Swept Wings and the B-47 Bomber

Sometimes technological advances are developed by one country and quickly adopted by another country that is more capable of using them in a process known as technology transfer. That is the case for swept wings, which are now common to almost all jet airliners, military jets, and all high-performance aircraft. Although a number of people had thought about them in the years before World War II, it was the German aeronautical engineers of the early 1940s who first proved that swept wings were useful, which appeared on the Messerschmitt Me 262 jet fighter. The United States Air Force in the post World War II era quickly adopted the technology and transferred it successfully to jet aircraft.

This was most particularly seen in the process of development that led to the jet bomber, the B-47. In the spring of 1944, the Bomber Project Office at Wright Field, near Dayton, Ohio, issued a requirement for a new jet bomber for the Army Air Forces (AAF). It had to be capable of flying faster than 500 miles an hour (805 kilometers per hour) at an altitude over 40,000 feet (12,192 meters) and a distance (or range) of 2,500 miles (4,023 kilometers) without refueling. These were ambitious requirements, but three manufacturers replied to the request. One of these was Boeing, which at the time was building the most advanced bomber of the war, the B-29 Superfortress. Boeing produced a design study named the Model 424. In simple terms, this was really little more than an existing bomber design with jet engines fitted in place of piston engines. The engines were mounted in pods below a thin, straight wing mounted high on the fuselage. Other companies submitted similar designs.

While Boeing was working on this design, World War II continued to rage in Europe. During the war, Nazi Germany conducted much advanced scientific research in many fields. Although the Germans did not achieve great breakthroughs in radar or atomic weapons, they did develop impressive aeronautical vehicles, including the world's first operational jet fighter, the Messerschmitt Me 262, and the first long range ballistic missile, the A4 (more popularly known as the V-2). As the war was winding down, the commanding general of the U.S. Army Air Forces, General Henry H. "Hap" Arnold, asked the famed aerodynamicist Theodor von Karman to lead a group of top scientists and engineers to Germany to learn about its technological advances.

In the spring of 1945, these engineers went to Europe. They followed closely behind the combat troops, so that they could be the first to discover the German technology, which they wanted to obtain before the Russians did. One of the people in this group was Boeing's chief aerodynamicist, George Schairer, who at the time was working at the Pentagon and was not connected to Boeing's Model 424 effort. Shortly before he left the United States, Schairer became aware of a proposal for "wing sweepback," which involved angling the wings back from their connection at the fuselage instead of extending them straight out.

Swept-back wings were not a new idea. Even before World War I they had occasionally been used as a way to shift an airplane's center of gravity to solve balance problems. W. Starling Burgess had used triangular fins attached to the upper wing on his 1910 biplane to give it inherent lateral stability. In 1939 a German engineer named Ludwig Bülkow and Dr. Albert Betz tested swept wing models for airplane manufacturer Messerschmitt in a wind tunnel. The tests demonstrated that such wings would allow airplanes to reach higher speeds. The results of these tests led the company to continue testing on swept-back wings throughout the war. When Schairer arrived at the Aeronautical Research Institute in Brunswick, Germany, he discovered these studies. Other research on wing sweepback was also conducted by the German companies Arado and Junkers.

In the United States, NACA engineer Robert Jones had discovered the concept of swept-back wings in January 1945, conducted wind tunnel tests in March, and published his results in May. But it took confirmation from the Germans before anyone went ahead with the idea. Once the German results proved that the benefits were real, Schairer immediately wrote a letter to Boeing about the results and provided a calculation for a wing with 29 degrees of sweep that clearly demonstrated the potential benefits.

Boeing's straight-wing Model 424 received a further study contract from the AAF, as did several of its competitors. But the plane's designers realized that they needed to make a number of modifications to reduce drag, such as moving the engines from the wings to the upper fuselage. They were in the midst of these modifications to their design when Schairer's letter arrived. Almost immediately they began...
modifying a model, which they were testing in their high-speed wind tunnel (Boeing owned the only private high-speed wind tunnel in the United States; the other two high-speed tunnels belonged to the government). They took their new design, now known as the Model 432, and calculated what angle of wing sweep would work best. With only limited data to work with, they decided upon 35 degrees.

Boeing engineers quickly produced a new model with the 35-degree swept-back wings, which they designated Model 448. It had thin, flexible wings angled back 35 degrees from the fuselage and horizontal stabilizers swept at the same angle. It had a vertical fin swept at 45 degrees. The engines were still mounted above the fuselage. When they presented the design to the Project Office in October 1945, the Air Force rejected it immediately because of the engine location, which was too close to the fuselage and which posed a fire danger. The AAF directed that the engines be mounted on the wings, away from the fuselage.

Boeing engineers went back to the drawing board. They faced a dilemma: how to mount the engines to the wings without creating a large amount of drag from the interaction of the airflow over the engines and the wings. They came up with a simple and elegant solution. They mounted the engines below the wings in pods mounted on thin struts that angled forward. This eliminated the drag problem, and because the engines were far from the fuselage, the fuselage could be slimmed down, further reducing drag. Each wing had two nacelles, with the outer nacelle holding a single engine and the inner nacelle containing two engines side by side. Boeing designated the new design the Model 450.

One final problem was left to overcome—how to mount the landing gear. The usual approach was to mount the gear inside the engine nacelles, but the engine nacelles were too thin for this. The Air Force Program Office suggested that Boeing use a “bicycle gear” whereby one set of tires is located forward of the other. The Boeing design team did this, with the gear at the front of the plane slightly higher than the rear so that the plane had a nose up angle to allow it to take off.

By early 1946, the AAF awarded Boeing a contract to build two XB-47 Stratojet prototypes. Boeing started manufacturing them in June and rolled out the first one in September 1947. Nevertheless, despite the novelty of the design, few people in the Air Force or Boeing were enthusiastic about the airplane. Many thought that it would serve as no more than a research plane, with little chance of becoming operational. Boeing management envisioned selling large numbers of much more conventional aircraft to the newly formed U.S. Air Force.

But by mid-1948, as the XB-47 was well into its flight test program, it became clear to the Air Force and Boeing executives that the airplane far surpassed all of its contemporaries with straight wings. By the end of the year, the Air Force ordered 10 copies. Test pilot Chuck Yeager was sent to follow a B-47 in a jet fighter to check its speed and radioed to the B-47’s civilian pilot “I can’t keep up.” The next day, the B-47 set a new cross-country speed record at an average of 609.8 miles per hour (981 kilometers per hour). Within only a few years, the plane became the primary bomber for the Strategic Air Command and eventually more than 2,000 of them were built.

Many people consider the B-47, which has otherwise been almost forgotten, as “the most influential jet aircraft of all time.” All of Boeing’s jetliners (as well as the venerable B-52 bomber) adopted the same swept-wing configuration and most of them also fitted their engines on the wings just like the B-47. Other airplane manufacturers around the world also adopted this configuration and it is standard for all large, fast aircraft.

--Dwayne A. Day

Sources and Further Reading:


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