DARPA'S STEALTH REVOLUTION

NOW YOU SEE THEM...

By Ian A. Maddock

F-117 stealth fighter aircraft of the 37th Tactical Fighter Wing stand on the flight line with canopies raised following their return from Saudi Arabia, where they took part in Operation Desert Storm. The first operational stealth aircraft, the F-117 captured the public imagination but was relatively primitive technology when contrasted with today's F-22 and F-35 "stealth" fighters.

Sgt. Mike Baquette

Low observable technology, widely known to the world as stealth, aims to reduce as much as possible the infrared, visual, acoustic, and radar signatures emitted by vehicles, whether they are seaborne, airborne, or on the ground. DARPA has been instrumental in developing the technologies necessary to achieve these goals.

EARLY EFFORTS

The history of signature management goes back over 100 years, beginning with camouflage designs on warships and later being applied to aircraft and eventually to submarines as well.

During World Wars I and II, attempts were made to reduce visual and even radar signatures, but it wasn't until Lockheed's "Skunk Works" produced the A-12/SR-71 aircraft that any success was gained in reducing an aircraft's radar cross section (RCS). The A-12/SR-71 employed radar-absorbing coatings and RCS reduction in the structural edges of the airframe, but a decade would pass before signature management was again attempted on an aircraft.

THE STEALTH REVOLUTION BEGINS

In 1974, the Department of Defense (DoD) hosted a Defense Science Board (DSB) study that identified the proliferation of advanced networked air defenses as a significant threat to U.S. aircraft. Wargaming a Soviet invasion across the Fulda Gap in Europe led to the conclusion that without some game-changing capabilities, U.S. and NATO forces would find victory extremely difficult.

Shortly after the DSB study, 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) nominated 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 technologies for aircraft with a substantially lower RCS than had ever been developed before.

U.S. Air Force photo

Above: Northrop Grumman's TACIT BLUE aircraft contributed to the development of the B-2A Spirit stealth bomber and E-8 Joint STARS' radar. It was known affectionately as "the whale" because of its shape. Right: Lockheed Martin's HAVE BLUE prototype featured a "faceted" stealth design and inward canted vertical stabilizers that were later revised into the "butterfly" tail of the F-117A.

Courtesy of DARPA

Ken Perko, who had worked in the Air Force's System Program Office for reconnaissance drones, became a TTO program manager. A study began of whether a manned stealth aircraft could be produced. Perko asked five U.S. aircraft companies to examine two questions. First, what were the signature thresholds that an air vehicle 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?

Only Grumman, Northrop, and McDonnell Douglas addressed the issue of signature reduction. Grumman's design wasn't competitive, and so in January 1975, DARPA issued contracts to McDonnell Douglas and Northrop to design a stealthy manned aircraft.

Management at Lockheed's Skunk Works soon learned of the DARPA competition. Lockheed had not been invited to participate because they had not produced a fighter in nearly 20 years and DARPA was unaware of their work on the A-12/SR-71 aircraft. The CIA allowed Lockheed to discuss the A-12 with DARPA Director George Heilmeier, who then allowed Lockheed into the study under a $1 contract – perhaps the best dollar that the U.S. government has ever spent!

The objectives of the Experimental Survivable Testbed (XST) – as it became to be known – were to identify precisely the signature levels that would permit an aircraft to avoid radar detection and to define an approach for achieving levels of reduction in RCS and other signatures. McDonnell Douglas was the first to identify what appeared to be appropriate RCS thresholds (although it couldn't design an aircraft to meet those values). DARPA used these thresholds as the program goals.

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

DARPA eventually chose Lockheed and Northrop to continue in the program and to construct one-third and full-scale pole models, which were then tested on a radar range to see which company best met DARPA's criteria for a high-stealth aircraft. Following the

DARPA's involvement in stealth technologies has made aircraft such as the F-22A Raptor possible. The F-22 combines stealth, supercruise, maneuverability, and many other features enabling a first-look, first-shot, first-kill capability that will provide continued air dominance for generations to come.

Photo by TSGT Michael Ammons, USAF

results of the "Pole Off," Lockheed was awarded the contract to build two demonstrator aircraft. Lead responsibility for the program was transitioned from DARPA to the U.S. Air Force Special Projects Office, and the program became known as HAVE BLUE.

Under HAVE BLUE, Lockheed built two manned technology demonstrators to validate Lockheed's pole model results. Even though these test vehicles made use of conventional off-the-shelf components and subsystems, they were truly revolutionary. Their shaping and materials were so important that their impact on aircraft survivability changed the way the U.S. Air Force fights. Technologies nurtured by DARPA included RCS reduction, RAM development, infrared shielding, reduced visual signatures, low-probability-of-intercept radar, inlet shielding, exhaust cooling and shaping, and other signature reduction disciplines. First flight occurred in April 1977, and both aircraft were tested extensively. Eventually both were lost during flight test mishaps, but the results were clear. On Nov. 16, 1978, Lockheed received a contract for full-scale engineering development of what would become the F-117.

In December 1976, DARPA and the U.S. Air Force initiated the Battlefield Surveillance Aircraft-Experimental (BSAX) program. The BSAX program's goal was to develop an efficient stealth reconnaissance aircraft with a low probability of intercept radar and other sensors that could operate close to the forward line of battle with a high degree of survivability.

Northrop began work in 1976 and was awarded a sole-source contract in 1977 for development of the BSAX aircraft. The BSAX aircraft, later known as TACIT BLUE, was unique in its approach to airborne radar integration, where the airplane was created around the radar instead of integrating a radar with an existing airframe. TACIT BLUE first flew in February 1982 and accumulated 135 flights (300-plus flight hours) over the next three years, often flying three to four flights weekly and on several occasions flying more than once a day. TACIT BLUE validated a number of innovative low observable developments and represented the first successful use of curved surfaces to achieve signature reduction instead of the two-dimensional approach employed on HAVE BLUE. The resulting aerodynamic benefit was instrumental in achieving lower drag and resultant higher speeds and longer endurance. According to the Air Force, "TACIT BLUE was one of the most successful technology demonstrator programs in Air Force history, meeting all program objectives and most low observable and sensor performance goals." The program's radar development also led to the E-8 Joint Surveillance Target Attack Radar System (Joint STARS).

TACIT BLUE contributed directly to the development of the B-2A Stealth Bomber. Stealth aircraft were first used in combat in 1989. Since then, they have revolutionized aerial warfare. F-117s and B-2s have dominated the skies over the Balkans, Afghanistan, and Iraq. The stealth revolution transformed military aircraft airframe design and development and led to major changes in industry leadership in fighter research and development.

Stealth technologies have also been applied to a wide range of weapon systems, including missiles, helicopters, ships, and even ground vehicles. DARPA's studies under their Teal Dawn program eventually resulted in the Advanced Cruise Missile. And the Sea Shadow was a faceted ship that demonstrated stealth technologies at sea. The lessons learned from Sea Shadow have been directly incorporated in the DDG 1000 Zumwalt-class ships and will benefit ship design into the foreseeable future.

THE REVOLUTION CONTINUES

Since the beginning of DARPA's involvement in low observable technologies in the 1970s, incredible advancements have been made in the field. Most recently these technologies have made other programs possible that are revolutionizing the military capabilities of 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 airborne stealth.

From the 1974 initiation of the XST to the combat vehicles of tomorrow, the impact of DARPA's stealth revolution is undeniable. From aircraft to munitions, ships, and even ground systems, the design of weapon systems will never be the same due to DARPA's innovations.