

In Feb. 9, 1949, an experimental Air Force bomber flew over the White House and down Pennsylvania Avenue, heading east and pulling up gently to clear the dome of the Capitol. It was the YB-49 flying wing, performing on orders from President Harry Truman. The aircraft had flown from Muroc AAB, Calif., to Andrews AFB, Md.

"I want the people to see what I'm going to buy," Truman reportedly told USAF Chief of Staff Gen. Hoyt S. Vandenberg. Photographers captured a stunning image of the flying wing over the Capitol looking like a messenger from the future.

Truman's jaunty remark notwithstanding, the stunt turned out to be only a tantalizing glimpse of American aeronautical ingenuity. In October, the YB-49 flying wing was canceled. Forty years passed before its successor flying wing, the B-2, took to the skies.

Today, B-2s make the news for their frequent shows of force in the Pacific. Their combat achievements over the last 15 years from Kosovo to Afghanistan, Iraq, and Libya are also well-known. What's often overlooked is the rare aeronautical achievement of this flying wing—and what it takes to keep those 20 precious aircraft flying as an effective fighting force.

At 25 years old, the B-2 remains the world's only combat-tested flying wing. For all its notoriety, the inherent grace and uniqueness of the B-2 in aviation history often escapes notice.

Flying wings began to take shape in the minds of aircraft designers as early as World War I. The Stout Batwing of 1918 attempted to blend fuselage and flying wing. Cartoons of cantilevered, batwing aircraft recurred through the 1920s and 1930s. Experiments in Europe and the US strove toward

PROMISE FULFILLED

By Rebecca Grant

It has never been easy, but the tiny B-2 fleet delivers range, payload, and stealth.

the unique lifting qualities that could be achieved with the flying wing. A blended wing promised efficient flight through low wing loading—the ratio of wing surface area to aircraft weight. The Horten brothers built a prototype for the Luftwaffe during World War II, and the Air Corps invested in flying wings beginning in late 1941.

“The flying wing bombers enjoyed all the usual financial support and governmental interest normally associated with a wartime program,” noted one historian. Jack Northrop built the XB-35 with piston engines and propellers, and from the start, the design was revolutionary. Plans for the B-35 sketched out an aircraft with nearly three times greater gross weight and wing area than the B-17 Flying Fortress. The clean shape of the wing promised lean fuel consumption and long range, alluring essentials in the days before air refueling. The technology of the day could not

deliver engines or flight controls to match, but the flying wing bomber idea stayed alive even after the war ended. Postwar research converted a few XB-35s to XB-49s and refitted them with jet engines.

Northrop’s flying wing offered outstanding performance for a bomber of the 1940s. A movie short from the era talked it up: “With its knife-like leading edge, there is little air drag, and every portion contributes to its lift.”

The technological promise—in this case, reaching high altitude and spanning the continents—was too enticing to pass up. Globe-spanning missions could be carried out with a 10,000-mile range. Plans at one point included a sleeping area for a relief crew of up to six.

The glamour factor reached its peak with the 1949 coast-to-coast flight and aerial display over Washington, D.C. The YB-49 averaged 511 mph on the flight.



B-2 bomber Spirit of Indiana flies over Whiteman AFB, Mo., in 2014.

"All the trees made it very hard to see straight ahead as I roared low over the city," pilot Robert L. Cardenas, then a major, told Smithsonian's *Air and Space Magazine* 60 years later. "The YB-49 was beautiful," he said, but "way ahead of its time." Cardenas judged the YB-49 to be only marginally stable in flight. The Air Force built more than 300 Convair B-36s instead and quickly moved on to the B-52.

It would take a war to actually develop a flying wing—in this case, an upswing in the Cold War. US-Soviet tensions increased with the Soviet invasion of Afghanistan in 1979. The chill gave renewed resolve to the secret USAF efforts to build an advanced bomber. The requirements of stealth and new confidence in computerized control made the flying wing design a natural choice. Stealth demanded a design with few perpendicular surfaces to minimize radar return. High altitude was another plus. The flying wing design met these criteria all around.

The flying wing also turned out to have a hidden generosity. The Air Force added requirements for low altitude, high-speed operations two years into the research and development program. At Northrop, the designers stepped back to reconsider the bomber's basic design.

"Fortunately, we were a flying wing," recalled the B-2's first program manager, Jim Kinnu.

"There's no contest, it's the right way to go," designer Irv Waaland remembered. Fresh studies showed the flying wing was still the best design for the mission and could even add fuel in the wings. Later, modifications to the trailing edge and a gust load alleviation system sealed the deal.

THRILL OF IT ALL

Back in 1948, with YB-49 tests underway, a Northrop promotional film touted the flying wing as a deluxe passenger design. The flying wing was spacious and company officials believed it might make a good airliner. Mock-ups showed well-dressed passengers viewing the ground through windows on the leading edge. "Snug as bugs in their magic carpet, air travelers can look down on mere Earthlings," the narration ran. "The sleek air Leviathan carries more cargo farther, faster, and with less fuel than any comparable plane." Stewardesses served drinks from a bar in the atrium-like passenger bay. This was the fantasy of flying-wing travel.

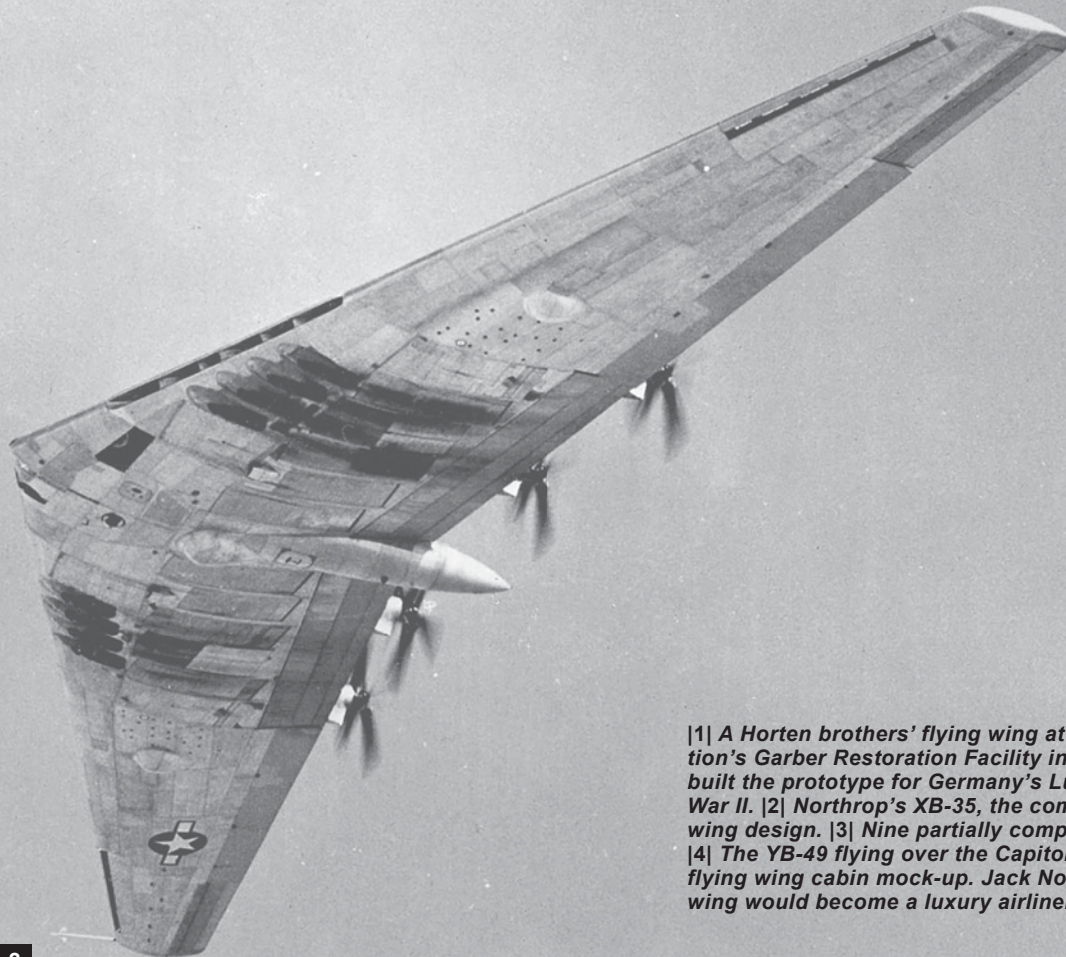
In reality, few have experienced the thrill of the flying wing—the B-2 cleared design hurdles but it was still a system ultimately destined for very limited production. That restricted the number of pilots and occasional passengers who would ever take flight in a flying wing.

A handful of deserving crew chiefs and civilian officials and a smattering of plum lucky writers have been the flying wing's only passengers. Less than 600 individuals—including all the test pilots, crew, and wing commanders—have flown in the B-2 since its debut in 1989.

It turns out the claims in the Northrop short movie promoting the YB-49 weren't far off. The feel of the flying wing is different from the majestic B-52 or high-performance F-16 and F-15 fighters. There's no glass bottom view, but the panorama from the sloping windscreen in the cockpit of the B-2 is breathtaking. The flying wing laps the air



Photo by Michael Katzmann



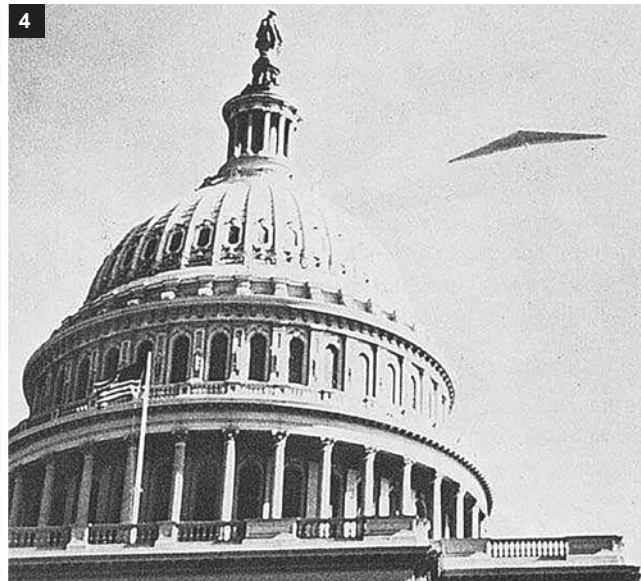
[1] A Horten brothers' flying wing at the Smithsonian Institution's Garber Restoration Facility in Maryland. The brothers built the prototype for Germany's Luftwaffe during World War II. [2] Northrop's XB-35, the company's original flying wing design. [3] Nine partially completed YB-35B airframes. [4] The YB-49 flying over the Capitol in 1949. [5] A Northrop flying wing cabin mock-up. Jack Northrop hoped the flying wing would become a luxury airliner.

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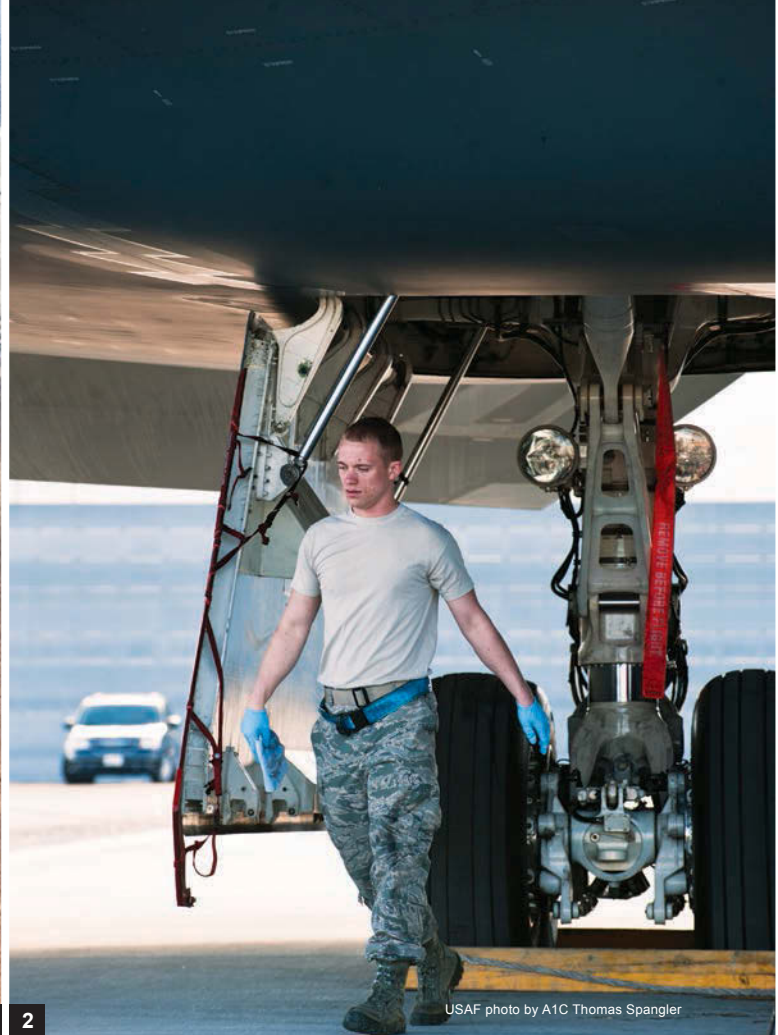
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USAF photo

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USAF photo by A1C Thomas Spangler

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with a feel for every current and delicate bump, yet the stiff wings barely flex. The big bomber can flip its wingtips to 45 degrees as it banks like a ballerina. The flight controls and mission avionics generate a sense of teamwork between pilot and airplane. The green 1980s typeface on the displays manages to look both retro and futuristic all at once.

The B-2 almost gives off the air of a sentient being. “She’s a computer we’ve taught to believe she is an airplane,” as one pilot put it.

The B-2 was intended to be the Air Force’s only bomber for the early 21st century, replacing the B-52 and B-1. That plan ended in 1992 when Congress halted production funding.

Yet the flying wings have done more than fulfill an aeronautical ambition. Their range, survivability, and payload continue to make them the single manned weapon capable of taking on the most difficult targets adversaries may present. “The strategic arsenal we have today is not about the Cold War,” said Adm. Cecil D. Haney, commander of US Strategic Command. “We’re not hanging on to Cold War apparatuses. This is about 21st century deterrence.”

Today these B-2s handle America’s two absolutely critical aviation missions.

The first is nuclear deterrence.

The second, unique to the B-2, is the ability to stealthily strike anywhere on the globe with conventional weapons, in support of international security objectives.

“We’re America’s 911 force,” Lt. Gen. James M. Kowalski, deputy commander of US Strategic Command, said of the B-2 fleet.

Those who dreamed up the flying wings past and present could hardly have imagined the level of skill needed to keep the bomber ready for its mission.

Maintaining that capability falls to a Whiteman AFB, Mo., team of pilots, maintainers, civilians, and contractors. For the B-2 force of 20 aircraft, it’s all about the lineup. The B-2 fleet must meet numerous requirements: Contribute to the nuclear deterrence posture, prepare for conventional missions, and keep aircrews current. Schedules are strained by the tiny fleet. It has high maintenance requirements and also needs several airframes to be in overhaul at any given time.

The wing’s greatest challenge is balancing the go-to-war posture for the B-2s with operational training and requirements for their aircrews. Many factors contribute: “how hard do you fly, which jets do you fly,” and so on, according to Col. Chase P. McCown, commander of the 509th Maintenance Group.

Wartime requirements come first. The 509th keeps a few B-2s in what the wing calls “pristine condition.” Those B-2s will be the ones tasked with immediate action should a crisis arise.

“We keep a few airplanes in a posture where if we are called today, they are ready today,” said McCown. “That is what the B-2 is designed to do.” Actual numbers in the pristine posture have fluctuated up and down depending on leadership preferences and global events.

Overall, the 509th is well-prepared for the job. “Right now we have a very good mix of jets in pristine condition and others we rotate through the flying schedule,” McCown stated.

[1] A YB-49, the jet-propelled variant of the Northrop XB-35 bomber. [2] SrA. Dustin Childs, a crew chief with the 509th Maintenance Squadron, finishes cleaning the landing gear doors of a B-2 during Red Flag 14-1 at Nellis AFB, Nev. [3] Col. Chase McCown, commander of the 509th Maintenance Group, says the unit keeps a few B-2s in “pristine condition” at all times—ready for combat. [4] Spirit of Washington comes in for a landing. The B-2 was badly damaged when an engine caught fire in 2010, but each aircraft in the tiny fleet is so valuable that the Air Force spent four years bringing it back into service. [5] A1C Steven McCray, a 13th Aircraft Maintenance Unit crew chief, signals the operations center that a Spirit bomber is airborne at Whiteman.

AFGSC channel video screenshot

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USAF photo

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USAF photo by SSgt. Nick Wilson

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The B-2s can't just sit in their hangars at Whiteman, however. Pilots must stay fresh on skills from formation flight to refueling. Because they typically fly just a few times a month, to sustain currency and work on tactics, they spend more hours in the simulators. Pilots also fly T-38 trainers to keep up their airmanship skills.

Scheduling maintenance in a way that meets deterrence demands and the flying schedule is intricate indeed. The B-2 is different from all the other steel and aluminum aircraft in the USAF inventory. “Our biggest maintenance driver is low observable [LO] work,” McCown said.

Whiteman has made readiness a priority, with exceptional results. Last year, the B-2 force experienced the best fleet health in the history of the program.

“Our three-year average for low observable maintenance man-hours per flying hour is 16.7,” reported McCown. In Fiscal Year 2014 we got it down to 13.5” man-hours per flying hour. A similar drop occurred as total maintenance man-hours per flying hour decreased from the three-year running average of 50.5 to a low of 46.2 hours in 2014.

Examining what goes into that statistic is a reminder that every flight of the stealth flying wing is a minor achievement in itself.

The flying wing shape flexes the entire bomber in flight. Such flexion isn't unusual in aircraft: The B-52's wingtip can reportedly bend 18 feet. However, on the B-2, the entire outer mold line flexes due to huge temperature differentials and other factors in flight. Vibrations and fuel can affect the tape and putty that seal the radar absorbent materials.

“Every time you fly the B-2 you generate low observable maintenance,” explained McCown. Over the years, modernization programs have greatly expanded the durability of each B-2's skin, but flight hours take their toll. Degradations grow worse on B-2s that haven't been in for depot maintenance, a process that takes place only once every seven years.

Keeping the fleet in shape is a complex process of diagnostics tools, schedule planning, and the expertise of experienced maintainers. According to McCown, the first line of defense is well-trained airmen who walk around the aircraft. They detect the visible flaws indicating where a B-2 may generate a signature hit from spots where the low observable configuration has degraded.

“We are responsible for keeping the radar cross-section of the B-2 as small as possible,” said MSgt. Aaron Thompson, 509th MXS signature diagnostics flight chief. “We identify all coating defects on the B-2 and drive the highest signature-impacting defects for repair.”

Maintainers also use a combination of handheld tools and larger equipment to perform diagnostics on sections of the B-2.

“Our main objective is buying the aircraft more radar detection time,” Thompson added. “We do that by visually looking for coating defects and also by nonvisual means, such as zonal radar imaging.”

“We have unbelievable diagnostic tools,” asserted McCown.

The combination of visual inspection and diagnostic analysis renders a status report on the overall low observable



USAF photo

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USAF photo by SSgt. Nick Wilson

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condition of each B-2. From that baseline, commanders prioritize work and select jets for routine flying operations or war-ready maintenance.

However, there's a twist. The 509th's mission requires that B-2s be ready to fight at any given moment. Overall mission capable rate numbers suffer as a result.

The process of prepping a B-2 can cause the aircraft to be listed as nonmission capable while specialized work is performed. In some cases, the 509th may take a single B-2, pull it out of mission capable status for 30 days, and perform underlying work to prepare it for war-ready status. Sometimes the jet is pulled for shorter periods of time; sometimes it may take longer, particularly after phase maintenance, a step necessary to overhaul engines, etc.

The rotation to meet rigorous low observable standards plays havoc with the standard method of calculating mission readiness. Simply put, the tracking of rates that give an accurate snapshot of an F-16 wing doesn't work for the B-2.

There's another twist. A B-2 may be listed as partially mission capable while maintainers correct a minor discrepancy in its low observables. However, that same B-2 "could still strike 805 of the targets in bad guy land," McCown explained. It just wouldn't be tasked against targets protected by the most advanced air defenses and fighters.

The complexities of low observable maintenance, diminishing spares, and so forth have created a tight relationship between the 509th and the B-2 system program office at Air Force Materiel Command at Wright-Patterson AFB, Ohio, led by Col. Robert A. Strasser. The SPO has rebalanced to focus as intensively on sustainment as on modernization programs. McCown praised Strasser, his counterpart, for efforts to meet today's requirements. The two often hold conversations about daily events on the flight line at Whiteman. "That kind of focus makes me very happy," McCown said.

USAF airmen—both Active Duty and reserve component—form part of the team. Department of Defense civilian employees, contract personnel, and specialists from Northrop Grumman are also part of the long-standing team for B-2 low observable maintenance. The civilians provide an enduring capability. "Some levels of expertise we just have not grown in the Air Force," noted McCown.

Can that work be accomplished away from the resources of Whiteman Air Force Base? The answer is yes.

"We deploy just like any other airframe," said McCown. B-2s on global missions "are chopped to the unit they deploy to," he said. They deploy as an autonomous package

[1] Spirit of South Carolina rests in a hangar while another B-2 takes off behind it. [2] A1C James Fulton gives the thumbs up signal to a stealth bomber pilot as he marshals a B-2 at Whiteman.

with good communications links to home station. However, the intent is for deployed maintainers to manage their own flow of work on flight lines at Guam, Australia, and other locations. "I try not to get out my 1,400-mile screwdriver too often," McCown joked.

PRECIOUS CRAFT

Each aircraft is so valuable that the Air Force went to extraordinary lengths to return the B-2 named *Spirit of Washington* to service after an engine start fire inflicted extensive damage to the bomber at Andersen AFB, Guam, on Feb. 26, 2010.

"The stealth bomber burned in a stealth fire that did far more damage than the service initially thought," wrote Mark Thompson of *TIME* magazine.

From extensive testing, the Air Force already knew that composite materials could smolder and reignite, posing unusual problems in firefighting and damage repair. In 2000, USAF had taken a composite wing box and set it afire over a pool of JP-8 fuel. "Surface temperature of the composite wing box dropped to room temperature while the internal layers continued to burn at 1400 degrees Fahrenheit, producing a bright red glow," the test team reported.

Bringing that B-2 back into service took four years and more than 1,000 parts ranging in size from small clips to massive sections that support the structure of the aircraft, reported the *Los Angeles Times* in a March 2014 story.

"With only 20 B-2s—as precious as those aircraft are—no one even questioned whether or not we'd make the investment," retired USAF Chief of Staff Gen. Norton A. Schwartz, told the newspaper. "When we found out the aircraft could be saved, civilian and military leadership agreed without hesitation."

Now *Spirit of Washington* is back and flying well in the lineup, McCown said.

All eyes await the Air Force's next bomber, in development by competing industry teams. This newcomer will have a long way to go to match the mystique of the B-2. ★

Rebecca Grant is president of IRIS Independent Research. Her most recent article for Air Force Magazine was "Jimmy Stewart's Air Force" in January.