American aircraft designers began discussing applying stealth technology to airplanes in the 1940s. But it was not until the 1950s that they actually began designs that took into account an airplane's radar signature. The U-2 spyplane, which was started in late 1954 by Lockheed Aircraft under a contract with the Central Intelligence Agency (CIA), was intended to be stealthy largely by flying at a very high altitude. Its designers expected that Soviet air defense radar would not be capable of detecting aircraft that high, although U.S. radar certainly could. The designers were wrong about Soviet radar, however, and the first U-2s to fly over Soviet territory were immediately detected. This prompted U.S. radar and aircraft experts to evaluate a number of ways to reduce the radar signature of the airplane. Because the U-2's shape was already established, they focused on adding things to the airplane that would absorb or scatter the radar energy that reached the plane. These included a fine wire mesh that was molded over the plane and covered with a paint that contained iron, and wires strung from the nose to the tail. However, none of these efforts reduced the airplane's radar signature very much, some of them significantly reduced its performance, and all were abandoned.

In 1958, the CIA began studying a replacement for the U-2 that could fly at speeds above Mach 3. This aircraft, soon named OXCART (possibly an inside joke because it implied a vehicle that moved very slowly), was intended to fly very fast and very high. It would also have a small radar signature, meaning that it would appear as a very small object on a radar screen. Its designers hoped that its small size and high speed, so that it would move a great distance between each pass of the radar beam, would cause radar operators to think the radar blip was only "noise" in the radar signal. The single-pilot OXCART, which was also designated the A-12 and built by Lockheed, had a number of radar-reducing features. It was coated with special materials that absorbed radar energy. Designers also developed parts of its structure to "trap" radar energy and prevent it from traveling back to its source. In addition, they added a chemical to the aircraft's special fuel to reduce its radar signature. Overall, the OXCART had a relatively small radar signature, but it was still visible on radar. The Air Force soon developed the two-seat Lockheed SR-71 Blackbird based on the OXCART design, and the Lockheed D-21 TAGBOARD reconnaissance drone. Both aircraft incorporated stealthy features.

During this time—the late 1950s and early 1960s—aircraft designers and defense planners in the United States were extremely aware of the importance of an aircraft's radar signature to its survivability. North American Aviation's Mach 3 B-70 Valkyrie bomber was canceled in 1961 because, among its other many problems, it had an enormous radar signature and could be spotted on radar a great distance away. The U.S. Army and CIA developed what could be considered a stealthy helicopter during the Vietnam War. There, they were primarily interested in reducing the amount of noise that the helicopter generated, and they named the helicopter The Quiet One. Reducing the heat an aircraft generates is also important, and most battlefield helicopters include systems like mufflers to reduce the heat coming from the engine exhaust. Stealthy characteristics were incorporated into some small planes, but they were not heavily applied to aircraft during the 1960s. This was primarily because significantly reducing radar reflections was very difficult to model mathematically.

The Arab-Israeli war of 1973 startled many U.S. Air Force leaders because a large number of Israeli aircraft were shot down by Russian-built surface-to-air missiles in a very short period of time. The experience in Vietnam had earlier also prompted Defense Department leaders to seek new aircraft that were not so susceptible to attack from surface-to-air missiles. They realized that any conflict with the Soviet Union could result in a large portion of the U.S. Air Force being shot down in the early days of the war. This prompted them to begin looking for ways to avoid this.

In the 1970s, a U.S. mathematician working for Lockheed Aircraft used a mathematical model developed by Russian scientist Pyotr Ufimtsev to develop a computer program called Echo 1. Echo made it possible to predict the radar signature an aircraft made with flat panels, called facets. In 1975, Lockheed Skunk Works engineers determined that an airplane with faceted surfaces could have a remarkably low radar signature because the surfaces would radiate 99.9 percent of the radar energy away from the receiver. They built a model called "the Hopeless Diamond" because it looked like a squat diamond and looked too hopeless to ever
Stealth Aircraft

The B-2 is a multi-role advanced technology bomber with stealth characteristics. The B-2's low observable, or stealth, characteristics give it the ability to penetrate an enemy's most sophisticated defenses. The low observability traits of the B-2 include greatly reduced infrared, acoustic, electromagnetic, visual and radar signatures.

In early 1977, the Defense Advanced Research Projects Agency (DARPA) gave Lockheed a contract to build and test two subscale models (about 60 percent of the size of an operational airplane) of a stealthy aircraft. The contract was known as Have Blue and was highly classified. Lockheed's plane looked like a squat pyramid with wings and two tails angled inward. When designers placed it on a tall pole outdoors and pointed a radar at it, it was virtually invisible. But they still wondered if it would fly. One Lockheed document stated that the "airframe exhibits just about every mode of unstable behavior possible for an aircraft—the only thing it doesn't do is tip back on its tail when it is parked."

Have Blue was not inherently stable in flight and would tumble out of control. But fortunately, computers also rendered this fact irrelevant, because aircraft designers for several years had been designing planes, like the F-16 fighter, that were kept stable by computers that constantly adjusted their flight controls in the same way that a person riding a bike is constantly making minute corrections to remain balanced. This same solution was applied to the Have Blue airplane. Lockheed engineers soon developed the Have Blue into a larger bomber aircraft given the designation F-117. Despite being designated a "fighter," the plane was always intended only to drop bombs, not fight other aircraft.

For the first time, every aspect of the F-117 was designed around stealth. For the plane's designers, reducing the radar signature was similar to the way that airplane designers of the 1920s had reduced drag: they identified the biggest causes of the problem and then eliminated them one by one. The cockpit, which is essentially a cavity that reflects radar in much the same way that an animal's eyes reflect light from a flashlight at night, was sharply angled and coated with a reflective material that deflected the radar energy in different directions. The airplane had no radar and its sensors and antennas could be retracted into the fuselage. The bombs, a major source of radar reflection on most airplanes, were stored internally in a bomb bay so that they reflected no radar energy. The inlets for the jet engines were covered with fine screens to prevent radar energy from reaching the face of the engine turbines. The exhaust was channeled through long narrow ducts lined with heat-absorbing material so that it was cooler by the time it exited the plane and therefore did not show up as well on heat detectors.

Five F-117 development aircraft were built and tested between 1981 and 1982. The first F-117 squadron was declared operational in 1983. Lockheed built a total of 59 F-117s for the Air Force. The F-117 was a highly secret aircraft during most of the 1980s. It was finally unveiled in 1989 and became famous in 1991 when it was used in heavily defended skies over Iraq during the Persian Gulf War. In 1999, an F-117 was shot down by a Russian-built missile over Yugoslavia, demonstrating that stealth was not invincible.

Although the F-117 is the most famous stealth aircraft, it was not the only one. Other stealth aircraft were designed and built during the 1980s. A weird and ugly-looking plane designated the Tacit Blue was built by Northrop and flown several times during the 1980s. It looked like an upside down bathtub with wings. Its purpose was to evaluate the possibility of flying behind enemy lines, but the plane proved difficult to fly and its mission soon proved unnecessary. The sole prototype was kept secret for years until it was finally placed in a museum. In the late 1980s, the U.S. Navy sought to develop an attack bomber designated the A-12 Avenger II (not to be confused with the A-12 OXCART), but it was never completed before it was canceled. Several drone aircraft, such as Lockheed's failed DarkStar, and Teledyne Ryan's semi-stealthy GlobalHawk, were also developed. During the 1990s the Army began development of the Sikorsky/Boeing RAH-66 Comanche helicopter, which incorporated technologies to reduce its radar and heat signature. The most successful stealth aircraft next to the F-117 is the B-2 Spirit bomber, first started in the late 1970s and not finished until the 1990s.

The B-2 bomber, which is much larger than the F-117, actually has an even smaller radar cross-section. Unlike the F-117, it is not angular. This was due to increasing computer power, which allowed designers to develop aircraft with smooth, rounded surfaces that achieved the same results as the flat, angled surfaces of the F-117. The F-22 Raptor interceptor, which first flew in the early 1990s, and the Joint Strike Fighter (JSF), also share these characteristics. The French Rafale and European Eurofighter/Typhoon also have stealth features.

--Dwayne A. Day

Sources and Further Reading:

http://www.centennialofflight.gov/essay/Evolution_of_Technology/Stea...


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