DARPA

STEALTH

Advancing National Security Through Fundamental Research

STEALTH

THE NEED AND OPPORTUNITY

A moth disappears against the bark of the tree on which it has landed. An octopus vanishes as its skin assumes the pattern and texture of its surroundings. That's stealth of an ancient and biological kind. Military stealth, in the form of reducing the "signature," or apparent presence, of assets like ships and planes, is way newer, but it has proven to be a transformative capability.

The history of such signature management goes back over 100 years, beginning with camouflage designs on warships and later on aircraft and submarines. During World Wars I and II, engineers tried to reduce both visual and radar signatures, but it wasn't until the late 1970s when Lockheed's "Skunk Works" produced the A-12 (Oxcart)/SR-71 (Blackbird) reconnaissance aircraft that the strategic and tactical power of reducing an aircraft's radar cross section (RCS) was realized. The A-12/SR-71 designs employed radar-absorbing coatings and RCS reduction in the structural edges of the airframe, but a decade would pass before engineers would take signature management on aircraft to higher levels of sophistication.

In 1974, the Department of Defense (DoD) hosted a Defense Science Board (DSB) study that identified the proliferation of advanced, networked air-defense systems as a significant threat to U.S. aircraft. In war-game exercises, a Soviet invasion across the Fulda Gap in Europe led to the conclusion that without some game-changing capabilities for making aircraft more survivable amidst the new threats, U.S. and NATO forces would find victory extremely difficult to achieve.

Shortly after the DSB study, the director of Defense Research and Engineering, Dr. Malcolm Currie, issued a memo stating that the level of innovation coming out of DoD research was inadequate, and he invited organizations to propose radical new ideas. Robert Moore, deputy director of DARPA's Tactical Technology Office (TTO), championed the idea of a "high-stealth aircraft." Based on the DSB study and with support from the Office of the Secretary of Defense, DARPA began its journey to develop the suite of technologies it would take for aircraft to fly with substantially lower RCS than ever before.

THE DARPA SOLUTION

DARPA challenged five U.S. aircraft companies to examine two questions. First, what were the radar signature thresholds that aircraft would have to achieve to be essentially undetectable at an operationally useful range? And second, what were the capabilities of each company to design and build an aircraft with the necessary signatures? By January 1975, DARPA had down-selected the five contenders to McDonnell Douglas and Northrop to design a stealthy aircraft. Unaware at the time of Lockheed's work on the A-12 and SR-71, DARPA had not invited the company to join the competition. After the CIA cleared the way for Lockheed to discuss the A-12 with DARPA director George Heilmeier, however, he allowed Lockheed to participate in the study with a $1 contract.

The objectives of the Experimental Survivable Testbed (XST), as the program was known, were to identify precisely the signature traits that would permit an aircraft to avoid radar detection and to define a pathway for delivering that capability. McDonnell Douglas was the first to identify what appeared to be appropriate RCS thresholds. Although the company was unable to design an aircraft with the specified RCS, DARPA adopted the thresholds as a goal of the program.

The basis for Lockheed's design was a computer program known as Echo 1, which allowed designers to predict radar return signals. Echo 1 was limited to calculations in only two dimensions, leading designers to a faceted design rather than a smooth, seamless one.

DARPA eventually selected Lockheed and Northrop to continue in the program and to construct one-third and full-scale nonflying models for testing on a radar range to see which design would best meet DARPA's criteria for high-stealth aircraft. Following the tests, DARPA awarded Lockheed the contract to build two demonstrator aircraft. Both test vehicles made use of commercial components, but their shaping and materials were so important that their impact on aircraft survivability changed the way the U.S. Air Force fights.

THE IMPACT

Through the XST program, DARPA nurtured technologies including RCS reduction, radiation-absorbent material development, infrared shielding, reduced visual signatures, low-probability-of-intercept radar, inlet shielding, and exhaust cooling and shaping. Lead responsibility for the program transitioned from DARPA to the U.S. Air Force Special Projects Office. That's when the program became known as Have Blue.

In 1977, DARPA and the U.S. Air Force awarded a contract to Northrop to develop the Battlefield Surveillance Aircraft Experiment program. Later known as Tacit Blue, the aircraft that emerged from the program was unique in its approach to airborne radar integration: rather than integrating an existing airframe around the aircraft's radar system, the design of Tacit Blue's airframe was driven by the radar system that its missions called for. What's more, Tacit Blue represented the first successful use of curved surfaces to achieve signature reduction. The resulting aerodynamic benefit was instrumental in achieving lower drag, higher speeds, and longer endurance.

Have Blue led directly to the Air Force's procurement of the F-117 stealth fighter. Tacit Blue laid the foundation for the Air Force's B-2 stealth bomber. The F-117 Nighthawk stealth aircraft flew its first combat mission in 1989 and was one of the transformational technologies employed during

Have Blue, the first practical combat stealth aircraft, made its first test flight by the end of 1977.

Operation Desert Storm. The B-2 stealth bomber debuted in 1989, became operational in 1997, and flew its first combat mission in 1999.

LOOKING AHEAD

The advent of stealth technology revolutionized air warfare, propelling the United States decades ahead of potential adversaries. Russia flew its first stealth combat aircraft, the Su-57, in 2010. However, delivery to the Russian air force, though slated for 2020, had yet to occur as of the writing of this article in June. China's stealth aircraft first flew in 2011 and went into service in 2018.

In the United States, stealth technologies are incorporated into a wide range of current weapon systems, including missiles, helicopters, ships, and ground vehicles. For example, DARPA's studies under the Teal Dawn program in the early 1980s eventually resulted in the Advanced Cruise Missile. Also, lessons learned from the Sea Shadow, a faceted ship that demonstrated stealth technologies at sea, are reflected in the design of DDG 1000 Zumwalt-class ships.

Since the beginning of DARPA's push for low-observable technologies in the 1970s, the field has continued to deliver ever more stealth capability for the U.S. armed forces. For the U.S. Air Force, stealth technologies have made aircraft such as the F-22 Raptor and F-35 Lightning II possible. These fifth-generation stealth aircraft can easily penetrate heavily defended areas and destroy targets while maintaining air dominance. Unmanned stealth aircraft such as the X-45 and the X-47 have proven other key technologies in the quest for ever more powerful airborne stealth.

From the 1974 initiation of the XST to the combat vehicles of tomorrow, the impact of DARPA's stealth revolution is evident on the world stage. From aircraft to munitions, ships, and even ground systems, the design of weapon systems has been transformed.

A restored Tacit Blue makes its way in 2015 to its then new home at the National Museum of the U.S. Air Force. (U.S. Air Force photo by Ken LaRock)

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