ManTech
Securing the Future

DARPA
Aviation
Programs

ManTech Support to Defense Research Project Agency's (DARPA) Aviation Programs — March 2021

A ManTech White Paper

BACKGROUND

ManTech SRS has a rich and proud aviation history spanning more than 30 years supporting research, development, test, and evaluation. Our legacy includes supporting many “firsts”: first X-Plane with forward swept wings (X-29); first trust vectoring, tailless and international X-Plane (X-31); and first Experimental Space Plane (XSP).

DARPA/NASA X-29: Our journey began in 1986 when we entered the era of X-Planes by providing key subject matter experts (SMEs) to the joint DARPA/NASA X-29 demonstrator program that tested a forward-swept wing, fly-by-wire canard control surfaces, and other novel aircraft technologies. The X-29 is a single-engine aircraft 48.1 feet long. Its forward-swept wing has a span of 27.2 feet. A General Electric F404-GE-400 engine producing 16,000 pounds of thrust powered each X-29. Empty weight of the aircraft was 13,600 pounds, while takeoff weight was 17,600 pounds. The aircraft had a maximum operating altitude of 50,000 feet, a maximum speed of Mach 1.6 and a flight endurance time of approximately one hour. Team ManTech supported the program from 1986 to 1993 by providing Subject Matter Experts to DARPA for stability & control, systems engineering, and test & evaluation.

X-29 Flight Test Video: https://www.youtube.com/watch?v=v-8MVnPHzio

Exhibit 1: X-29 high alpha flight test with spin chute and flow field tufts over NASA's Ames-Dryden Flight Research Facility (later redesignated the Dryden Flight Research Center), Edwards, California.

DARPA/NASA X-31: In 1988 we supported the first international X-Plane, the DARPA/NASA/German X-31 Enhanced Fighter Maneuverability experimental fighter designed to test three-dimensional thrust vectoring technologies to provide super maneuverability. The novelty of the X-31 trials was computer control of its revolutionary flight controls (the canard wing and engine baffles) to effect maneuvers impossible for conventional jet fighters. The X-31 program also proved the viability of a (simulated) tailless fighter design and was one of the first experimental aircraft programs to introduce and employ helmet-mounted displays for pilots. Team ManTech supported the X-31 program from 1988 to 1995 with our stability & control, flutter, airworthiness, instrumentation, and test & evaluation SMEs.

X-31 video clip: https://www.youtube.com/watch?v=x1E3xpePbmA

Dryden Flight: Research Center EE94 42734-6 1994 Photo Visualization Quasi-Tailess X-31

Exhibit 2: X-31 Enhanced Fighter Maneuverability Demonstrator.

Advanced Technology Tactical Transport: In 1990 we supported DARPA's Advanced Technology Tactical Transport (ATTT) proof-of-concept demonstrator to explore design features and gather data to enhance short takeoff and landing and long-range performance. The original design was updated with a revised tail, with a twin-boom configuration replacing the original single cruciform tail unit, with the fuselage shortened and a rear-loading ramp fitted. The revised layout improved handling, lowering minimum single-engine safety speed (which was previously significantly higher than the stall speed). Thirteen test flights were flown to evaluate the revised layout. From 1990 to 1993 Team ManTech provided performance, stability and control, handling qualities SMEs to support and document this successful test demonstrator effort.

Exhibit 3: Scaled Composites Advanced Technology Tactical Transport.

DARPA/USAF/USN Unmanned Combat Aerial Vehicle System (UCAV): In 1999, DARPA and the U.S. Air Force chose Boeing to build two X-45A air vehicles with stealthy, tailless airframe, a 34-foot swept back wingspan, 27-foot-long fuselage, weighing 8,000 pounds empty, and will carry a variety of precision strike munitions. In June 2000, two contracts for technology demonstrators were also awarded to Boeing for the X-46A and to Northrop Grumman for the X-47A. However, in April 2003, the Air Force and the Navy efforts were formally combined under the joint DARPA/United States/Navy J-UCAV program, later renamed J-UCAS (Joint Unmanned Combat Air Systems), and the X-46 program was terminated as redundant. In May 2003 DARPA contracted with Boeing and Northrop Grumman to produce modified X-45C and X-47B demonstrators, respectively, to meet potential needs of the US Air Force and US Navy. During its first flight, May 22, 2002, the X-45A, nicknamed the "Elsie May," flew for 14 minutes at NASA's Dryden Flight Research Center at Edwards Air Force Base, Calif., reaching airspeed of 195 knots (224 mph, 361 kph) and altitude of 7,500 feet (2286 meters). Flight characteristics and basic aspects of aircraft operations, particularly the command and control link between the aircraft and the mission-control station, were demonstrated successfully. In April 2004, the X-45A test flights included a precision weapon drop in with a 250-pound inert weapon released from its internal weapons bay, and the first unmanned, autonomous multi-vehicle flight in August 2004 under the control of a single pilot. Flight tests were successfully concluded in 2005. Team ManTech supported the UCAV and J-UCAS programs from 2004 to 2007 by providing scientific, engineering, and technical assistance with stability & control, systems engineering, and flight test support SMEs.

https://www.boeing.com/news/frontiers/archive/2002/june/i_pw2.html

Exhibit 4: The Boeing X-45A UCAV took to the skies above the Mojave Desert, marking the maiden flight of the world's first such plane built specifically for combat.

DARPA Oblique Flying Wing: In 2005 ManTech began support for DARPA's Oblique Flying Wing X-plane demonstrator, known as the Switchblade, envisioned to become the first-ever flight tests of a tailless, supersonic, variable sweep oblique flying wing. Leveraging technologies and flight test data from NASA's AD-1, the proposed radical aircraft was to be a flying wing that could be asymmetric swept in flight. The design concept was believed to give it a unique combination of high speed, long range, and extended endurance. The program hoped to produce data to be used when considering future military aircraft designs. Wind tunnel tests and the aircraft design were completed. The design was noted to be "workable and robust," but the program was cancelled, citing difficulties with flight control systems. Team ManTech provided SMEs from 2006 to 2010 to conduct R&D, develop the concept, and provide stability & control, systems engineering and ground test support. https://en.wikipedia.org/wiki/Oblique_wing#DARPA_Oblique_Flying-Wing_(OFW)_Project

Exhibit 5: Artist rendering of the radical oblique flying wing design.

DARPA Solar Powered UAS Vulture: In 2006 ManTech supported the DARPA's Vulture program which helped developed critical enabling technologies for an Unmanned Aerial System (UAS) to remain on-station, uninterrupted for more than five years by harvesting solar energy. One of Vulture's goals was to advance energy storage system technologies to ultimately enable a re-taskable, persistent pseudo-satellite capability in an aircraft package. Team ManTech provided SMEs from 2006 to 2016 to conduct R&D, develop the concept, and provide systems engineering, provide airworthiness analysis, ground test, project management, budget, and administrative support. The program was eventually cancelled but resulted in many solar cell and energy storage breakthroughs. https://www.darpa.mil/program/vulture

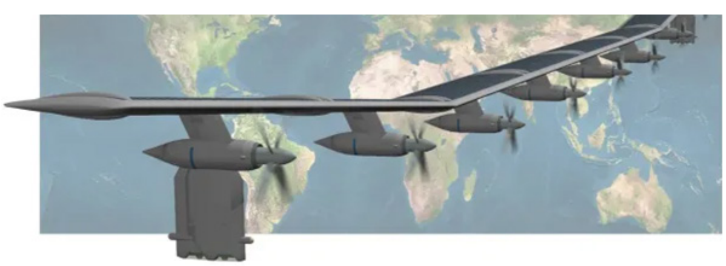

Exhibit 6: An artist rendering of Vulture.

DARPA ALASA Program: In 2011 DARPA began the Airborne Launch Assist Space Access (ALASA) program with the goal to develop a significantly less expensive approach to routinely launching small 100-pound satellites into LEO within 24 hours of call-up, for less than $1 million per launch. ALASA leveraged radical advances in launch system technology to develop complete launch vehicles that require no recurring maintenance and support along with no specific integration to prepare for launch. The program resulted in a viable system design with an expendable launch vehicle from an F-15E fighter aircraft. Serving as a reusable first stage, the F-15E would fly to high altitude and release the launch vehicle, which would carry the payload to the desired location in LEO. The launch vehicle technology demonstrator incorporated commercial-grade avionics, advanced composite structures and a novel propulsion system utilizing a new monopropellant that combines nitrous oxide (N2O) and acetylene without the need for a separate oxidizer such as liquid oxygen. The program established and demonstrated procedures to mix, store, transfer and use the monopropellant. The N2O-acetylene mix, called NA7, is extremely energetic, however, and the challenges of working with it as a practical rocket propellant have yet to be surmounted. In 2015, DARPA conducted four subscale static tests of the propulsion system on test stands. Two tests resulted in explosions due to the "finicky" nature of the NA7 propellant. These tests were anomalous and pointed to the need for additional tests as part of refining the engine design and assessing the viability of the mix for use as a safe monopropellant. In 2015 DARA rescoped the program by ceasing development of the ALASA launch vehicle technology demonstrator and focusing on the monopropellant safety testing and certification. Team ManTech supported the program from 2011 to 2018 by providing Scientific, Engineering, and Technical Assistance support with individual SMEs in systems engineering, propulsion, chemistry, guidance, navigation, control, airworthiness, launch, RMA, avionics, and test & evaluation. https://www.darpa.mil/program/airborne-launch-assist-space-access

Exhibit 7: An artist rendering of the ALASA concept.

ALASA Concept video: https://www.youtube.com/watch?v=BOaJWoVLhAc

Aerial Reconfigurable Embedded System: In 2012 ManTech began support of DARPA's Aerial Reconfigurable Embedded System (ARES) program whose goal was to develop a vertical takeoff and landing (VTOL) flight module designed to operate as an unmanned platform capable of transporting a variety of payloads. The ARES VTOL flight module was designed to have its own power system, fuel, digital flight controls and remote command-and-control interfaces. Twin tilting ducted fans would provide efficient hovering and landing capabilities in a compact configuration, with rapid conversion to high-speed cruise flight. The flight module would travel between its home base and field operations to deliver and retrieve several different types of detachable mission modules, each designed for a specific purpose like cargo resupply, casualty evacuation and ISR. ARES was designed with a future path towards semi-autonomous flight systems and user interfaces for optionally manned/controlled flight. Team ManTech provided SME support from 2012 to 2018 to conduct R&D, develop the concept, and provide systems engineering, vibration, airworthiness analysis, ground test, project management, budget, and administrative support. The program was eventually cancelled. https://www.darpa.mil/program/aerial-reconfigurable-embedded-system

Exhibit 8: An artist rendering of ARES.

ARES Concept Video: https://www.youtube.com/watch?v=bj_poqLMLyI

DARPA Experimental Space Plane: In 2012 ManTech began support to DARPA's Experimental Space Plane (XSP) program whose goal was to build and fly the first of an entirely new class of hypersonic aircraft that would provide short-notice, low-cost access to space. DARPA envisioned a fully reusable unmanned vehicle, roughly the size of a business jet, which would take off vertically like a rocket and fly to hypersonic speeds. The vehicle would be launched with no external boosters, powered solely by self-contained cryogenic propellants. Upon reaching a high suborbital altitude, the booster would release an expendable upper stage able to deploy a 3,000-pound satellite to polar orbit. The reusable first stage would then return to Earth, landing horizontally like an aircraft, and be prepared for the next flight, potentially within hours. Team ManTech provided SMEs from 2012 to 2019 to conduct R&D, develop the concept, provide systems engineering, propulsion, stability & control, airworthiness analysis, ground test, project management, budget, and administrative support. The program was eventually cancelled but demonstrated many critical technologies to include 10 successful AR-22 (RS-25) engine firings within 240 hours to prove propulsion readiness for launch on demand with rapid turnaround. https://www.darpa.mil/program/experimental-space-plane

Exhibit 9: An artist rendering of the Experimental Space Plane.

XSP concept video: https://www.youtube.com/watch?v=9AkXp4VSB0k

DARPA Gremlins X-61A: ManTech began support of the DARPA X-61A Gremlins program in 2014 whose goal is to demonstrate air launch and air recovery of four Unmanned Aerial Vehicles (X-61A Gremlins Air Vehicles) within 30 minutes. Gremlins should dramatically expand potential uses of unmanned air vehicles in conflict situations. Gremlins Air Vehicles (GAVs) are being designed to be equipped with a variety of sensors and other mission-specific technologies and be launched from various types of military aircraft. After air retrieval of GAVs, they would be transported back to the ground where crews could prepare them for another mission within 24 hours. Team ManTech provided SME support from 2014 to 2020 to conduct R&D, develop the concept, and provide systems engineering, airworthiness analysis and flight test support. The program is ongoing and in the final phases of flight test. https://www.darpa.mil/news-events/2020-12-10

Exhibit 10: October 2020 flight test over Dugway Proving Grounds, a X-61A Gremlins drone flies behind a C-130 during retrieval tests (DARPA).

DARPA's MISSION NEED

DARPA's singular and enduring mission is to make pivotal investments in breakthrough technologies for national security. DARPA explicitly reaches for transformational change instead of incremental advances. DARPA has created many breakthrough technologies that have revolutionized defense, including stealth, unmanned aerial systems, and precision-guided munitions. Many DARPA-developed technologies have had sweeping societal and economic impacts, including portable GPS receivers, new types of computer chips, voice-recognition software, interactive and personal computers, and, most famously, the ARPANET and its successor, the internet. DARPA does not respond to validated requirements, but perceived needs. DARPA works within an innovation ecosystem that includes academic, corporate, and governmental partners, with a constant focus on the Nation's military Services, which work with DARPA to create new strategic opportunities and novel tactical options. DARPA benefits greatly from special statutory hiring authorities and alternative contracting vehicles that allow the Agency to take quick advantage of opportunities to advance its mission. These legislated capabilities have helped DARPA continue to execute its mission effectively.

DARPA's success has been attributed to the pursuit of ambitious goals, using temporary project teams with project time limits, and remaining independent. DARPA has an unwavering commitment to Pasteur's Quadrant pushing the frontiers of basic science to solve a well-defined, use-inspired need. Since DARPA doesn't have any laboratories of its own and uses teams of contractors, such as ManTech, to provide scientific, engineering, and technical assistance.

MANTECH RESPONSE

ManTech provides Scientific, Engineering and Technical Assistance (SETA) support to DARPA through a robust team of employees and a network of +70 subcontractors to support niche and highly technical disciplines. Like DARPA, ManTech is forward thinking by building teams who instill a culture of teamwork, dedicated work ethic, attention-to-detail, flexibility, and proactivity. ManTech's program managers are good stewards of DARPA's precious resources with an ethos of delivering on time as promised and within budget. Our systems engineering processes is specifically tailored to DARPA's disciplined risk managed approach, steeped with intelligent agile processes, and augmented by decades of lessons learned. To remain relevant, we maintain strong relationships with DARPA's Government partners, UARCs, FFRDCs, and academia to garner their commitment through trust, common interests, and vision.

SUMMARY

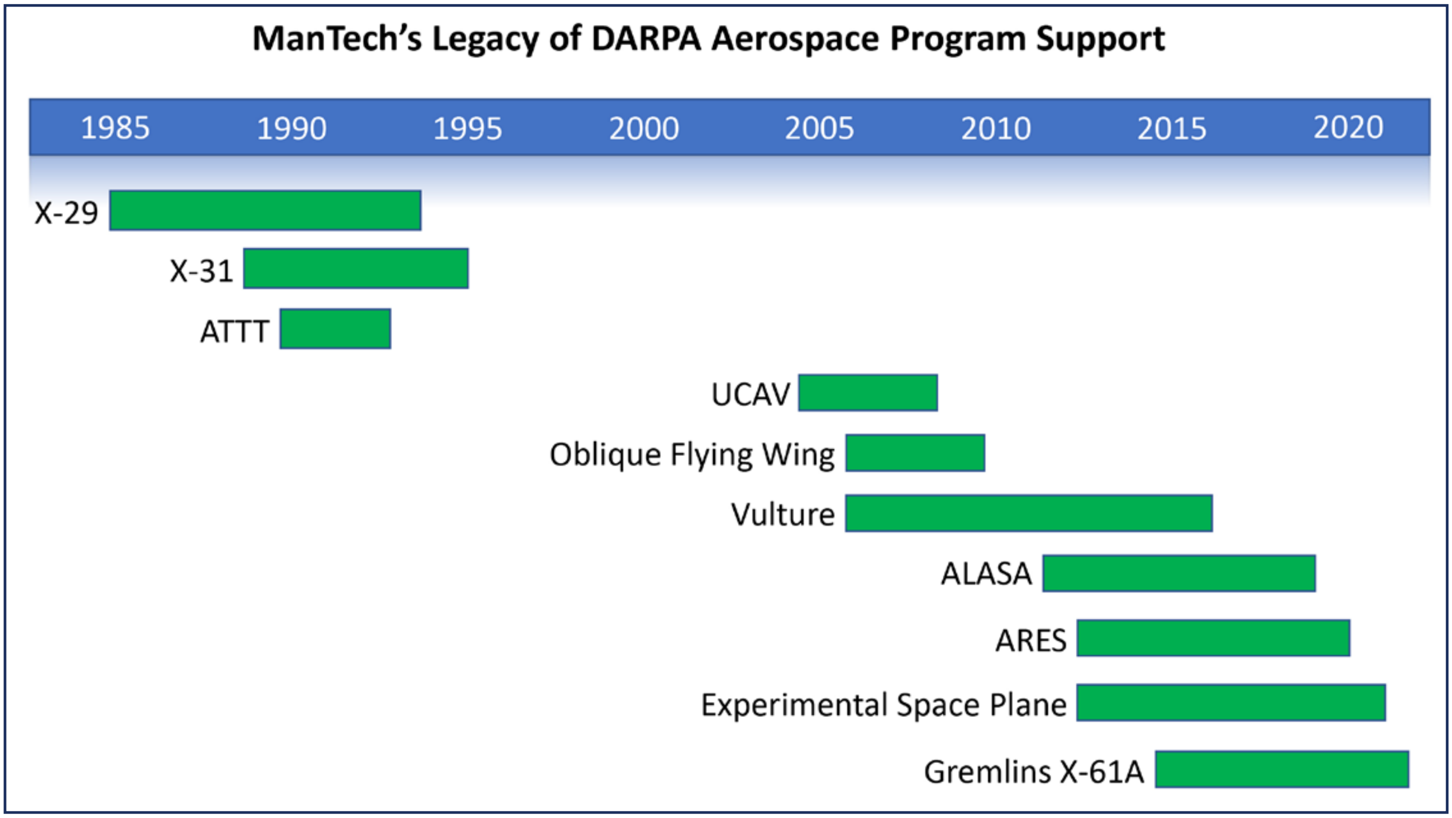

Exhibit 11: ManTech's Involvement in revolutionary aerospace programs.

History shapes, guides, and defines us. These DARPA programs inspired the innovative culture we are known for and shapes our destiny. DARPA and ManTech share common values and have a passion for being at the cutting edge of technology. Our people, processes, tools, and experience are keys to our success at DARPA. To stay at the forefront, ManTech embraces our pioneering culture; strategically plans for innovation; will continue to nurture and take care of our people; and will continuously evolve our processes and tools. ManTech does this while securing our future.

LEARN MORE
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