Aerospace Industries T-X

An offering from Sierra Nevada Corp. and Turkish Aerospace Industries was announced as a late entrant into the T-X competition. According to *Aviation Week*, "the two businesses have quietly set up shop in Centennial, Colorado, as Freedom Aircraft Ventures LLC, to develop a lightweight, all-composite trainer."[55] Additional information on this offering was not released, and the team is not known to have submitted a bid.

Issues for Congress

DOD's APT T-X acquisition strategy poses a number of questions for Congress, including the following:

- Given the USAF's position on the looming pilot shortage, the anticipated purchase of 350 T-7A aircraft, and the current fleet size of 430, what are the minimum and optimum recapitalization levels needed? Should the number of new aircraft increase, would a corresponding increase in GBTS be appropriate?
- Is there an opportunity to consolidate the USAF's five pilot training locations into fewer bases? Is a study warranted at this time to further consolidate pilot training?

[55] Drew, James, *Sierra Nevada Corp., TAI Team To Offer Freedom Trainer For T-X,* Aviation Week, December 16, 2016. http://aviationweek.com/defense/sierra-nevada-corp-tai-team-offer-freedom-trainer-t-x.

- Given the ramp-up in F-35A purchases, additional KC-46 lots, and development of the B-21 bomber, what is the impact of a fourth major defense acquisition program to the USAF budget? Should the training fleet be recapitalized sooner to accommodate the increase in the number of fifth-generation platforms?
- What, if any, acquisition reform initiatives need to be in place to facilitate faster procurement of the T-7A?
- Should the USAF consider the T-7A, with modification, as a light-attack fighter to take advantage of the fifth-generation capabilities required in the T-X system?
- Considering that the winning bid was less than 50% of the Air Force's projected cost, can Boeing execute the program on time and within budget?

Appendix A. Air Force Pilot Training

How Does the USAF Produce Pilots?

The USAF uses a deliberate, competitive process to select pilot candidates. Once chosen, candidates undergo a lengthy academic and flight training program.

Pilot Candidate Selection

The USAF pilot selection process begins with a battery of academic and psychomotor tests; candidates must also meet flight physical requirements and anthropometric standards. The USAF uses a Pilot Candidate Selection Method (PCSM) tool to predict the ability of a prospective candidate to complete pilot training. The PCSM score is a combination of performance on the Test of Basic Aviation Skills (TBAS) and Air Force Officer Qualifying Test (AFOQT) and the total number of flying hours the candidate has already accumulated from civilian flight training. A pilot selection board, composed of senior USAF aviators, uses the PCSM score along with other *whole-person concept* factors to select candidate pilots.[56] According to some researchers, higher scores on the PCSM may predict

- greater probability of successfully completing training;
- reduced flight hours needed to complete training;
- a higher class rank; and
- greater likelihood of being fighter aircraft qualified.[57]

The TBAS is a computerized psychomotor test to measure a candidate's motor skills, cognitive aptitude, and attitude toward risk. The candidate manipulates a joystick, throttle, and rudder pedals to accomplish tasks to measure directional orientation, listening skills, horizontal tracking, aircraft tracking, and combining all actions at once.[58]

The AFOQT is a standardized test similar to the Scholastic Aptitude Test. It measures applicants' aptitudes for various officer commissioning programs and includes a specific portion dedicated to measuring aptitude for pilot and combat systems officer career fields. Regardless of the desired field, the AFOQT is mandatory for application for a commission in the USAF. The AFOQT has been used for officer selection since 1957 and has been updated about every seven years.[59] The *pilot composite*, another test for pilot selection, measures a candidate's knowledge of aviation and mechanical systems, his or her ability to determine aircraft attitude from a flight instrument graphic, his or her spatial ability and knowledge of aeronautical concepts, and his or her ability to interpret and read tables and scales.[60]

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[56] The *whole person concept* considers the individual's performance, leadership potential, breadth of experience, job responsibility, professional competence, specific achievements, and education.

[57] Carretta, Thomas, "US Air Force Pilot Selection and Training Methods," 2000, at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA430320.

[58] Baseops.net, "Test of Basic Aviation Skills," at https://www.baseops.net/militarypilot/tbas.html.

[59] Carretta, Thomas, "US Air Force Pilot Selection and Training Methods," 2000, at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA430320.

[60] Ibid.

Flight Training

Pilot candidates enter flight training by attending the Introductory Flight Training (IFT) course. IFT is a civilian flight instructor-led program administered in Pueblo, CO.[61] The course provides a pilot candidate the opportunity to complete flight ground school and a 25-flight-hour screening program. Doss Aviation administers the IFT program for the USAF. IFT prepares USAF students to enter Specialized Undergraduate Pilot Training (SUPT), Undergraduate Combat Systems Officer Training, or Undergraduate Remotely Piloted Aircraft Pilot Training. According to Doss Aviation, the two primary objects of IFT are to

- provide the Air Force an opportunity to screen aviation candidates prior to undergraduate flight training attendance; and
- begin the development of the student's aviation skills in order to enhance his/her ability to succeed in undergraduate flight training.[62]

Doss Aviation operates Diamond DA20-C1 aircraft (see **Figure A-1**) to execute the IFT program.

Figure A-1. Diamond DA20-C1

Doss Aviation IFT Aircraft

Source: http://www.dossifs.com/index.php?option=com_content&view=article&id=64&Itemid=83.

Following IFT, student pilots attend either the Euro-NATO Joint Jet Pilot Training (ENJJPT) program or the Specialized Undergraduate Pilot Training (SUPT) program. ENJJPT is located at

[61] Baseops.net, "Specialized Undergraduate Pilot Training," at https://www.baseops.net/militarypilot.

[62] Doss Aviation IFT website, "USAF Initial Flight Training," at http://www.dossaviation.com/usaf-ift.

Sheppard AFB, Texas, and is a three-phase, 55-week training program taught by USAF and Euro-NATO country instructor pilots. Upon graduation, the new pilots will attend follow-on training on their assigned aircraft at various bases around the country. There are eight ENJJPT classes per year with six-week entry/graduation cycles. Each ENJJPT class has 20-25 students.[63]

Euro-NATO Joint Jet Pilot Training Phases[64]

Phase I—Academic Classes and Preflight Training:

- Aerospace Physiology and Altitude Chamber sessions
- Ejection Seat/Egress Training and Parachute Landing Falls
- Aircraft Systems Course

Phase II—Primary Aircraft Training (T-6)

- 26-Week, 125-hour flight training instruction
- Basic flying skills to include contact, instruments, low-level navigation, formation (2-ship)
- Basic and Advanced Instruments Course
- Mission Planning/Navigation Course
- Aviation Weather Course

Phase III—Advanced Aircraft Training (T-38)

- 26-Week, 135-hour flight training instruction
- Prepares graduates for fighter/bomber assignments
- Contact, Instruments/Navigations, Formation-Basic and advanced (2/4-ship), Low-level (1/2-ship)
- Follow-on aircraft assigned based on merit and instructor recommendation

Pilots selected to fly fighter aircraft attend the Introduction to Fighter Fundamentals (IFF) course at Sheppard AFB, Texas. There are 15 ENJJPT IFF classes per year, and the course lasts approximately eight weeks. Following IFF, the pilots transition to training on their assigned aircraft at bases throughout the United States, depending on aircraft assignment. **Table A-1** identifies the respective aircraft and training base.

Table A-1. Follow-on Fighter Aircraft Training Bases

Aircraft	Training Base
F-15C Eagle	Kingsley Field, OR
F-15E Strike Eagle	Seymour Johnson AFB, NC
F-16 Fighting Falcon	Luke AFB, AZ
A-10 Thunderbolt II	Davis-Monthan AFB, AZ
B-52 Stratofortress	Barksdale AFB, LA
B-1B Lancer	Dyess AFB, TX
T-38 Talon	Sheppard AFB, TX

Source: https://www.baseops.net/militarypilot/enjjpt.html.

Notes: Pilots may be assigned as a First Assignment Instructor Pilot (FAIP) in the T-38. FAIPs selected for ENJJPT will only be assigned to instruct at ENJJPT and attend Pilot Instructor Training at ENJJPT.

[63] Air Education & Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations," at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

[64] Baseops.net, "Euro-NATO Joint Jet Pilot Training," at https://www.baseops.net/militarypilot/enjjpt.html.

SUPT is a joint USAF and USN pilot training program conducted at Vance AFB, Oklahoma, and Naval Air Station Whiting Field, Florida. The program lasts approximately 54 weeks. Upon graduation, the new pilots attend follow-on training in their assigned aircraft at bases throughout the United States, known as Formal Training Units (FTUs). There are 15 SUPT courses per year at each SUPT base. A class enters and graduates SUPT every eight weeks. SUPT classes are typically 8-10 student pilots.[65]

USAF and USN students complete primary flight training on the T-6 aircraft. Some USAF students complete their primary flight training at Columbus AFB, Mississippi, or Laughlin AFB, Texas, flying the T-6. Following primary flight training, students assigned to the fighter/bomber track will go on to train on the T-38, concentrating on low-level tactics, instrument procedures, formation flying, and navigation training. Pilots selected for airlift and tanker aircraft complete their advanced training on the T-1A at Columbus AFB, Mississippi; Laughlin AFB, Texas; or Vance AFB, Oklahoma. Airlift and tanker pilots are introduced to crew resource management techniques, air-to-air refueling, airdrop missions, and radar positioning and navigation.[66] Students selected to fly multiengine turboprop aircraft train on the Navy's T-44 or Air Force's C-12 turboprop trainers at Naval Air Station Corpus Christi, Texas, and are introduced to C-130 training mission profiles. Very few students are selected to fly helicopters; however, their advanced training is conducted at Fort Rucker, AL, in the UH-1 Huey. **Table A-2** identifies the respective airlift, tanker, and helicopter training bases. SUPT graduates assigned to a fighter/bomber aircraft attend IFF at Randolph AFB, Texas, or Columbus AFB, Mississippi. There are 12 IFF courses per year with a four-week entry/graduation cycle.[67]

In addition to academic classes and flight instruction, students are also required to train in aircraft simulators to apply learned techniques and to be prepared for the cockpit. Experts agree that simulators provide a cost-effective means of instruction to help reduce the burden and cost of aircraft operations and maintenance. Also, simulators allow instructors to introduce a variety of emergency conditions that pilots may confront during flight operations in a safe and controlled environment. The emergency simulations are critical to enhance the student pilot's awareness and skills in preparation for encountering similar emergencies in flight.

[65] USAF Air Education & Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations" at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

[66] Baseops.net, "Specialized Undergraduate Pilot Training," at https://www.baseops.net/militarypilot.

[67] Air Education & Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations," at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

Table A-2. Follow-on Airlift, Tanker, Helicopter, Reconnaissance Aircraft Training Bases

Aircraft	Training Base
KC-135 Stratotanker, C-17 Globemaster III	Altus AFB, OK
KC-10 Extender	Travis AFB, CA, and Joint Base McGuire-Dix-Lakehurst, NJ
C-5 Galaxy	Joint Base San Antonio, TX
C-130 Hercules	Little Rock AFB, AR, and Dobbins ARB, GA
MC-130 Combat Talon, HC-130, UH-1N, HH-60 Pave Hawk, CV-22 Osprey	Kirtland AFB, NM
C-21	Keesler AFB, MS
U-28A	Hurlburt Field, FL
MC-12	Meridian, MS

Source: https://www.baseops.net/militarypilot.

Advancements in Pilot Training

A 1996 USAF research project demonstrated that advancements in aircrew training methods and technologies allow ground-based pilot training to move beyond training procedural skills to training wartime mission skills.[68] As training resources become scarce, analysts agree that more realistic and advanced synthetic training environments have evolved to support more complex training requirements. One of the major advancements is the ability to link a variety of training simulators, constructive models, and live aircraft in a wide area network to accomplish mission training. According to USAF researchers, modeling and simulation increase scope and realism of warfighter training at an affordable cost.[69] Simulator networking allows construction of large confederations of disparate simulators which permit multiservice and allied country joint combined training in a variety of military mission sets. In addition, simulated combat environments provide instructional advantages, such as avoiding range constraints like electronic warfare restrictions and enabling real-time kill removal during an air battle.[70]

One major consideration in using simulators for aircrew training is spatial awareness development. Spatial awareness is the ability to comprehend the spatial parameters of an air-combat or flight-training mission. The challenge lies in the difficulty the pilot has mentally visualizing a three-dimensional (3-D) environment while using two-dimensional displays.[71] Technology has advanced to supply more realistic 3-D views through virtual reality, allowing pilot trainees to experience spatial situations in a computer-generated virtual battlespace. Spatial cognition trainers augment academic instruction by allowing the trainee to practice visualization skills that mimic in-flight spatial problem-solving situations.[72]

Past aircrew training relied heavily on actual aircraft flight training to provide realistic mission training. Aircraft training devices were used to prepare the aircrews to use limited flying hours effectively. The increase in training requirements due to fourth- and fifth-generation[73] fighter

[68] Andrews, Dee H. and Carroll, Lynn A., "R&D Advances in USAF Pilot Training," September 1996, at https://www.researchgate.net/publication/235193358_RD_Advances_in_USAF_Pilot_Training.

[69] Ibid.

[70] Ibid.

[71] Ibid.

[72] Ibid.

[73] Fifth-generation aircraft incorporate the most modern technology and are considered to be more capable and advanced than earlier generation aircraft.

aircraft, coupled with the high cost of flight hours, reduced both the quality and quantity of available aircrew training.[74] USAF analysts agree that the advent of distributed mission training (DMT) and advanced distributed simulation technology can significantly improve aircrew training. DMT allows multiplayer, multisite training scenarios from individual and team participation to full-theater battles.[75] USAF analysts believe that expanding on-demand, realistic training opportunities will significantly improve aircrew training and help overcome limited training resources.[76] According to the USAF, the planned T-X program includes state-of-the-art Ground-Based Training System (GBTS) requirements to take full advantage of the advancements in pilot modeling and simulation training.[77]

According to a Defense Media Network article, the cost to train a USAF fighter pilot is $2.6 million and the cost to train an airlift pilot is $600,000.[78] USAF analysts argue that the increased use of simulators is a cost-saving imperative. Simulator use reduces flight-hour costs, airframe flight hours, and maintenance. AETC commented that

> current Air Force live flight/simulator training balance varies from pipeline to pipeline. Primary training that all USAF pilots go through in the T-6 Texan II demonstrates the current emphasis on live flight. The division between live flight and simulation events is 65 percent/35 percent. That equates to about 87 hours in the aircraft and 46 hours in the simulator.
>
> For the airlift/mobility pipeline where students fly the T-1 Jayhawk, the current balance is similar, 71 percent of events occurring in the aircraft and 29 percent in the simulator. This will shortly change, however. The USAF is working its way through a "tech refresh" of its T-1 simulation devices, which will grow significantly in capability. With T-1 flight training total time scheduled to drop to 130 hours, the pipeline will move toward a 60/40 percent live flight/simulator split by 2013.[79] This represents 76.5 hours of aircraft time and 53.5 hours of simulator time.
>
> As the Air Force's upgrade to the TH-1H Iroquois helicopter with its new engine and glass cockpit progresses, the live flight/simulator balance for rotary-wing students will go from 77 percent/23 percent to 74 percent/26 percent. The fighter-bomber track sees students in the venerable T-38C Talon 71 percent of the time, comprising 96 hours, and in the simulator 29 percent of the time or 39 hours.[80]

According to AETC, all flying training programs have seen a drop in flight times of approximately 15% and a move to integrate more simulator time. However, the USAF maintains that although simulation is complementary to live flight across all training programs, this is not true for new pilots. Undergraduate pilot training is biased to live flight training to ensure the student pilot experiences enough live flight that he or she can appreciate what occurs in simulation.[81] Analysts agree that simulators can help reduce the costs of pilot training; however,

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[74] Ibid.

[75] Ibid.

[76] Ibid.

[77] USAF Air Education & Training Command, "Advanced Pilot Training (APT T-X) Concept of Operations" at https://www.fbo.gov/utils/view?id=99751ca4edfc3d8c6260cb6a65f62276.

[78] Tegler, Eric, "Air Force Flight Simulators May Help Cut Training Costs, Defense Media Network," at http://www.defensemedianetwork.com/stories/virtual-bargain/.

[79] CRS was not able to confirm if the 60/40 percent live flight/simulator split was accomplished by 2013.

[80] Tegler, Eric, "Air Force Flight Simulators May Help Cut Training Costs, Defense Media Network," at http://www.defensemedianetwork.com/stories/virtual-bargain/, p. 1.

[81] Ibid.

the extent of the reduction is unknown. According to financial analysts, the global flight simulator market, both military and commercial, is expected to grow 4.5% by 2022 as a result of the need to cut costs associated with pilot training while ensuring aviation safety.[82] High-fidelity full-motion simulators are very expensive and require energy, maintenance, and personnel to operate and maintain. The initial cost of the system along with continuous maintenance, upgrades, and operation costs must be considered in making comparisons to live flight operations. Analysts have yet to define all the variables that go into calculating costs associated with simulator versus live flight training costs.[83]

The Navy is also planning to progressively boost simulator fidelity to improve full-immersion mission experience for its pilots and sensor operators. The Navy's aviation simulation master plan for 2020 "is designed to cautiously and progressively increase the amount of cost-saving virtual training while maintaining enough in-aircraft practice to ensure safety."[84] According to *Aviation Week* reporting, the Government Accountability Office (GAO) has reported that

> the Navy as of 2012 was using simulators for 18-20% of Boeing F/A-18 Hornet training, 39% of Romeo training and 41% for Sikorsky MH-60 Sierra training. The Navy uses the Romeo primarily for anti-submarine warfare and anti-surface warfare missions, while the Sierra is used primarily for search and rescue, medevac, utility and vertical replenishment missions.
>
> With upgraded MH-60 Romeo and Sierra, F/A-18E and F, and EA-18G TOFTs [Tactical Operational Flight Trainer], however, the Navy estimates it will be able to boost the virtual training ratio to approximately 50% for the MH-60 fleet, and more than 30% for the F-18s by 2020. Capt. Craig Dorrans, program manager of PMA-205 at the Naval Air Systems Command says crews for the Boeing P-8A Poseidon, the replacement for the P-3, will probably be able to perform as much as 70% of their training in a TOFT. The P-8A is based on the Boeing 737-800, allowing the military to leverage commercial simulation capabilities already developed.
>
> Training for Fire Scout pilots is already moving to 100% synthetic training. "We're Looking at 100% simulation to train aircrew for the Fire Scout and MQ-4 Triton," Dorrans says. "The cockpit is already separated from the aircraft. Everything that you see on the ground in the cockpit, you can simulate."[85]

[82] EINPresswire.com, "Flight simulator market to Grow at CAGR of 4.5% According to Forecast from 2017 to 2022," April 27, 2017, at http://brazilbusiness.einnews.com/pr_news/378150197/flight-simulator-market-to-grow-at-cagr-of-4-5-according-to-forecast-from-2017-to-2022.

[83] Ibid.

[84] Croft, John, "U.S. Navy Expanding Simulator Use to Cut Costs," December 2, 2013, at http://aviationweek.com/awin/us-navy-expanding-simulator-use-cut-costs.

[85] Ibid.

Appendix B. Prior Legislative Activity

FY2019 Funding Request

The FY2019 Administration budget request included $265.465 million for the Advanced Pilot training program. Congress authorized the full amount in the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (H.R. 5515).

In Division A of the Department of Defense and Labor, Health and Human Services, and Education Appropriations Act, 2019, and Continuing Appropriations Act, 2019 (H.R. 6157), Congress appropriated the Advanced Pilot Training program $245.465 million, a reduction of $20 million, citing "ECO (engineering change orders) excess to need."

FY2018 Funding Request

The FY2018 Administration budget request included $105.999 million for the Advanced Pilot training program. Congress authorized the full amount in the FY2018 National Defense Authorization Act (H.R. 2810).

In Division C of the FY2018 Consolidated Omnibus Appropriations Act (H.R. 1625), Congress appropriated the Advanced Pilot Training program $86.199 million, a reduction of $19.8 million, citing "contract award delay."

FY2017 Funding Request

The Administration's proposed FY2017 defense budget requested $12.377 million in Air Force research and development funding to continue APT T-X development and acquisition.[86] **Table 2** represents the USAF's portion of the Future Years Defense Program (FYDP) submission dedicated to the T-X and the $12.377 million requested budget for FY2017.

Table 2. Air Force RDT&E Budget Request FY2017

Cost ($ in millions)

	Prior Years	FY15	FY16	FY17	FY18	FY19	FY20	FY21	Cost to Comp	Total Cost
APT (T-X)	0.000	8.201	10.395	12.377	105.699	263.274	272.973	277.816	670.087	1,620.822

Source: Air Force FY2017 Budget Materials submitted to the DOD, http://www.saffm.hq.af.mil/Portals/84/documents/FY17/AFD-160208-051.pdf?ver=2016-08-24-102123-043.

Notes: This represents only the Research, Development, Test and Evaluation budget. Procurement, MILCON, and Operations & Maintenance budget requirements will start in FY2020.

FY2017 Defense Authorization Act (H.R. 4909/S. 2943)

The Administration's FY2017 budget request included $12.377 million for the Advanced Pilot Training program.

[86] The requested funding is found in the Air Force's research, development, test and evaluation (RDT&E) account in program element (PE) 0605223F, Advanced Pilot Training.

House

The House Armed Services Committee, in its report accompanying H.R. 4909, recommended funding the Advanced Pilot Training program at $12.377 million, the requested level.

Senate

The Senate Armed Services Committee, in its report accompanying S. 2943, recommended funding the Advanced Pilot Training program at $4.477 million, $7.9 million below the requested level, finding that the funds were early to need given the current contract award schedule.

Final Action

The conference report accompanying H.R. 4909, as passed, recommended $7.377 million, a reduction of $5 million from the Administration's request, finding the funds were early to need.

FY2017 Appropriations

Division C of the FY2017 Consolidated Appropriations Act (H.R. 244) appropriated $7.377 million for the Advanced Pilot Training program, reducing the requested amount by $5.0 million as "early to need."

FY2016 Funding Request

The Administration's FY2016 defense budget request included $11.395 million in Air Force research and development funding to continue APT T-X development and acquisition.[87]

FY2016 Defense Authorization Act (H.R. 1735/S. 1376)

The House Armed Services Committee and Senate Armed Services Committee both recommended funding the Advanced Pilot Training program at $11.395 million, the requested level.

FY2016 Defense Appropriations Act (H.R. 2685/S. 1558)

The House Appropriations Committee recommended funding the Advanced Pilot Training program at $10.395 million, a reduction of $1 million from the Administration's request, with no accompanying language. The Senate Appropriations Committee recommended funding the Advanced Pilot Training program at the Administration's request, $11.395 million.

H.Rept. 114-139 accompanying H.R. 2685 funded the Advance Pilot Training program at $10.395 million, a reduction of $1 million from the Administration's request.

[87] The requested funding is found in the Air Force's research, development, test and evaluation (RDT&E) account in program element (PE) 0605223F, Advanced Pilot Training.

FY2015 Defense Authorization and Appropriations (H.R. 4870)

H.Rept. 113-473 and S.Rept. 113-211 accompanying H.R. 4870 funded the Advance Pilot Training program at $8.201 million, the Administration's requested level.[88] FY2015 was the first year of funding to execute the program.

[88] Ibid.

Appendix C. APT Capability Gap Summary

	Task	Gap Description	Category
1	**Basic Aircraft Control** Basic aircraft control is the ability to operate the aircraft throughout the flight envelope within the course training standards. This includes advanced handling (e.g., aerobatics, high angle-of-attack [AOA] flight, high-speed flight and high-G awareness exercises).	The T-38 Family of Systems (FoS) does an adequate job in basic aerobatics and basic aircraft control cognitive development. The basic aircraft control skill sets learned in an APT configured with the T-38 FoS will not readily transfer to the 5th-generation aircraft Formal Training Unit (FTU). The T-38 FoS cannot replicate the fly-by-wire aircraft feel and other 4th- and 5th-generation performance such as high-AOA maneuvering, high-altitude maneuvering, and higher thrust-to-weight ratios. The T-38C life support systems are also not representative of 5th-generation systems (oxygen, pressure breathing for G, etc.).	Lack of existing capability; need for recapitalization; proficiency
2	**Emergency Procedures** Emergency Procedures means the ability to perform emergency operating procedures within the course training standards.	From a procedural perspective, the T-38 FoS does an adequate job enabling this task. The basic tenets for handling emergencies are aircraft independent: maintain aircraft control; analyze the situation and take proper action; and land as soon as conditions permit. Nonetheless, each aircraft has unique procedures for dealing with emergencies. The 5th-generation aircraft will have more computer-controlled systems with emergencies diagnosed and manipulated via these computer systems. Also, the F-35 is a single-engine aircraft. *Engine out* emergency training is more challenging without an instructor in the same aircraft.	Proficiency
3	**Operational Availability** Operational Availability means the ability to provide systems for operational needs. Operational Availability consists of three components: reliability, maintainability, and supportability.	Although the current figures are positive, the T- 38 FoS is beginning to show its age. The increasing nonmission-capable maintenance (NMCM) rate and cannibalization actions reflect areas of concern. There are issues with engines, airframes, landing gear, and avionics. Also, fuel supplies and the cost of fuel may affect Operational Availability, as well as the cost per flying hour.	Sufficiency

	Task	Gap Description	Category
4	**Normal Procedures** Normal Procedures means the ability to perform normal operating procedures within the course training standards	The T-38 FoS does an adequate job enabling this task. Moreover, the T-38's high airspeed enhances the pilot's cognitive decision cycle development. Nonetheless, the limitations borne from a lack of 4th- and 5th-generation aircraft capabilities in the T-38 FoS affect portions of this area. First-time landings in the F-35 will be challenging.	Proficiency
5	**Advanced Cockpit/Crew Resource Management (CRM)** Advanced CRM means the ability to prioritize mission tasks and operate on-board sensors and systems for maximum situational awareness and mission effectiveness. Advanced systems include hands-on throttle and stick (HOTAS).	The T-38 FoS lacks the necessary 4th- and 5th-generation aircraft systems for adequate Advanced CRM training. The T-38 FoS has no radar, sensors, or data-link capability.	Lack of existing capability; need for recapitalization; proficiency
6	**Advanced Air-to-air (A/A)** Advanced A/A Mission Employment means the ability to perform advanced A/A mission employment within the course training standards. Advanced A/A mission employment supports the introduction of tactical A/A mission employment fundamentals to include tactical offensive and defensive maneuvering as it applies to air-to-air (e.g., Air Combat Maneuvering [ACM], Air Combat Training [ACT]) operational combat tactics; low altitude employment challenges and hazards (e.g., Low Altitude Training [LOWAT]); night vision device employment; and air refueling operations.	The T-38 FoS lacks the necessary performance, cockpit visibility, avionics, and sensors for 4th- and 5th-generation aircraft familiarization training in Advanced A/A Mission Employment. The T-38 FoS has no air refueling capability.	Lack of existing capability; need for recapitalization; proficiency
7	**Support Infrastructure** Support Infrastructure means providing infrastructure to support effective and efficient training operations. This task includes base facilities (e.g., academic classrooms, briefing rooms, runway, air traffic control, etc.). It also includes training airspace and compliance with operational environmental policies (e.g., noise abatement, restricted over-flight, etc.).	USAF foresees airspace and range access challenges. Recent examples (Luke AFB, NAS Oceana, and Nellis AFB) suggest airfield encroachment will continue to be an issue. Moreover, commercial air operations may further erode access to training airspace and training ranges.	Sufficiency
8	**Instruments and Navigation** Instruments/Navigation means the ability to perform instrument/navigation procedures within the course training standards and AFMAN 11-217.	Although the T-38 FoS does an adequate job enabling basic Instruments/Navigation, the trend away from "radio-type" navigation to the National Airspace Structure use of Global Positioning System (GPS) and micro-wave capabilities creates limitations. Also, the T-38C anti-ice deficiencies and high density altitude takeoff and landing limitations inhibit all-weather training.	Lack of existing capability; need for recapitalization; proficiency

	Task	Gap Description	Category
9	**Formation** Formation means the ability to perform formation flight within the course training standards; this supports the performance of two-/four-ship operations from briefing to debriefing as a wingman and lead.	Although the T-38C aircraft does an adequate job enabling basic formation, it is deficient in enabling autonomous formation operations. These operations include night, all-weather, and beyond-visual-range formation activities. The T-38 FoS lacks lighting, radar, data-link, and Night Vision Goggle (NVG) systems. Also, the T-38 simulators lack the visual clarity necessary to enhance advanced formation activities.	Lack of existing capability; proficiency
10	**Basic Air-to-Air (A/A)** Basic A/A Mission Employment means the ability to perform basic A/A mission employment within the course training standards. Basic A/A mission employment supports the introduction of basic A/A mission employment fundamentals to include basic offensive and defensive maneuvering (e.g., Basic Fighter Maneuvers [BFM], sustained high-G maneuvering), as well as low-altitude navigation environment challenges and hazards (e.g., Low Altitude Step Down Training [LASDT]).	Although the T-38 FoS does a reasonable job enabling BFM skills development using classic offensive and defensive maneuvers, the lack of sustained high-G capability and 5th-generation fly-by-wire and computer-aided maneuvering capabilities limits the T-38 FoS BFM relevance and applicability in comparison to 5th-generation aircraft. Also, the T-38 FoS lack of sensors, data-link, and automation constrains the development of this task.	Lack of existing capability; need for recapitalization; proficiency
11	**Advanced Air-to-Ground (A/G)** Advanced A/G Mission Employment is the ability to perform advanced A/G mission employment within the course training standards. Advanced A/G mission employment supports the introduction of tactical A/G mission employment fundamentals to include A/G (e.g., Surface Attack [SAT], Close Air Support [CAS]) operational combat tactics; low altitude employment challenges; and hazards and night vision device employment.	The T-38 FoS lacks the necessary performance, avionics and sensors for 4th- and 5th-generation aircraft familiarization training in Advanced A/G Mission Employment. The T-38 FoS has no capability to enable training with advanced weapons such as J-series, laser guided, and data-link versions.	Lack of existing capability; need for recapitalization; proficiency
12	**Pilot Throughput** Pilot Throughput means the ability to provide the capacity to graduate Headquarters USAF-tasked numbers of pilots on-time. Pilot throughput is a force structure issue independent of the FoS's capabilities. The objective is to graduate a sufficient number of pilots at a rate adequate to meet USAF FTU pipeline requirements as well as ensuring adequate pilot production is maintained to sustain operational unit requirements.	Although the definition states Pilot Throughput is independent of the T-38 FoS capabilities, the analysis team wanted to capture Cockpit Anthropometric Accommodation. The T-38 aircraft limits the population of potential pilots.	Lack of existing capability

Source: United States Air Force Advanced Pilot Training Family of Systems Analysis of Alternatives Update Final Report, 21 August 2014, Version 3.0. Document is For Official Use Only. Requests for source document copy must be referred to AETC/A5RX, Randolph Air Force Base, Texas, 78148.

Appendix D. System Specification for the Advanced Pilot Training Program Aircraft System

Solicitation FA8617-17-R-6219
Section J – Attachment 3
Aircraft System Specification for the Advanced Pilot Training (APT) Program

PRF APT-ACFT-1001
9 December 2016

PERFORMANCE SPECIFICATION

SYSTEM SPECIFICATION

for the

ADVANCED PILOT TRAINING (APT) PROGRAM

AIRCRAFT SYSTEM

Version 1.0

Prepared by:
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