The Resurgence of the Flying Wing in the 21st Century

The highly anticipated B-21 Raider—named in honor of the legendary “Doolittle Raiders” who bombed Tokyo, Japan in April 1942—under development by Northrop Grumman, will be the first Air Force bomber manufactured in the twenty-first century. The concept of the “flying wing,” however, is over 100 years old, originating in the early 1900s. First, in February 1, 1910 German aeronautical engineer, Hugo Junkers, applied to patent a flying wing-concept airplane. Just months later, British Army Lieutenant, John William (J.W.) Dunne, successfully flew his tailless, swept wing model “D.5” just over two miles, making the aircraft the world’s first flying wing to achieve sustained flight.

Four years after this flight, the Burgess Company, an American aircraft manufacturer, reproduced Dunne’s subsequent model D.8 for both the U.S. Army and Navy, the latter of which was equipped with floats for landing on water. According to one passenger of the Burgess D.8, the airplane displayed remarkable stability and ease of control.

In the United States, it would be aircraft designer John “Jack” Northrop who was most responsible for making the flying wing concept a reality. The initial appeal of the flying wing was the reduction in drag that it offered. Distributing weight evenly across an aircraft’s wings, as opposed to up and down a conventional fuselage, enabled engineers to eliminate the tail section. Jack Northrop’s X-216H “flying wing” was his first attempt at crafting an all-wing aircraft. It was not a true flying wing due to its twin tail booms, however, it provided a foundation from which he would develop subsequent flying wing airframes. With the assistance of preeminent aerospace engineer, Theodore von Kármán, Northrop’s team was able to overcome fundamental challenges of controlling tailless, flying wing aircraft in their experimentation with the N-1M (1940). They controlled the pitch and roll of the aircraft by using elevons on the trailing edge of the wing, which served the function of both elevator and aileron. A split flap mechanism on the tips of the wings took the place of a conventional rudder and were originally angled downward, presumably for improving maneuvering stability, but was ultimately straightened. All of these adjustments made it possible to eliminate control structures like tail booms altogether.
They also made additional changes to the N-1M’s structure to address a Dutch roll when the aircraft moved on its vertical axis.\footnote{4}

Over the years, the Northrop Corporation produced numerous experimental flying wing prototypes for the Army Air Force (AAF). The XP-79 (1945), for instance, was one of the more radical designs for a couple of reasons. First, the pilot flew the plane in a prone position, reminiscent of the 1903 Wright Flyer. Second, its engineers constructed the airframe using welded magnesium alloy instead of conventional, riveted aluminum. As it were, the AAF cancelled the XP-79 project shortly after the prototype crashed on its maiden test flight, killing the pilot, Harry Crosby.\footnote{5}

Through designing and testing various prototypes, Northrop remained committed to the flying wing concept, paving the way for larger flying wing airframes in the X/YB-35 (1946) and its jet-powered evolution, the YB-49 (1947). With a wingspan of 172 feet, they dwarfed the smaller N-1M and XP-79 prototypes and were far more powerful. The X/YB-35 was powered by four Pratt & Whitney R4360 Wasp Major, 3,000 hp engines, each turning a pair of four-bladed, counter-rotating propellers.\footnote{6} It could reach altitudes of around 40,000 ft. and had a top-end speed of just over 390 mph, while its range varied greatly depending on speed and payload, maxing out at around 8,150 miles. It required a crew of nine airmen and could be armed with up to 20 .50 caliber machine guns and, originally, 44,000 lbs. of bombs.\footnote{7} Nonetheless, the XB-35’s range, ceiling and speed while carrying the required payload failed to meet the specifications laid out in Northrop’s 1941 contract, not to mention the fact that it was delivered three years late and 400 percent over its $2,910,000.00 budget. Much of the problems stemmed from the aircraft’s intricate radial engines and propeller systems—some of which were out of Northrop’s control—and repeatedly delayed flight testing; the XB-35 widely failed to meet Air Force specifications.\footnote{8}

AAF jet propulsion research provided a lifeline for Northrop’s flying wing. On 1 June 1945, the AAF ordered two YB-35s to be equipped with eight Allison J35-A-15 jet engines. The jet powered YB-35 would be designated YB-49. While the performance of the YB-49 improved, the inefficient, fuel-guzzling jet engines further reduced its range to roughly 3,500 miles. Moreover, the reconfiguration reduced the conventional bomb load the YB-49 could carry and eliminated the possibility of it delivering an atomic bomb. As a result, Air Material Command reclassified it as a medium bomber.\footnote{9}
In addition to the complications that emerged from reconfiguring the airframe, flight control issues with pitch and yaw plagued the YB-49’s capability as a bomber. Even the installation of an autopilot system—referred to by its developers as “Little Herbert”—did not alleviate its flight control issues. “Little Herbert” effectively eliminated the yaw, but pitch problems remained, as its Air Force test pilot noted. Unfortunately for Northrop, “Little Herbert” did little to improve the bombing accuracy of the YB-49, which took four times longer to achieve bomb run stability compared to the Air Forces’ main bomber at the time, the B-29, and had circular target miss distance twice as great as that of the B-29. Unsurprisingly, Air Force test pilots judged Northrop’s flying wing to be unsuitable for use as a bomber.

In April 1948, however, the leadership of the Air Material Command (AMC) met and determined that the YB-49 might have another use as a strategic reconnaissance platform. Thus, another reconfiguration of Northrop’s airframe resulted in the YRB-49A (1950). Outfitted with six J-35-A-19 jet engines, two of which were attached beneath the wing, the aircraft had a top-end speed of 439mph. The space previously occupied by bomb bays were converted to store extra fuel tanks, which increased its fuel capacity to 14,688 gallons. Sixteen cameras and a ground tracking radar recorder were added to the prototype. In August 1948, the Air Force ordered 30 YRB-49 prototypes and required Northrop Aircraft, Inc. to deliver three per month. While this was a positive development, it accentuated another ability that the YRB-49 lacked—availability. Production capacity at the young Northrop facility was comparatively small and was unable to keep up with the Air Force’s delivery schedule. The Air Force cancelled Northrop’s contract for the remaining, undelivered YRB-49s in January 1949.

Overall, as one researcher of Northrop’s flying wing program contends, there were four mutually reinforcing factors that converged at the same time to seal its fate. First among them was the impressive improvements made to the competing, long-range B-36 bomber by the end of 1948. Second, General Curtis LeMay, an ardent supporter of the B-36, took command of Strategic Air Command (SAC) in October 1948. The third factor was President Truman’s reduction to the FY 1950 defense budget. LeMay, having to operate under these fiscal constraints and as a proponent of the B-36, was prepared to dispense with the B-54 and YRB-49 programs in order to keep B-36 development resourced and supplied. This was where the aforementioned technical shortcomings of Northrop’s flying wing program came home to roost; its supporters had little ammunition to expend in its defense. Conceptually sound in design, the Northrop flying wings proved to be decades ahead of their time.

Forty years after the Air Force cancelled the YRB-49 program and thirty years ago this past July, a Northrop flying wing once more took to the skies in the form of the B-2 Spirit stealth bomber. As one author notes, “in the B-2, history has again repeated itself, in programmatic issues caused by Northrop’s limited production capacity, in defense acquisition cutbacks caused by a changing world situation, and in the resulting cuts in B-2 procurement.” In 1983 the Northrop team began an “extensive, costly, and time-consuming” redesign of the B-2 as Air Force needs increasingly came into focus.
The roughly two billion dollar, six-year process “nearly killed the program and the company.” The redesign significantly increased the per-unit cost of the B-2. This development, coupled with the collapse of the Soviet Union and the secretive nature of the “Advanced Technology Bomber” (ATB) program led to confusion among lawmakers as to the mission and strategic advantage the B2 would provide in the post-Cold War landscape. As a result, the budget for, and number of stealth bombers planned to acquire, gradually decreased from the initial order 132 at an estimated cost of $70.2 billion in 1989 to 75, then 50, and finally just 20 by 1992.16

Quite unlike Northrop’s experience with the flying wings of the 1940s, however, the B-2 was highly anticipated due to the promise of low observability, or stealth, technology. The flying wing airframe already emitted smaller radar cross-section (RCS) than conventional aircraft. In addition, Northrop constructed the B-2 with materials such as carbon-fiber composite plastics and covered the aircraft with an anti-thermal coating to absorb acoustic, infrared, visual and radar signatures, which greatly reduced the possibility of being identified by various types of detection systems. According to the Air Force in 1990, the RCS of the B-2 is the size of an insect.17 Secretary of the Air Force, Donald Rice, predicted in 1991 that “The B-2’s proven stealth performance will confound enemy defenses and its range and payload will enable it to strike targets with a degree of confidence and precision aviation has never seen before.”18 The B-2’s performance in combat operations over Serbia, Afghanistan, Iraq and Syria has proven Rice’s prophecy to be quite accurate.

As the Air Force’s next generation, long-range, stealth bomber, the B-21 Raider—another Northrop flying wing—promises to far exceed the capabilities of the B-2, benefitting from the continuous advancement of stealth and electronic warfare capabilities since the Spirit entered service in 1997. To be sure, the flying wing appears to have secured its place in the Air Force’s bomber fleet well into the 21st century.19

References:

1 “The Dunne Aeroplane,” Flight: First Aero Weekly in the World, (June 18, 1910): 459-62. Dunne designed the D.5, but it was the Short Brothers that manufactured the plane.
3 William W. Suit, In Search of the Ideal Airframe: USAF All-Wing Aircraft and the Development of Stealth (Wright-Patterson AFB, OH: Air Force Materiel Command History Office, 1995), 3. Suit points out that the drag coefficient of the YB-35, for example, was 0.0113 as opposed to the conventional airframe of the B-29, which had a drag coefficient of 0.023.
4 Smithsonian National Air and Space Museum, “Northrop N1M,” airandspace.si.edu, accessed September 30, 2019, https://airandspace.si.edu/collection-objects/northrop-n1m. NOTE: Dates in parentheses indicate the aircraft’s first flight.
6 Chong, Flying Wings & Radical Things, 266. To be precise, the two XB-35s were powered by two Pratt & Whitney R-4360-17 Wasp Major engines and two Pratt & Whitney R-4360-21 Wasp Major engines, while the thirteen YB-35s produced were outfitted with two Pratt & Whitney R-4360-45 Wasp Major engines and two Pratt & Whitney R-4360-47 Wasp Major engines.
7 Suit, In Search of the Ideal Airframe, 54-5. It is also worth noting that the N-9M (1942) was a subscale mockup of the XB-35 intended to test out concepts to be applied to full-scale model. The last surviving N-9M was restored by the Planes of Fame Museum in Chino, CA and was often flown at nearby airshows. As widely covered in the news, the lone N-9M perished, tragically, with its pilot in a crash at a Riverside, CA airshow in April 2019.
14 NASA and the Air Force Flight Dynamics Laboratory developed digital fly-by-wire flight control systems in the late 1960s and 1970s, which enabled pilots to overcome the instability issues experienced in Northrop’s flying wings of the 1940s. See John T. Correll, “Jack Northrop and the Flying Wing: It wasn’t killed quite as dead as they thought,” Air Force Magazine (February 2017): 73.
16 Chong, Flying Wings & Radical Things, 215, 248. President Clinton announced in March of 1996 that additional funds ($493 million) had been added to FY 1996 budget to bring the original B-2 test aircraft up to full operational capability, adding one more B-2 to Air Force’s inventory (21).
17 Maj Gen Mark Barrett, USAF (Ret.), Col. Mace Carpenter, USAF (Ret.), Survivability in the Digital Age: The Imperative of Stealth (Arlington, VA: The Mitchell Institute for Aerospace Studies, 2017), 14; Given the accepted rate of technological advancement (Moore’s Law), the RCS of the B-21 will be significantly smaller.
18 Quoted in Bruce Wolf, “Chapter VI – Strategic Systems,” in History of the Aeronautical Systems Center, CY 1991, Volume I (Wright-Patterson Air Force Base, OH: History Office, Aeronautical Systems Center, 1992), 270, 276. As for the range and payload Secretary Rice referenced, its four F-118-GE-100 engines help the B-2 fly over 6,000 miles before needing refueled, while it can carry up to 50,000 pounds of conventional or nuclear bombs. See Suit, In Search of the Ideal Airframe, 44.