B-2 Spirit in action

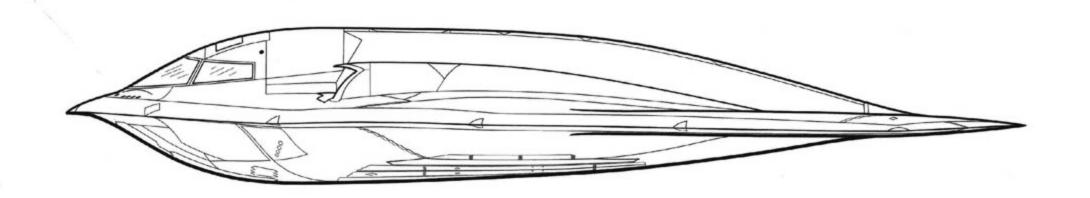
Aircraft Number 178
squadron/signal publications

B-2 Spirit

By James Goodall

in action

Color by Don Greer
Illustrated by Andrew Probert and Richard Hudson



Aircraft Number 178 squadron/signal publications



A 509th Bomb Wing B-2A Spirit drops a 4700 pound (2131.9 kg) GBU-37 'Bunker Buster' weapon on an al-Qaeda terrorist installation in Afghanistan on 5 October 2001. Spirits flew from Whiteman Air Force Base (AFB), Missouri to attack Taliban and al-Qaeda targets during Operation ENDURING FREEDOM. This US anti-terrorist campaign was launched in response to the attacks on New York City, Washington, DC, and western Pennsylvania on 11 September 2001.

Acknowledgements

When I began this adventure, I had no idea of just how many people would be instrumental in helping me put this book together. Glumly, I anticipated the same level of non-cooperation that I had experienced when writing other publications in the past. Not so with the B-2 community! To my delight, I received quite the opposite reception from the fine group of men and women associated with this vital program. Their encouragement and contributions were absolutely terrific from start to finish, and I deeply appreciate their enthusiasm for this project.

A very special thanks goes to my wonderful wife, Nora, for her invaluable assistance. Without her exceptional talent and the substantial amount of time she dedicated to working on this book, it would not be of the enhanced quality you see today.

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Current and Former Members of the 509th Bomb Wing:

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The B-2A prototype, Air Vehicle One (AV-1, 82-1066) flew its sixth successful test mission on 8 November 1989. Flight objectives were to conduct additional envelope expansion tests and the first aerial refueling. Piloting the Spirit on the six hour, three minute flight were Lt Col John Small and Northrop's chief test pilot, Bruce Hinds. (Jim Goodall)



Introduction

The quest for a Low Observable (LO) or 'stealth' aircraft began during the height of World War Two, when radar was first used to provide early warning against fleets of enemy aircraft. This resulted in engineers worldwide investigating ways to foil this new method of tracking aircraft maneuvers.

The first attempt to construct a LO aircraft was made by two German brothers, Walter and Reimer Horten. In 1943, they designed a novel twin-engine flying-wing bomber and reconnaissance aircraft, the **Ho IX** (later redesignated Gotha **Go 229**). The Hortens fashioned their aircraft from layered plywood with a core of glue, sawdust and a key ingredient – charcoal. This core was added to absorb radar waves. Due to the war effort and the corresponding shortage of raw materials, the German government chose not to invest in the manufacture of experimental aircraft at that time.

Enter American aircraft designer Jack Northrop. He had been dreaming about creating a flying wing aircraft since the 1920s, but it wasn't until the late 1940s that he was able to actually begin building one. Northrop faced some major hurdles with his concept of an aircraft without a conventional fuselage or tail. The US government was interested in his idea and ordered the piston-engined XB-35 bomber. This was soon overtaken by jet engine technology and the US placed a large order for Northrop's YB/YRB-49 jet bomber. The YB/YRB-49 contract was later rescinded and all 13 airframes (some ready to fly) were ordered destroyed.

Still, researchers kept looking for other means to make aircraft less visible on radar. Ferriteimpregnated, radar-absorbing, rubber-like materials were used on early Lockheed U-2 'spyplanes,' but the results were disheartening. Finally, in 1962, Lockheed's Clarence 'Kelly' Johnson and his famous team at the 'Skunk Works' plant designed and flew the first successful

John K. 'Jack' Northrop (1895-1981) stands in front of the XB-35A at Muroc Army Air Field (now Edwards Air Force Base), California in 1946. The XB-35A was the first large flying wing aircraft to fly and made its initial flight on 25 June 1946. Northrop is regarded as the 'Father of the B-2,' for his long-time interest in flying wing aircraft. (Northrop)



stealth aircraft – the highly secret **A-12 Blackbird** developed for the Central Intelligence Agency (CIA). It wasn't until 1979 and the Iranian hostage crisis, coupled with the Soviet invasion of Afghanistan, that President Jimmy Carter was prompted to authorize continued development of the second-generation stealth aircraft, the Advanced Technology Bomber (ATB) – later named the **B-2 Spirit**. By that time, computer technology had progressed to the point where it could be trusted to aid in controlling the aircraft's movement and improve bombing accuracy. (These problems helped doom the YB-49 project.)

In building the B-2, a new concept called Computer-Integrated Manufacturing (CIM) was used. In CIM, the definition of each and every component used in construction is stored in a computer database. The same database is then used to control machine tools and robots that actually put the aircraft together.

Building such a structure out of metal would have been exceedingly difficult, consequently it was handily constructed of carbon-fiber composites that absorb radar energy. The elements had to be built to exceptionally high standards of quality, and assembled and finished to extraordinary tolerances. In a sharp break from past practices, B-2 engineers designed and fabricated final production tooling directly from data in the three-dimensional Computer-Aided Design (CAD) system, thus bypassing the prior usage of 'development' tooling.

Aircraft technology has continued to yield innovative new offensive weaponry. Stealth aircraft (capable of dropping both conventional and nuclear weapons) can now fly with impunity directly into enemy airspace, drop their payload, hit a target as small as 3.3 feet (1 M), and fly back out without even being detected!

A variety of technologies were combined in order to make the B-2 'invisible' to radar. These technologies include a smooth surface, 'flying wing' design, Radar-Absorbent Materials (RAM), and Electronic Countermeasures (ECM). Each of these features contributes in the attempt to fool enemy air defense systems. The aircraft's low Radar Cross-Section (RCS)

Workers put finishing touches on the prototype YB-49A (42-102367) at Northrop's assembly plant in Hawthorn, California in 1947. The YB-49A was a jet-powered modification of the original propeller-driven XB-35A. Both the XB-35A and the YB-49A had the exact same wing span as today's B-2A – 172 feet (52.4 M). (Tony Landis Collection)



reduces the range at which ground-based and air-based radars can detect the aircraft. The RAM absorbs most of the radar's signal, and the aircraft's wing-shaped and rounded design redirects much of the remaining power away from the radar source. Special low-noise General Electric F118 turbofan engines are buried deep inside the B-2A's fuselage, prohibiting any direct view of the engine faces from the inlets. The inlet air intakes and exhaust ejectors are placed on the top of the aircraft, hiding the jet engine's compressor blades from radar detection. Additionally, hot gases are mixed with cool air before leaving the exhaust thereby reducing the B-2's Infrared (IR) signature and keeping heat-seeking missiles or detection systems from locking onto the aircraft. ECM is a last-resort attempt to confuse the radar operator through jamming and ghost imaging.

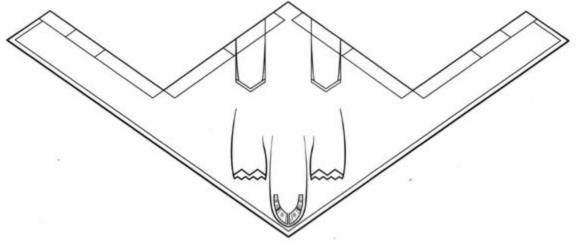
The most impressive characteristic of stealth is, of course, its low observability on radar. Stealth works by incorporating some other rather peculiar technologies that reduce or eliminate telltale radar return signals. Stealth aircraft such as the B-2, the Lockheed F-117 Nighthawk, the Lockheed Martin F-35 Joint Strike Fighter (JSF), and the soon-to-be-operational Lockheed Martin/Boeing F-22A Raptor are covered with a layer of RAM. It reduces to a minimum any signal that might be inadvertently reflected back to its source. The paint and composite structures making up the airframe also reduce or absorb radiant energy.

The B-2's shape is vastly different from that of any other aircraft in today's military. Some common aircraft features that were found to be incompatible with stealth are engines in external pods, vertical stabilizers, tail assemblies, and external stores. The successful stealth design had to meet a number of potentially conflicting requirements. The aerodynamic and structural challenges of the long-range, large-payload bomber had to be overcome, while at the same time maximizing the low-observable characteristics of the aircraft.

The stealth bomber has a 'bat-wing' shape designed to reduce its radar cross-section, as well as visual recognition – especially on the horizon. The smooth blending of the main fuselage into the wing area produces a flying wing shape when viewed from above or below. The stair-step shape presented by the aircraft from these perspectives is offset by the wing edges that produce opposing reflections, aiding in the cancellation of any reflected radar energy. The B-2 engine inlets, when viewed from above, have a dramatic 'W'-shaped design that looks rather like jagged teeth.

The aircraft's shape consists of all curves, yet they are not consistent identical curves; the curves continually change in radius. There is no abrupt distinction between body and wing. The dorsal hump rises smoothly from the top surface, but the underside swells gradually from the outermost trailing edge to the centerline. It looks something like an ovoid from the rear or front,

Early B-2 Configuration



with minimal overall cross section. Lockheed's earlier F-117 utilizes a faceted surface design (each panel is always at an odd angle to the next one), while the Northrop-designed B-2 adheres to a smooth-blending concept.

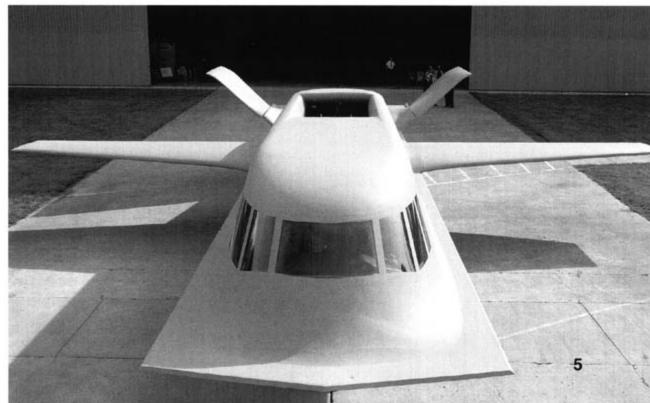
Ease of maintenance and deployability were also important considerations. Additionally, the aircraft had to be able to communicate, detect targets, navigate and perform other functions – all without revealing its location.

The B-2, as built, is naturally unstable due to the fact that most of its mass is aft of the center of lift. This makes the Digital Flight Control System (DFCS) the most critical subsystem on the aircraft. It is a quadruple fly-by-wire (or possibly a fly-by-light) system. The DFCS controls the eight large flaps that comprise most of the B-2's trailing edge. These flaps can be used to increase or decrease lift on take-off or landing. The DFCS also controls two smaller flaps located directly behind the over-wing exhausts. These can turn the emissions directly upward or downward via the Coanda effect, in which air adheres to the aircraft's surface even while curving away from the engines' axis. The B-2 is the first aircraft to use thrust vectoring for flight control.

The stealth technology benefits are obvious, especially knowing that 70 percent of all Sovietstyle air defense systems use radar detection and tracking. The primary threat to aircraft is radar, and what makes stealth possible is the achievement of a major reduction in the aircraft's RCS. Former Air Force Chief of Staff Larry Welch was quoted as saying, "The B-2's RCS is in the insect category."

In addition to the above, however, the other elements of air defense detection and tracking (IR, Electro-Optical [EO], and visual contrails) must also be circumvented if an aircraft is to be considered truly 'stealthy.'

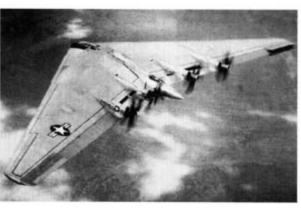
The Northrop TACIT BLUE stealth reconnaissance testbed was declassified in 1998. The sole example built was retired to the US Air Force Museum at Wright-Patterson AFB in Dayton, Ohio. Information gained from the TACIT BLUE was used to refine the use of Radar Absorbent Materials (RAMs) for the B-2 Spirit. (Northrop Grumman)



Development



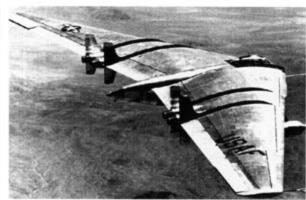
Northrop N-9M First Flight 27 December 1942



Northrop XB-35 First Flight 25 June 1946

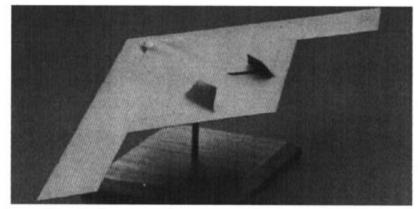


Northrop YB-49 First Flight 21 October 1947

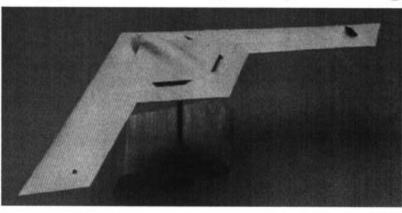


Northrop YRB-49A First Flight 4 May 1950

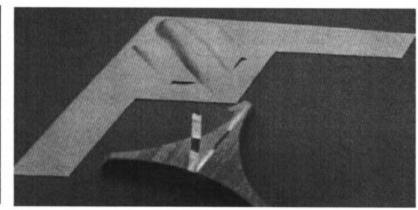
Early B-2 Advanced Technology Bomber (ATB) Configurations, 1979



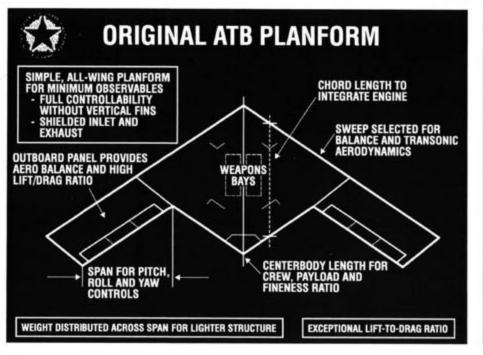
1. Inward canted fins were ineffective

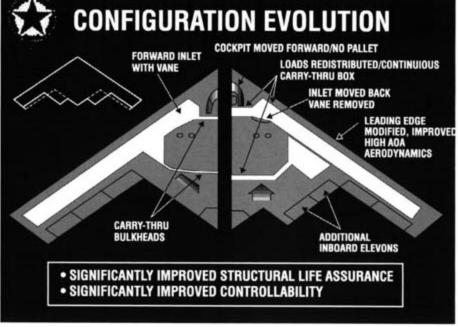


2. Wing tip mounted fins using wing tip mounted reaction jets

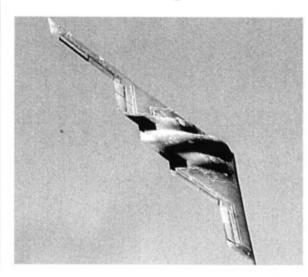


No fins and split flaps were selected for final design





Final B-2 Configuration



B-2A Spirit

The B-2 was publicly revealed on 22 November 1988, when Air Vehicle One (AV-1, serial number 82-1066) was rolled out of its hangar at Air Force Plant 42, Palmdale, California. AV-1 carried out its first taxi tests on 10 July 1989. The Spirit's first flight occurred on 17 July 1989 when it was flown from Palmdale to Edwards AFB, California by Northrop's B-2 Division Chief Test Pilot Bruce J. Hinds and copilot Col Richard S. Couch. The flight lasted one hour and 52 minutes.

The Spirit's wingspan of 172 feet (52.4 M) is exactly the same as Northrop's earlier XB-35 and YB-49 flying wing bombers. The B-2 is 69 feet (21 M) long and 17 feet (5.2 M) high. The aircraft weighs 153,700 pounds (69,718.3 KG) empty and 375,000 pounds (170,100 KG) fully loaded.

Approximately 80 percent of the B-2's structure is built from composite materials. These materials primarily consist of glass, carbon, or graphite fibers woven into either a cloth or tape format. The fiber cloth or tape is molded into shape with a binding polymer and then cured with heat. Composite parts are stronger, lighter, and more durable than aluminum counterparts. Radar Absorbent Materials (RAM) are incorporated into the external structure. The load bearing internal structure consists of titanium and aluminum.

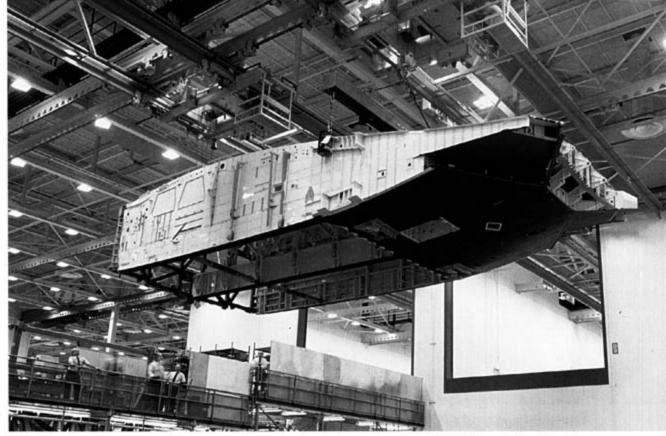
Four 19,000 pound thrust General Electric F118-GE-100 non-afterburning turbofan engines power the B-2. The F118 was derived from the F101 used by the Rockwell (now Boeing) **B-1B Lancer**, and has a bypass ratio of 0.87:1 as opposed to the F101's ratio of 2:1. Although the F118 uses more fuel at subsonic speed, it requires less air than the F101 and the inlet is therefore smaller and simpler. Shielding the engine fan face from radars is vital in meeting Low Observability (LO) objectives. The Spirit can reach a speed of 680 MPH (1094.3 KMH) and a service ceiling of 50,000 feet (15,240 M).

The engine exhausts are built into the wing upper surface and are well ahead of the trailing edge. They lead into a pair of 'U'-shaped exhaust ejectors that flare outwards. The key to reducing the Infrared (IR) signature is to ensure that the exhaust dissipates as soon as possible after leaving the aircraft. The hot exhaust gases are blended with cold bypass air, which further promotes heat reduction. B-2 fuel capacity is approximately 135,000 pounds (61,236 KG) of Jet A or JP-8 fuel, and the aircraft can be refueled in flight by Boeing KC-135 Stratotanker or McDonnell Douglas KC-10 Extender aerial refueling tankers via the flying boom. An inflight refueling receptacle is mounted on the upper fuselage centerline. The Spirit has an unrefueled range of approximately 6000 miles (9655.8 KM).

The B-2's main sensor is the Hughes AN/ALQ-181 radar. It has 21 separate modes, including navigation, penetration of defended areas, high-resolution ground mapping, and target search and detection. There are two electronically scanned antennae, one on each side of the nose wheel bay. It has classified Low-Probability-of-Intercept (LPI) features in both signal performance and operational techniques, making it less likely to show on an enemy's electronic surveillance equipment.

The AN/ALQ-181 has a synthetic-aperture mode that allows it to paint a picture of the target. This allows the Global Positioning System (GPS)-Aided Targeting System (GATS) to compute the local GPS bias and thus enhance weapons delivery accuracy.

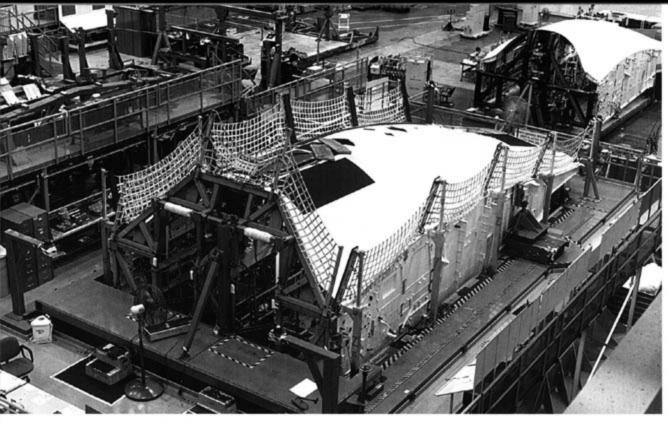
The B-2 is equipped with the Northrop Grumman AN/ZSR-63 defensive avionics suite. The AN/ZSR-63 is believed to actively cancel radar returns, in much the same manner that 'white noise' silences sound by being the precise opposite of received pulses. ('White noise' is noise which has a constant energy per unit bandwidth in hertz.)



The Boeing Company built the aft-center fuselages for all 21 B-2As at its Seattle, Washington plant. This was the B-2's largest single section. Aft-center fuselages were flown from Seattle to the final assembly facility at Site 4, Air Force Plant 42 in Palmdale on Lockheed C-5B Galaxies. This section – delivered to Northrop in December of 1993 – was destined to become part of AV-21, the SPIRIT OF LOUISIANA (93-1088). (Boeing)

Boeing was also the prime contractor for the B-2 outer wings. Hinges along the aft trailing edge support the split rudder (outboard) and outboard elevon (combination elevator and aileron). The long and seamless wing sections were flown by C-5Bs from Seattle to the B-2 final assembly facility at Site 4 in Palmdale. (Boeing)





Aft-center fuselage Assembly 21 takes shape at Boeing's Seattle plant. Located nearby is Assembly 20, intended for the SPIRIT OF PENNSYLVANIA (AV-20, 93-1087). The latter Spirit was the first Block 30 (full standard) B-2A delivered to the Air Force. Unlike most aircraft manufacturing facilities, Boeing's production line was as quiet as your typical office cubical. (Boeing)

The first three B-2As near completion at Site 4, Air Force Plant 42 in Palmdale. The lead airframe is AV-1 (82-1066), named the SPIRIT OF AMERICA after upgrading to full operation standard. Next in line is AV-2 (82-1067), later christened the SPIRIT OF ARIZONA, followed by AV-3 (82-1068), the SPIRIT OF NEW YORK. A white, paper-like protective material covers the airframe before painting. Workers use the black rubber mats to walk on the B-2's surface. (Northrop Grumman)





Cockpit assemblies for three B-2s are lined up at Northrop Grumman's assembly line in Palmdale. The near assembly went into AV-11, the SPIRIT OF WASHINGTON (88-0332). This was followed by AV-10, for the SPIRIT OF SOUTH CAROLINA (88-0331), and AV-12, for the SPIRIT OF KANSAS (89-0127). The cockpits were mated to the Boeing aft-center fuselage assemblies in another area of Site 4. (Northrop Grumman)

The first B-2A (82-1066) is parked in front of its hangar at Air Force Plant 42 in Palmdale, California after the Spirit's rollout on 22 November 1988. Guests attending the rollout were kept 200 feet (61 m) from the aircraft to prevent close inspection of the B-2's secret details. (USAF via G. Phillips)



The B-2 Combined Test Force at Edwards was responsible for flight testing Engineering, Manufacturing and Development (EMD) aircraft. The B-2 was initially assigned to the 6520th Test Squadron/6510th Test Wing. Aerodynamic performance and airworthiness formed Block 1 of the test program, which was completed in 13 flights totaling 67 hours (up to 30 June 1990). Block 1 also included the first airborne refueling on November 8, 1989, and the first flight with an all-USAF crew on 3 May 1990.

The second prototype, AV-2 (82-1067), flew from Palmdale to Edwards on 19 October 1990, and AV-3 (82-1068) did likewise on 18 June 1991. AV-2 took over flight envelope expansion tests from AV-1 and also carried out flutter, load, landing gear and weapons bay door tests. AV-3 was the first aircraft fitted with the Hughes AN/ALQ-181 radar and it performed much of the avionics testing.

Block 2, the critical LO testing, began on 23 October 1990. During the 11th test flight (on 26 July 1991), AV-1 showed a larger reflection than had been expected from one particular aspect on one radar frequency. It was later determined this had been caused by incorrectly applied RAM on the wings' leading edges. It was clear from the tests, the B-2 was even stealthier than the F-117, and by then the latter had been proven in combat over Iraq where it had penetrated the air defenses around Baghdad without detection.

By the time the first aircraft was delivered to the USAF on 17 December 1993, the B-2 had achieved several important milestones. It completed fatigue testing to 20,000 hours; undertaken all navigation and autopilot trials; passed static load tests; and completed flutter clearance. It also performed a simulated 9.2-hour bombing mission, cleared the flight-refueling envelope with both KC-10 and KC-135 tankers, and flew at 80% of the maximum take-off weight.

(Below) B-2A AV-4 (82-1069) leads two Lockheed YF-117As over the northern shore of the Salton Sea in southern California's Imperial Valley. The two Blackhawks were assigned to the F-117 Test Force Facility at Site 7, Air Force Plant 42 in Palmdale. AV-4 was nicknamed CHRISTINE during flight test and named the SPIRIT OF INDIANA when placed in operational service. (US Air Force)



(Above) The B-2A prototype, AV-1 (82-1066), approaches the main runway at Edwards AFB, California to complete its maiden flight on 17 July 1989. Split rudders on the outer wing trailing edges are deployed for low speed control. This Spirit was nicknamed FATAL BEAUTY and was assigned as a flight-test-only aircraft to the 6520th Training Squadron, 6510th Training Wing of Air Force Materiel Command. In May of 1996, the Air Force decided to upgrade AV-1 to Block 30 production standards. (Northrop Grumman)





Northrop Grumman B-2A Spirit Specifications

Wingspan:.....172 feet (52.4 M) Length:.....69 feet (21 M) Height:.....17 feet (5.2 M)

Empty Weight:.....153,700 pounds (69,718.3 κg) Maximum Weight:...375,000 pounds (170,100 κg)

Powerplant:.....Four 19,000 pound thrust General Electric F118-GE-100

turbofan engines

Armament:.....Maximum of 50,000 pounds (22,680 kg) of conventional or

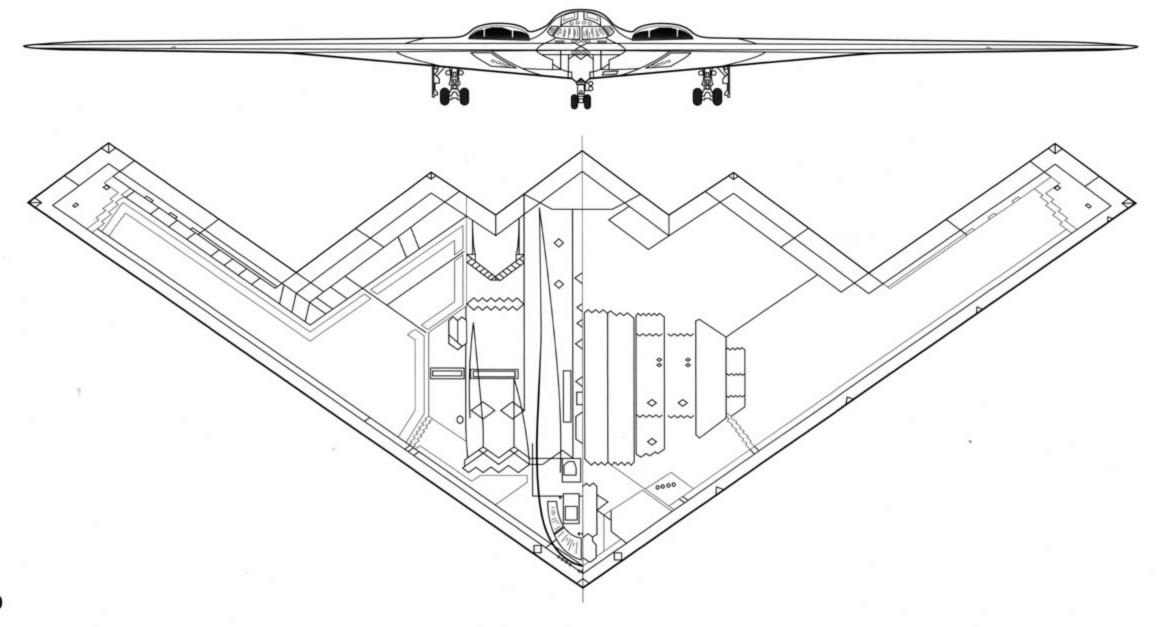
nuclear bombs and guided weapons

Performance

Maximum Speed:.680 мрн (1094.3 кмн) Service Ceiling:....50,000 feet (15,240 м)

Range:.....Approximately 6000 miles (9655.8 км) unrefueled

Crew:.....Two





AV-1 (82-1066) flies over California's Mojave Desert on an early test flight. The trailing wire static calibration unit is mounted on the aft fuselage, between the engine exhausts. This measures static pressure away from disturbances caused by the B-2 airframe. The calibration unit was only installed on Spirit prototypes. (Northrop Grumman)

The first B-2A (82-1066) touches down at Edwards AFB on its maiden flight on 17 July 1989. Two auxiliary air intake doors are fitted on top of each engine nacelle. These doors open only during taxiing, take-offs, and landings to provide additional air to the Spirit's four engines under these conditions. (Northrop Grumman)





AV-9, the SPIRIT OF CALIFORNIA (88-0330), taxis on the Northrop Grumman ramp at Site 4 in Palmdale. AV-1, later named the SPIRIT OF AMERICA, is parked off the taxiway. Behind AV-1 are two 'Iron Birds' (non-flyable static test airframes): AV-998 and AV-999. Plastic cocoons protect the two static airframes from weather damage. (Northrop Grumman)

A McDonnell Douglas KC-10A Extender (79-1951) refuels AV-1 over Edwards AFB during a test flight. The KC-10A – a tanker/transport derivative of the DC-10 airliner – was assigned to the 22nd Air Refueling Wing at March AFB, California. The first B-2 in-flight refueling – from a KC-10A – occurred on 8 November 1989. (Northrop Grumman)





This Douglas YEA-3B Skywarrior (N160TB; BuNo 144856) takes off on a test flight from Holloman AFB, New Mexico. The former Navy electronic warfare aircraft was modified to carry a complete B-2A electronics suite for in-flight testing. A radar antenna is mounted atop the vertical stabilizer, while a 'frisbee' antenna is mounted on the tailcone's end. (Tony Landis)

AV-5 (82-1070) – named FIRE & ICE; later, the SPIRIT OF OHIO – undergoes cold weather and extreme heat soaks in the McKinley Climatic Laboratory at Eglin AFB, Florida. This test is part of the B-2's certification process, demonstrating the aircraft's structural integrity under climatic extremes. Snow formed during the cold soaking lies on the hangar floor. This laboratory can hold temperatures ranging from -65° Fahrenheit (-18.3° Celsius) to +165° Fahrenheit (73.9° Celsius) for several days. (Northrop Grumman)





The extensively modified YEA-3B Skywarrior (N160TB) retracts its landing gear shortly after taking off from Holloman AFB. The Skywarrior was operated by Thunderbird Aviation on behalf of Hughes, manufacturer of the B-2's AN/ALQ-181 radar. The tail-mounted 'frisbee' antenna is deflected at a 20° angle. (Tony Landis)

B-2 Upgrades

Link-16 – Providing line-of-sight data for aircraft-to-aircraft, aircraft-to-C² (Command and Control), and aircraft-to-sensor connectivity, Link-16 is a combat force multiplier that provides military services with fully interoperable capabilities and greatly enhances tactical C³I (Command, Control, Communications, and Intelligence) mission effectiveness. Link-16 provides increased survivability, develops a real-time picture of the combat theater, and enables aircraft to quickly share information on short notice.

EHF Communication – The command and control of nuclear forces requires a survivable communication system. To satisfy this requirement, the USAF plans to deploy an advanced Extremely High-Frequency (EHF) satellite communications constellation. This constellation will provide a survivable, high-capability communications system. The B-2 will be fitted with an EHF communication capability satisfying Department of Defense (DoD) requirements.

Digital Engine Controller – The B-2's current analog engine controllers are high-failure items. New digital engine controllers will improve the B-2's performance and increase reliability and maintainability.

Computers – With advances in computer technology and increased demands on the system, the B-2's computers will need to be replaced. Although reliable, maintaining the present computers will become increasingly difficult and costly.

Signature Improvements – The B-2's signature meets operational requirements against today's threats. As advanced threats proliferate, it will be prudent to investigate advanced signature reduction concepts and determine if it is necessary to improve the B-2's Low Observable (LO) signature.

Production

The prime contractor (responsible for overall system design and integration) is Northrop Grumman's B-2 Division. Boeing Military Aircraft Company, Vought Aircraft Company, Hughes Radar Systems Group, and General Electric Aircraft Engine Group are also key members of the aircraft contractor's team. Another major contractor is Hughes Training Inc. (HTI) – Link Division (formerly known as CAE) – Link Flight Simulation Corporation. This organization is responsible for aircrew training devices such as the weapon systems trainer and the mission trainer. Northrop Grumman and its major subcontractor, HTI (excluding Link Division), are responsible for developing and integrating all aircrew and maintenance training programs.

Total B-2 production ended at 21 aircraft in 1997. All six development aircraft were updated to Block-30 production standards and delivered to the US Air Force's 509th Bomb Wing (BW) at Whiteman AFB, Missouri. The Air Force accepted delivery of production B-2s in three configuration blocks designated as Block 10, Block 20, and Block 30. Delivery was comprised of six test aircraft, ten Block 10, three Block 20, and two Block 30 aircraft.

Block 10-configured aircraft provided limited combat capability with no capability to launch guided weapons ('smart bombs'). The Block 10 model was able to carry 2000 pound (907.2 KG) Mk 84 conventional bombs or gravity nuclear weapons.

Block 20-configured aircraft had an interim capability to launch nuclear and conventional munitions, including the Ground Positioning System (GPS)-Aided Munitions (GAMs). The Block 20 model has been tested with the CBU-87/B Combined Effects Munition (CEM) cluster bomb.

Block 30-configured aircraft are fully capable and meet the essential employment capabilities defined by the Air Force. The first fully configured Block 30 aircraft (93-1087, the SPIR-IT OF PENNSYLVANIA) was delivered to the Air Force on 7 August 1997. Compared to the Block 20s, the Block 30s have approximately twice as many radar modes together with enhanced terrain-following capability and the ability to deliver additional weapons, including the Joint Direct Attack Munition (JDAM) and the Joint Stand-Off Weapon (JSOW). Other features include incorporation of configuration changes needed to make B-2s conform to the approved radar signature; replacement of the aft decks; installation of remaining defensive avionics functions; and installation of a contrail management system. All B-2s are up to the Block 30 configuration standard. This process began in July of 1995 and was completed in early 2000.

Air Vehicle Seven (AV-7) to AV-16 were built to Block 10 standards (B-2A-10-NO). This limited the B-2 to carrying 16 B83 free-fall nuclear weapons or 16 2000 pound Mk 84 'iron' bombs and restricted its employment to missions of two or three aircraft flown from Whiteman, but with the option of recovering to a friendly base. AV-12 through AV-16 were upgraded to Block 20 standards in 1996/97.

AV-17 to AV-19 were built to Block 20 standards. This gave the aircraft the ability to carry up to 36 Cluster Bomb Units (CBUs) or 16 2000 pound JDAM inertial-guided bombs. A GPS-Aided Targeting System (GATS) was installed in conjunction with JDAM. Block 20 allowed partial low-level terrain following and a deployable mission-planning system to permit multi-aircraft deployments to forward bases.

AV-20 and AV-21 were built to the definitive Block 30 standards. This allowed the aircraft to carry 80 500 pound (226.8 KG) Mk 82 bombs, 80 580 pound (263.1 KG) Mk 62 mines, or 36

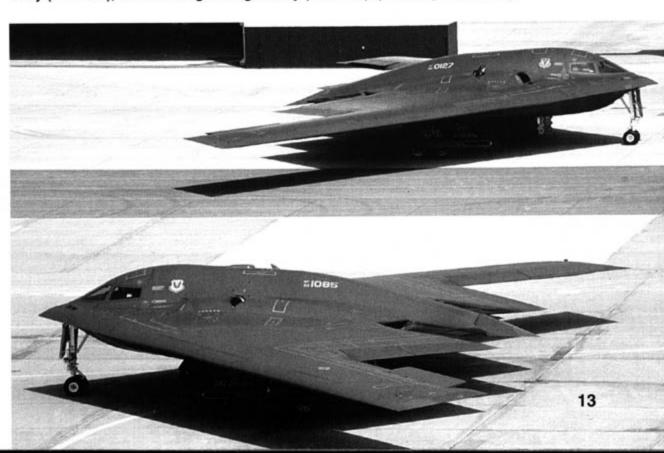
750 pound (340.2 kg) Mk 117 firebombs. A Milstar satellite communication system was added and the mission planning system became fully functional.

Primary maintenance responsibilities for the B-2 are divided between three facilities throughout the United States. The Oklahoma City Air Logistics Center (ALC) at Tinker AFB, Oklahoma is contracted to perform avionics software maintenance. The Ogden ALC at Hill AFB, Utah maintains landing gear and trainers under Air Force contract. Periodic depot maintenance is performed at the Northrop Grumman facility at Air Force Plant 42 in Palmdale, California.

In May of 1996, the Air Force decided to upgrade AV-1 (82-1066) to operational Block 30 status. This B-2A – named the SPIRIT OF AMERICA – brought the operational fleet up to 21 aircraft.

The basis for the useful life of the B-2 includes data from initial Developmental Test and Evaluation analysis. Data indicates that the aircraft should be structurally sound to approximately 40,000 flight hours using current mission profiles. Analysis further suggests that the rudder attachment points are the first structural failure item. The B-2 has not implemented an Aircraft Structural Improvement Program (ASIP) similar to the other bombers, and this makes it difficult to predict the economic service life and attrition rate. A national projection based on the B-52 predicts that one aircraft will be lost every ten years. This attrition rate, plus attrition due to service life, will erode the B-2 force below its requirement of 19 aircraft by the year 2027.

The SPIRIT OF OKLAHOMA (AV-18, 93-1085) passes the SPIRIT OF KANSAS (AV-12, 89-0127) on the Whiteman AFB ramp. AV-18 was delivered to the 509th Bomb Wing on 15 May 1996, while AV-12 joined the unit on 17 February 1995. B-2s are painted overall Gunship Gray (FS36081), with markings in Light Gray (FS36495). (Northrop Grumman)

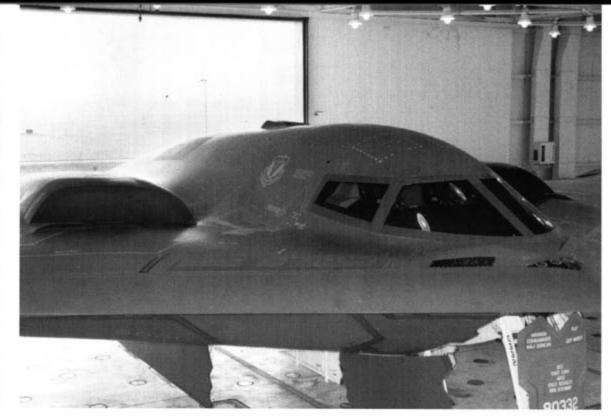




'Hairpins' connect leading edge sections of Block 20 B-2As, including the SPIRIT OF ALASKA (AV-15, 90-0040). One of these 'hairpins' is below the windshield. Spirits built or upgraded to Block 30 standard use one-piece leading edges, eliminating the 'hairpins' and providing a slight reduction in radar reflectivity. The last of the Block 20 B-2s, the SPIRIT OF OKLAHOMA (AV-18, 93-1085), was sent to Northrop Grumman for Block 30 upgrade on 17 December 1998. (Jim Goodall)

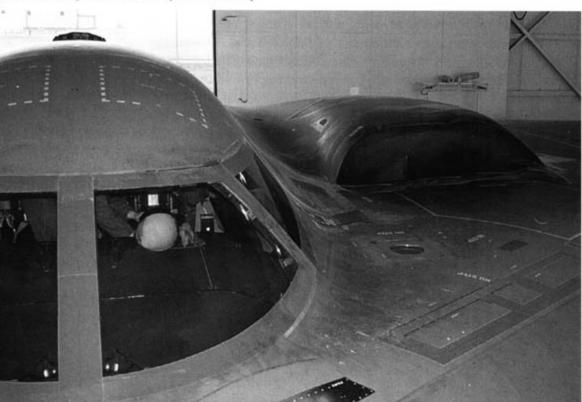
The round window immediately below the port cockpit window houses the astro-tracker. This device is fitted to Block 30 B-2As and is similar to the type installed on SR-71s some years before. The Spirit crew uses the astro-tracker in conjunction with the Global Positioning System (GPS) and the ring-laser gyro platform. Combined, these devices tell the crew exactly where the aircraft is at any moment in time – or at least within a few meters as the worst case scenario. (Jim Goodall)





Block 30 B-2As, including the SPIRIT OF WASHINGTON (88-0332), are fitted with onepiece wing leading edges. These eliminated the need for multi-piece leading edges, connected with 'hairpins.' The leading edges are in the same Gunship Gray (FS36081) finish as the rest of the airframe. Upgraded Spirits (including earlier Block 20 aircraft) also have sets of four static ports in front of the windshield. These ports measure airspeed, angle of attack, sideslip, and pitch and yaw for the flight instruments. (Jim Goodall)

The B-2's laminated acrylic windshield is approximately three to four inches (7.6 to 10.2 cm) thick. A fine gold-colored wire mesh is placed between the inner and outer clear panels. This mesh keeps hostile radar waves out of the cockpit and retains cockpit reflections inside the aircraft. Light gray dashes mark the emergency egress panel immediately above the ejection seats. (Jim Goodall)





The B-2's engine inlet drops down from the aircraft upper surface to the engines buried inside. A special boundary layer inlet just below each intake smooths airflow into the main conduit. This air is then diverted to the exhaust system for cooling, thus reducing the B-2's infrared signature. Specific images of the Spirit's engine inlets were off-limits to the general public until mid-2001. (Jim Goodall)

A B-2 pilot is greeted by the Crew Chief following a 12-hour flight from Whiteman AFB to Andersen AFB for GLOBAL POWER. The working relationships formed between B-2 aircrew members and ground support personnel are some of the best in the military. The weapons bay doors are open and the wind deflectors extended at the bay's front. (Northrop Grumman)

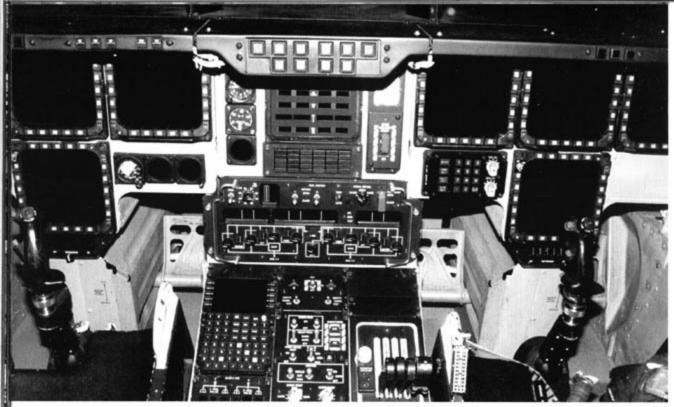




The SPIRIT OF PENNSYLVANIA (AV-20, 93-1087) was one of the three 325th Bomb Squadron B-2As deployed from Whiteman AFB, Missouri to Andersen AFB, Guam in October of 1998. This was for GLOBAL POWER, an Operational Readiness Exercise (ORE) which validated the Spirits' readiness to deploy to overseas locations. AV-20 was the first Block 30 B-2A, which has full weapons capability. It was delivered to the 509th Bomb Wing at Whiteman AFB on 7 August 1997. (Northrop Grumman)

A pilot enters the B-2A SPIRIT OF PENNSYLVANIA (93-1087) during an Engine-Running Crew Change (ERCC) exercise at Andersen AFB, Guam. The upper wing engine inlets mean that B-2A pilots do not have to contend with the fear of being sucked into the inlets as they do with pod-mounted engines. The weapons bay doors are usually open when the Spirit is on the ground. (Northrop Grumman)

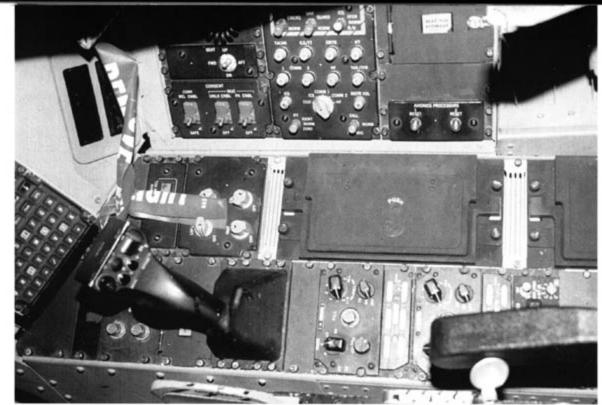




Both B-2 crewmen – Pilot to port, Mission Commander to starboard – have four multifunction color display units. These units present flight information on Cathode Ray Tubes (CRTs), which are easier to read than conventional flight instruments. The Pilot's navigation input screen is mounted on the forward port side of the center console, with the weapons ejection controls and bleed air panel aft of this screen. The center of the console includes (fore-aft): the oxygen system control, flight controls, and fuel jettison controls. (Jim Goodall)

The Pilot's throttles are mounted on the port console in the B-2's roomy cockpit. Lighting controls are placed aft and outboard of the throttles. A toggle switch ahead of and outboard of the throttles operates the auxiliary engine air intakes. The landing gear lever is placed on the forward cockpit wall. Controls for the environmental control system and communications equipment are mounted along the port cockpit wall. (Jim Goodall)





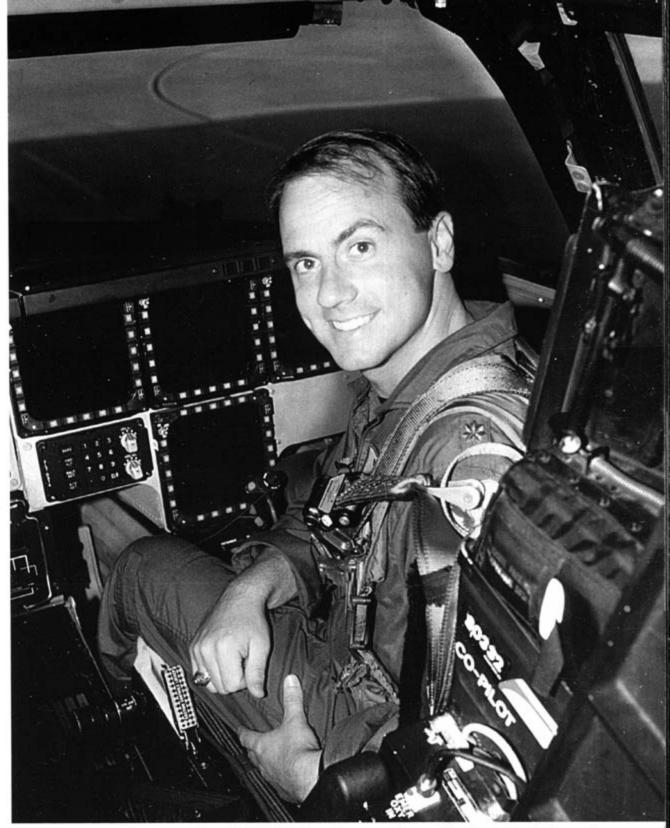
The Mission Commander's starboard console includes all of the tools needed to guide the bombs to their targets. The control stick mounted on the forward console section is the weapons system cursor. This updates the Global Positioning System (GPS)-guided weapons in conjunction with high resolution Hughes AN/ALQ-181 radar. A keypad for a second navigation input screen is mounted ahead of the weapons system stick. Communications equipment controls are placed on the starboard cockpit wall, while lighting controls and storage bins are fitted to the console. (Jim Goodall)

Both Spirit crewman use a floor-mounted control stick. The large gray button on the black stick grip top activates control surface trim, while the smaller red button beside the trim switch releases weapons. The autopilot/steering disengage switch is placed on the port side, while the nose gear steering button is placed at the grip bottom. (Jim Goodall)

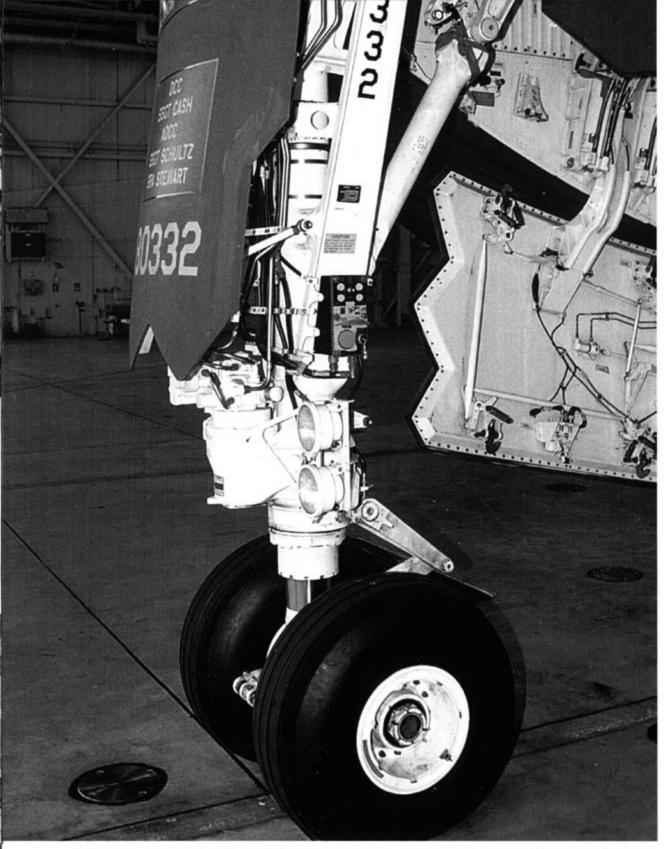




Major Harry Foster, B-2 Command Pilot, sits in the port cockpit seat. He is one of the select few who made the transition from 'pointy-nosed' aircraft to the powerful Spirit. Foster had over 450 B-2 flight hours when he had the honor of flying on 'Night Two' of Operation ALLIED FORCE on 24 March 1999. It was the first of two successful missions he flew during the Kosovo War. The yellow ejection seat actuating handle is mounted on the side. (Jim Goodall)



Major Tony 'Red Corvette' Monetti, B-2 Mission Commander, smiles from the starboard seat as he prepares for a training mission over the upper Midwest plains. Monetti began his career with B-52Hs at K.I. Sawyer AFB, Michigan, moved to Ellsworth AFB, South Dakota to work with the B-1Bs, and was later chosen to fly the B-2. Monetti completed two successful missions during Operation ALLIED FORCE. With 600-plus hours in the aircraft, Monetti claims he still loves to fly the B-2. (Jim Goodall)



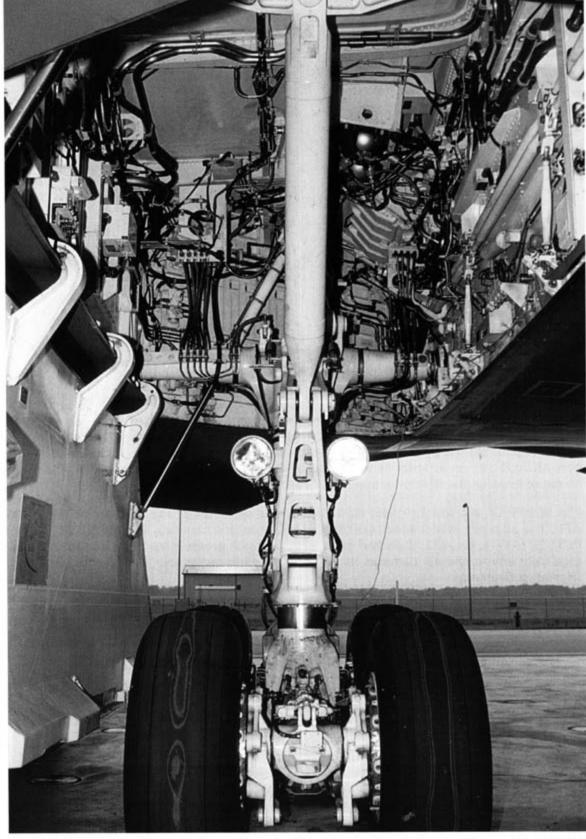
B-2As are equipped with a Boeing nose landing gear and Goodyear tires. Two taxi and landing lights are mounted on the port side of the strut. A hydraulic ram pulls the gear strut aft inside the gear bay. One landing gear door is mounted ahead of the strut, while the other is hinged to starboard on the undersurface. (Jim Goodall)



The SPIRIT OF PENNSYLVANIA (AV-20, 93-1087) waits in its hangar at Whiteman AFB for the next mission. The starboard AN/ALQ-181 radar antenna appears slightly lighter than the rest of the airframe. Painted aft of the cockpit windows is the 509th BW insignia. The B-2 appears 'fat' when viewed near the nose section; however, when seen from various angles, the aircraft's shape generates illusions that are significantly different. (Jim Goodall)

Boeing also manufactures the B-2A main landing gear assemblies. Goodyear tires are fitted on each wheel, which has cooling holes for the carbon disc brakes. B-2 landing gears and gear bays are painted Gloss White (FS17875). The landing gear door opens outward, aided by two hydraulic rams on the fore and aft door sections. (Jim Goodall)





Each B-2A main landing gear is equipped with a Dowty Decoto hydraulic ram. It pulls the gear up and forward on retraction and pushes the gear down and aft on extension. Landing gear retraction or extension occurs in 15 seconds. Two landing and taxi lights are mounted on the main gear strut, immediately below the ram attachment point. (Jim Goodall)

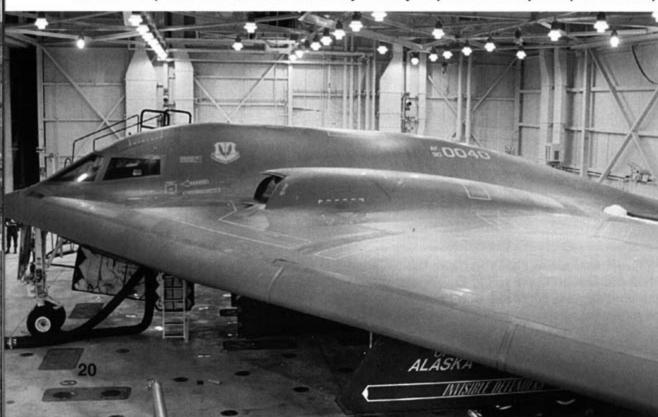


Natural metal brake lines run down the main landing gear strut's aft side. Black hydraulic lines provide pressure to the lower gear assembly. Hydraulic pressure is used to change the landing gear geometry during retraction and extension. The Spirit's landing gear can be extended at speeds up to 258 MPH (415.2 KMH). (Jim Goodall)



The Spirit's wing leading edge varies in camber (curvature) and design from the nose to the wingtip. This results in an apparent droop on the nose leading edge, which becomes rounded along the remaining leading edge. This B-2A is the SPIRIT OF PENNSYLVANIA (93-1087), the first Block 30 Spirit. Exercise equipment for the pilots' use is placed along the hangar wall. (Jim Goodall)

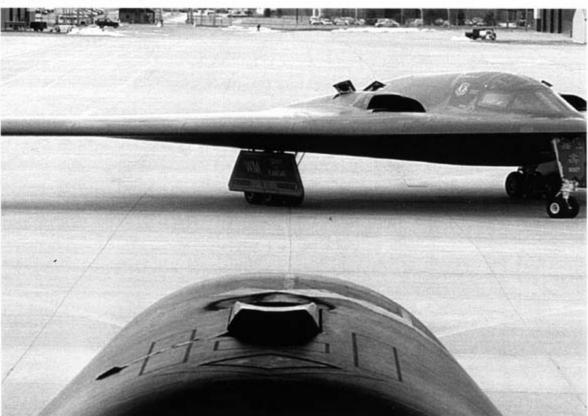
The SPIRIT OF ALASKA (90-0040) sits in its hangar. This Block 20 B-2A's leading edge sections are separated by 'hairpins.' Spirits upgraded to Block 30 standard replaced the multi-section leading edges with seamless, one-piece leading edges. The upgrade also included improved avionics and the ability to carry all precision weapons. (Jim Goodall)





Leading edges of B-2 landing gear and weapons bay doors are serrated (a 'zig-zag' pattern). This minimizes the radar returns from gaps between the doors and the gear and bay edges. A pilot stands by the cockpit entrance door and ladder. The four circles aft of the port AN/ALQ-181 radar antenna are faired sensor ports for flight instruments. There are no panel lines on the Spirit; its surface is seamless. (Jim Goodall)

The SPIRIT OF KANSAS (AV-12, 89-0127) taxis toward one of the hangars at Whiteman AFB. The auxiliary intake doors are fitted atop the engine nacelles. The SPIRIT OF WASH-INGTON (AV-11, 88-0332) is parked in its hangar, which protects the radar absorbing coatings from environmental damage. Its in-flight refueling receptacle is raised for servicing. (Northrop Grumman)



Air Refueling

Interview with Major Scott Vander Hamm, B-2 Pilot, 509th Bomb Wing (BW), March of 1998

(Vander Hamm flush; author indented.)

Is the B-2 an easy aircraft to refuel in flight?

It is very easy, and this is not to slam some of the guys who don't refuel, but it's very easy for the BUFF [Big Ugly Fat Fellow] guys. The BUFF (that's the **B-52**) is a very difficult plane to refuel and so when they come in here, it's a similar picture. All they have to get used to is the throttle response and how it causes a slight pitch up and down. Once they get used to that, they are very solid, and by and large the guys who came from single-seat aircraft that line up on the center, it takes them only a couple sorties to get comfortable. The only thing about the B-2 – you cannot get complacent with refueling. You're in such close proximity... The refueling is made by the closure and we used to say to close at no greater than a foot per second. That Tech[nical] Order has just been changed to say, 'Close at as slow a rate as possible.' We interact with the KC-135. If we come in too quickly, we will push their autopilot and cause them to get into a PIO [Pilot-Induced Oscillation, a pitch movement; this is also called 'porpoising']. And we've actually kicked off their autopilot before. So we have a bow wave similar to that of the C-5.

Is air refueling with the KC-10 easier?

Very much. His envelope is larger. As you come up there, you don't push him around nearly as much because he's so much bigger, and once you get into position (because his envelope is low) you cannot get out...

He sort of sucks you in from the ...

He doesn't really suck you in, but if you try to go right or left, his engines (those two engines) are creating pushback to the center. I guess you could have a limited disconnect with him. I never have – not an inadvertent disconnect – so yes, the KC-10 is much easier to refuel against.

When you're air refueling, as you bring on fuel, does your angle of attack change dramatically or does your CG [Center of Gravity] change?

Not dramatically. On one of the missions that I did to Hawaii, we took on quite a big on-load – approximately 100,000 pounds (45,360 kg) of gas – and what you do notice is that your throttles...in light weight, they're kind of back, and as you finish the throttles are up a little higher. But the AOA [Angle Of Attack], it changes by degree but nothing noticeable, so what happens when the aircraft is heavyweight is that it gets a little more sluggish. You put a throttle response in and it takes a little while for it to move, so you have to be very patient when you're heavyweight.

What is the maximum gross weight of the B-2?

We can take-off at 311,500 pounds (141296.4 KG) and during in-flight refueling go up to 336,500 pounds (152636.4 KG). With the B-52, you could refuel that aircraft up to...525,000 pounds (238,140 KG), but the max[imum] on the ground was 488,000 pounds (221356.8 KG) for take-off.



A McDonnell Douglas KC-10A Extender refuels B-2A AV-3 (THE GHOST; 82-1068), while AV-4 (CHRISTINE; 82-1069) waits its turn during in-flight refueling tests. These B-2s were later renamed the SPIRIT OF NEW YORK and the SPIRIT OF INDIANA, respectively. The Spirit can receive fuel from either the KC-10 or Boeing KC-135 tankers. (USAF)

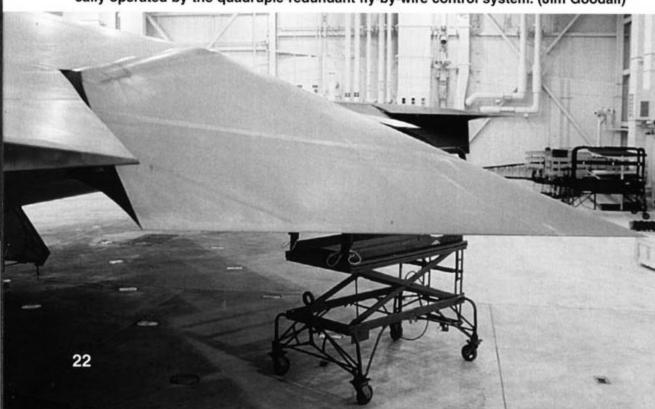
A B-2A receives fuel from a KC-10A en route to attacking al-Qaeda and Taliban targets in Afghanistan during Operation ENDURING FREEDOM in the fall of 2001. The refueling receptacle rotates to close when it is not needed. (USAF)





The trailing edge control surfaces are dropped while the B-2A SPIRIT OF WASHINGTON (88-0332) sits in its hangar. This is due to the lack of hydraulic power to these surfaces when the engines are shut off. The lower half of the split rudder is drooped, while the upper half rests parallel to the wing upper surface. (Jim Goodall)

The one-piece movable 'beaver tail' is in a full down position. Its function is to control the B-2's angle of attack during take-offs and landings, and to reduce airframe 'shake-rattle-and-roll' at low altitudes. The 'beaver tail' and all other flight control surfaces are hydraulically operated by the quadruple-redundant fly-by-wire control system. (Jim Goodall)





The B-2A SPIRIT OF MISSOURI (AV-8, 88-0329) is parked in its servicing hangar at Whiteman AFB, Missouri. A series of round metal circles on the hangar floor are part of the fire suppression system. If the various sensors in the hangar detect a fire or flash, the entire hangar will fill up with fire suppression foam in a matter of seconds. This applies to camera flashes as well as actual fires; this system was turned off prior to the author taking flash photographs for this book. (Jim Goodall)

A B-2 is prepared for pre-flight inspection inside its dedicated servicing hangar at Whiteman AFB. The hangar is open at both the front and rear, with the rear opening allowing jet exhausts to be vented outdoors. The US Air Force restricts any viewing of the B-2 from the rear at air shows, due to the classified nature of the low-observable engine exhaust system. (Jim Goodall)



Weapons

The B-2 has two weapons bays located in the lower centerbody. Each bay contains a set of bomb racks or a Boeing Advanced Applications Rotary Launcher (AARL). A launcher can accommodate only one type of weapon at a time, so each bay may contain only one weapon type; however, the two bays may hold different types of weapons.

In the nuclear role, the B-2 can carry up to 16 of the following weapons:

AGM-129 Advanced Cruise Missile (ACM)

The Raytheon (formerly General Dynamics) ACM was built as a stealthy replacement for the Boeing AGM-86, but production was curtailed at the end of the Cold War in 1991 and only 461 AGM-129s were built. The ACM carries a W80-1 nuclear warhead, with a yield ranging from five Kilotons (Kt¹) to 200 Kt. The AGM-129 is 22.25 feet (6.8 m) long with a 10.75 foot (3.3 m) wingspan, weighs 3700 pounds (1678.3 kG), and has a range of 4800 miles (7724.6 km). It has a number of design features that reduce radar cross-section including a minimal number of straight edges, low-power sensors, forward-swept wings, fuselage RAM, a flush inlet, and shielded exhaust.

B61

The B-2 carries the Mod 11 version of the B61 free-fall nuclear weapon. This has a variable yield of between ten and 340 Kt. The weapon's casing is specially strengthened, making it suitable for employment against hard-buried targets.

B83

The B83 is the USA's second-most powerful nuclear weapon, with a variable yield of up to 1.2 Megatons (Mt²). (The nine Mt B53 bomb carried by B-52s is the most powerful US nuclear device.) It is optimized for accurate, low-level supersonic delivery against hard targets, but can also be used as an airburst weapon (with or without parachute retardation).

The B-2 is more likely to be employed to drop conventional weapons. Although it only has two weapons bays, it can carry approximately the same amount as the B-1B (which has three weapons bays) or the 'Big-Belly' modified B-52Ds used during the air campaign over Vietnam.

Mk 82 (80)

The 500 pound (226.8 kg) Mk 82 is a gravity bomb and was the first weapon cleared for use by the B-2. In 2003, the B-2 will have a JDAM version of this weapon called the GBU-30.

GPS-Aided Munitions (GAMs) (16)

The USAF and Northrop Grumman developed the Global Positioning System (GPS)-Aided Munition (GAM) system as an interim precision munition for the B-2. GAM is a tail kit that fits on the 2000 pound (907.2 kg) Mk 84 general-purpose bomb (GBU-36/B) or the 4700 pound (2131.9 kg) BLU-113 penetrator (GBU-37/B). GAMs use GPS guidance to more accu-



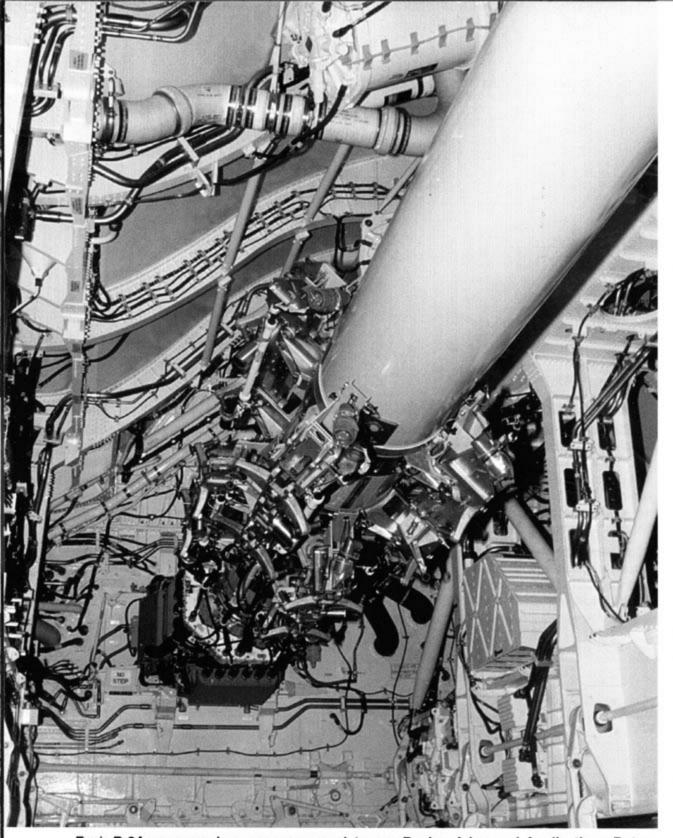
Nuclear weapons cleared for B-2 use are placed on a weapons handling trailer. The B61-11 deep penetrator bomb on the right is a modified version of the standard B61-7 bomb currently in the US Air Force inventory. The B61 is 11 feet 9.5 inches (3.6 $\,\mathrm{M}$) long and weighs approximately 720 pounds (326.6 $\,\mathrm{KG}$). It has a selectable yield from 300 to 340 kilotons of TNT. The third weapon from the right is the B83 thermonuclear bomb. It has a selectable yield up to 1.2 megatons and the B-2A can carry up to 16 of these 2000 pound (907.2 $\,\mathrm{KG}$) weapons at one time. (Jim Goodall)

A civilian technician and his military counterpart inspect an Advanced Applications Rotary Launcher (AARL). The AARL was configured after this inspection to carry the 2000 pound GBU-32 Joint Direct Attack Munition (JDAM). Eight JDAMs can be carried by each AARL. (Northrop Grumman)



¹ One kiloton equals the explosive force of 1000 tons (907.2 MT) of trinitrotoluene (TNT)

² One megaton equals the explosive force of one million tons (907,200 MT) of TNT



Each B-2A weapons bay can accommodate one Boeing Advanced Applications Rotary Launcher (AARL). This is the same launcher fitted to the B-1B Lancer strategic bomber. The AARL can hold eight weapons, including JDAMs, AGM-129 Advanced Cruise Missiles, B61 or B83 nuclear bombs. The launcher releases the weapon at the six o'clock position, out of the weapons bay. A vast amount of wiring, cables, and other fixtures line the walls and ceiling. (Jim Goodall)

rately guide weapons to target locations. The GBU-37 was added to the B-2 arsenal in late 1997. All of the approximately 100 GAMs built were delivered to the 509th BW. It may be assumed that most, if not all, were expended during Operation ALLIED FORCE against Yugoslavia in 1999.

Joint Direct Attack Munitions (JDAMs) (16)

The B-2's primary conventional weapon is the precision-guided 2000 pound GBU-32 Joint Direct-Attack Munition (JDAM). The Boeing JDAM is basically a tail kit that turns a 2000 pound Mk 84 general-purpose bomb (or a BLU-109 penetrator bomb) into a GPS-aided Inertial Navigation System (INS)-guided precision weapon. It is estimated that 700 GBU-32s were dropped by B-2s during Operation ALLIED FORCE in 1999, with an estimated 87 percent target destruction rate.

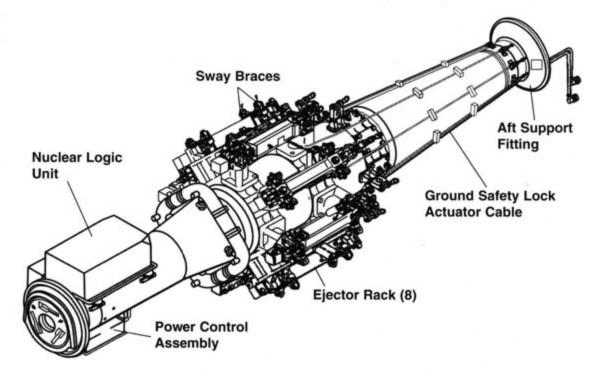
CBU-87 (36)

The CBU-87 Combined-Effects Munitions (CEM) contain 202 BLU-97/B combined-effects bombs, which when released have a footprint of approximately 600 feet (182.9 M) wide by 1000 feet (304.8 M) long. The bomblets are effective against light armor, personnel and materiel. Each bomblet is approximately 7.8 inches (19.8 cm) long and 2.4 inches (6.1 cm) in diameter. The CBU-87 is 7.5 feet (2.3 M) long and 1.3 feet (0.4 M) in diameter and weighs 948 pounds (430 kg).

CBU-89 (36)

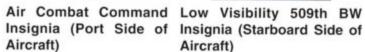
The CBU-89 Gator is an area-denial cluster weapon containing 72 BLU-91/B anti-tank and 22 BLU-92/B anti-personnel mines. In this configuration it weighs just under 1000 pounds (453.6 KG). It is 7.5 feet (2.3 M) long and 15 inches (38.1 CM) in diameter. The size of the mine-field depends on the height from which the weapon is released, but it is typically 500 feet (152.4 M) wide by 1300 feet (396.2 M) long.

Advanced Applications Rotary Launcher





Missouri on 17 December 1993.





Insignia (Port Side of Insignia (Starboard Side of Aircraft)





A B-2A drops two 2000 pound (907.2 kg) Joint Direct Attack Munitions (JDAMs) over Afghanistan in the fall of 2001. Spirits bombed Taliban and al-Qaeda targets at night during

Operation ENDURING FREEDOM. The missions originated at Whiteman AFB, with the B-2s recovering at Diego Garcia following their raids on Afghanistan.



SPIRIT OF NEW YORK (AV-3, 82-1068) at Edwards AFB, California.



SPIRIT OF MISSOURI (AV-8, 88-0329)



Starboard Gear Door of SPIRIT OF WASHINGTON (AV-11, 88-0332)



Port Gear Door of SPIRIT OF WASH-INGTON



AV-5 (82-1070) was named FIRE & ICE for climatic testing. This B-2A was renamed the SPIRIT OF OHIO when delivered to the 509th BW in 1997.



SPIRIT OF NEBRASKA (AV-13, 89-0128)



SPIRIT OF HAWAII (AV-16, 90-0041)



SPIRIT OF PENNSYLVANIA (AV-20, 93-1087)







The Mission Commander's and Pilot's names are displayed on the nose gear door of B-2As, including the SPIRIT OF MISSOURI (88-0329)

MISSION PILOT
COMMANDER
COL W PERCIVAL LT COL J GEORGE

CBU-97 (36)

The CBU-97 Sensor-Fused Weapon contains ten BLU-108/B submunitions, each containing four armor-penetrating projectiles with sensors to detect infrared targets. At a pre-set altitude, the rocket motor fires to spin the submunitions and initiate an ascent. Each submunition then releases its four projectiles that are lofted over the target area. The projectile's sensor detects a vehicle's infrared signature and its explosively-formed penetrator fires at the heat source. The CBU-97 is 7.5 feet (2.3 m) long and 15 inches (38.1 cm) in diameter and weighs 925 pounds (419.6 kg). It can cover an area of approximately 500 feet by 1300 feet.

AGM-154 Joint Standoff Weapon (JSOW) (16)

The Raytheon JSOW is a low-cost glide weapon with a standoff capability from 20 miles (32.2 km) to 50 miles (80.5 km), depending on the launch altitude. It is a launch-and-leave weapon that employs a tightly coupled GPS/INS navigation system for midcourse navigation, and imaging infrared and datalink systems for terminal homing.

The JSOW is just over 12.8 feet (3.9 M) long and weighs between 1000 and 1500 pounds (453.6 to 680.4 kg). Extra flexibility has been built into the missile by its modular design that allows several different submunitions, unitary warheads, or non-lethal payloads to be carried. JSOW-A (AGM-154A) dispenses 145 BLU-97 combined-effects bomblets which are used to attack soft targets such as Surface-to-Air Missile (SAM) sites or airfields. The JSOW-B (AGM-154B) dispenses six BLU-108 anti-armor submunitions. The B-2 became operational with JSOW in mid-2000.

AGM-158 Joint Air-to-Surface Standoff Missile (JASSM) (16)

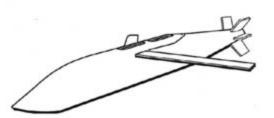
The Lockheed Martin JASSM is a precision cruise missile designed for launch from outside area defenses in order to hit a variety of fixed and relocatable targets. After launch, it will be able to fly autonomously over a low-level, indirect route to the target area where an independent terminal guidance system will guide the missile in for a direct hit.

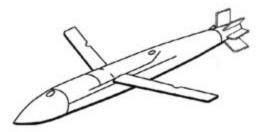
JASSM's midcourse guidance is provided by a GPS-aided Inertial Navigation System (INS) protected by a new anti-jam GPS null-steering antenna system. An Imaging Infrared (IIR) seeker and a target recognition system guide the missile in the terminal phase. These provide aim-point detection, tracking and strike capabilities. The AGM-158 is 14 feet (4.3 M) long, weighs 2250 pounds (1020.6 KG), and has a range exceeding 200 nautical miles (230.3 statute miles/370.6 KM).

JASSM is scheduled to be available to the B-2 sometime in 2002/2003.

AGM-154 JSOW

AGM-158 JASSM

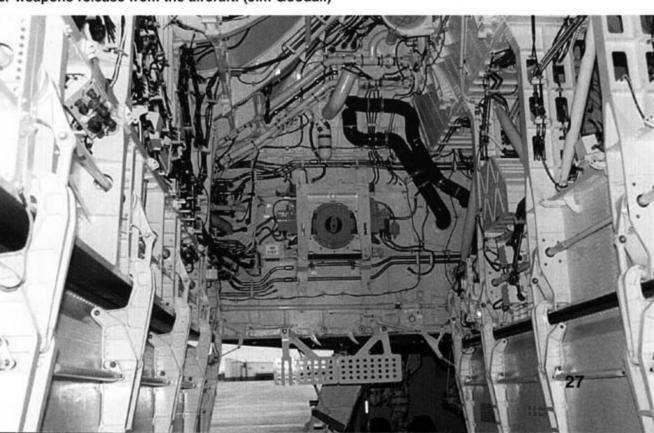






Weapons technicians maneuver a 2000 pound (907.2 kg) GBU-32 JDAM on a standard Air Force weapons loader underneath a B-2A for attachment to the rotary launcher. Each rotary launcher holds eight JDAMs. (Northrop Grumman)

The AARL was removed from this B-2A weapons bay, revealing its fairly clean appearance. The two bay doors rotate on their hinges during weapons loading, lying flat against the fuselage undersurface. Perforated wind deflectors mechanically deploy anytime the weapons bay doors are opened. These improve airflow around the weapons bay for cleaner weapons release from the aircraft. (Jim Goodall)





A Joint Direct Attack Munition (JDAM) configured 2000 pound BLU-109 bomb is placed on a trailer near a B-2. A GPS receiver in the tail unit precisely guides the weapon. Strakes fitted to the centerbody aid the JDAM in accurately flying to its target. The Spirit can carry 16 2000 pound JDAMs – eight per weapons bay. (Jim Goodall)

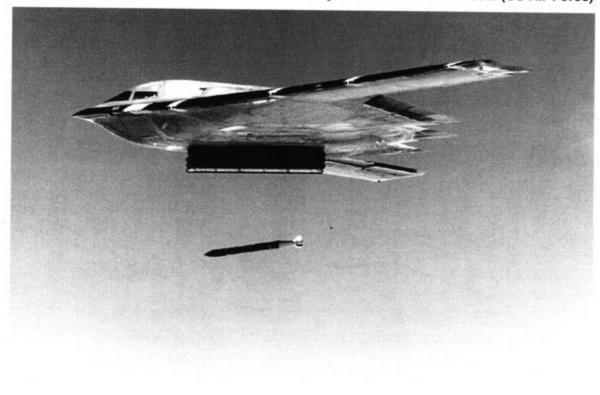
The most powerful JDAM weapon available to B-2 crews is the 4700 pound (2131.9 KG) GBU-37/B (formerly GAM-113) hard-nosed 'Bunker Buster.' When dropped from an altitude of 45,000 feet (13,716 M), this weapon can penetrate three to four layers of 12 foot (3.7 M)-thick reinforced concrete. A sensor in the tail assembly detects how many floors the 'Bunker Buster' has penetrated. The Mission Commander can select the required detonation level. (Jim Goodall)

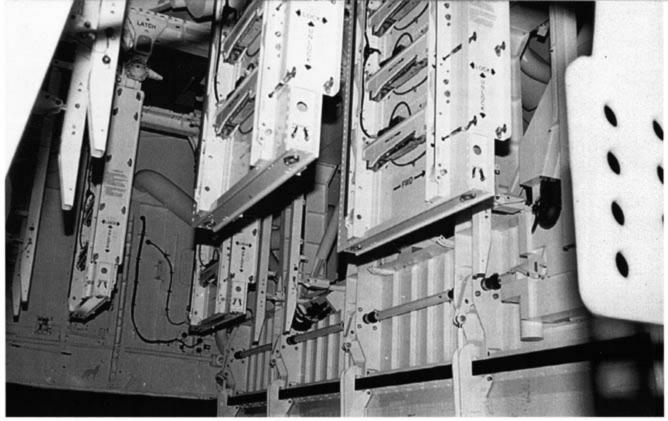




A bomb loading crew maneuvers a 2000 pound GBU-32 JDAM to the starboard weapons bay of the SPIRIT OF MISSISSIPPI (AV-6, 82-1071). The bomb is supported on the hoist section of an MJ-1 lift truck – the standard Air Force ordnance loading vehicle. B-2s dropped approximately 650 JDAMs on Yugoslav targets during Operation ALLIED FORCE in 1999. (Northrop Grumman)

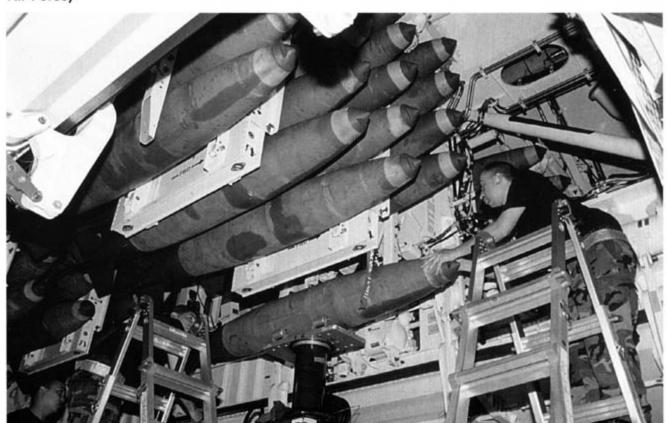
The workhorse of the B-2 Combined Test Force was AV-4 (82-1069), used for weapons certification. On 21 March 1997, AV-4 dropped the first 4700 pound GBU-37/B 'Bunker Buster' weapon. During this time period, the AV-4 was nicknamed CHRISTINE (after the Stephen King horror story), because crewmen thought the aircraft was possessed. AV-4 was named the SPIRIT OF INDIANA after delivery to the 509th BW in 1999. (US Air Force)





Employing two weapons bays allows the B-2A to handle two different types of ordnance at the same time; however, you cannot mix the type of weapons in the same bay. One example of mixed weapons loads aboard a Spirit is loading 40 500 pound bombs in one bay and four 4700 pound GBU-37/B bombs in the other bay. Weapons racks are simple to install, allowing for varied weapons loads. The B-2's weapons bay interior is painted Gloss White (FS17875). (Jim Goodall)

Armorers perform the intricate task of loading 500 pound (226.8 κ G) Mk 82 general purpose bombs into one of the B-2's two bomb bays. The weapons are loaded in four columns of ten bombs per column in each bay. The Spirit can hold 80 Mk 82s, a total of 40,000 pounds (18,144 κ G) of ordnance. (US Air Force)





AV-3 (82-1068) drops 500 pound Mk 82 bombs over the Nellis AFB bombing range in Nevada during weapons certification testing. This B-2A was nicknamed THE GHOST during flight testing. The Spirit's 50,000 pound (22,680 κg) bomb load is 4000 pounds (1814.4 κg) less than the load carried by a 'Big Belly' modified B-52D during the Vietnam War. By 2002, B-2As will also carry the 500 pound GBU-31. It is a precision-guided JDAM (Joint Direct Attack Munition) version of the Mk 82 bomb. The GBU-31 will allow B-2 mission commanders to target 80 different sites in all weather and light conditions from 50,000 feet (15,240 м). (Northrop Grumman)

Interview with Major Scott Vander Hamm (continued), March of 1998

(Vander Hamm flush; author indented.)

I started out as a navigator in the B-52. When General [John T.] Chain [Commander of Strategic Air Command from 1986 until 1991] wanted to go with a three-person aircraft (two pilots and a navigator) and found out that that was not going to happen, he pushed hard to have some navigators go to pilot training. I was one of those that benefited from that. I went to pilot training and I flew the B-1 for four years as a pilot, aircraft commander and instructor pilot, and then out of the B-1 I was selected to come to the B-2...

Comparing the B-52 and the B-1 with the B-2, obviously the new aircraft is going to be a better aircraft, but how do you as a...member of the crew see the B-2 versus the older-generation aircraft workload-wise?

Workload-wise, Northrop Grumman did a great job of automating a lot of things that we would normally have to do by hand, so the automation has taken off a lot of the workload... The BUFF [B-52] had six crew members and the B-1 was down to four, so there was a little bit of automation. Now the B-2 has more automation. There are crunch points in missions (combat or training) when you have to have things very well choreographed. If you're flying along and you get to a point where you do one thing wrong, you could cost yourself more time

An early B-2A Block 10 flies over the Mojave Desert near Edwards AFB, California. The outboard split flaps are slightly open, their normal in-flight position. These surfaces function only in low-speed flight to provide secondary pitch and roll control for the Spirit. Early B-2s had black leading edges instead of the Gunship Gray edges of Block 30 aircraft. (Boeing)

to work around that than you would have otherwise, so those crunch points need to be choreographed and worked out in simulators and things. In our training process we train through those crunch points. So yes, I'd say it's very simple to fly and the automation helps out quite a bit.

The B-2 was designed for high altitudes, however we have a TF [Terrain-Following] capability. If the particular threat we are going against is going to put us in that regime, we have the ability to fly hands-off TF like the B-1 at low altitude.

Much like the F-117, low observable is as much the avoidance of hostile locations. Is there a lot of mission planning involved?

Yes. In fact, here the 509th OSS [Operational Support Squadron] does all of our mission planning and they are integrally involved with every aspect of our mission. If they don't do a good job, then we will not be as successful. It's a mission that's highly dependent on their expertise to fly the course that we need to fly. Obviously, if we have a choice we're not going to fly through a threat – we're going to circumvent it. They do really good at giving us the best route of flight for the particular scenario we're up against.

Because of the GE [General Electric] engines that they use in the B-2, coupled with a very low wing loading, it has been assumed that the aircraft has a very, very high altitude capability – in excess of 70,000 [21,336 M] feet. Can you comment?

A B-2A Spirit flies low in formation with America's other current strategic bombers. A Boeing B-52H Stratofortress (nicknamed the 'BUFF') assigned to the 917th Wing at Barksdale AFB, Louisiana flies atop the formation. Between the B-52 and the B-2 is a Rockwell B-1B Lancer (a.k.a. the 'Bone') assigned to the 28th Bomb Wing at Ellsworth AFB, South Dakota. (USAF)



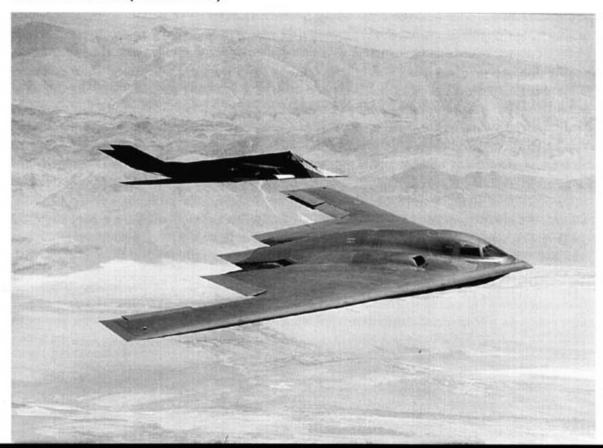
Fifty thousand feet [15,240 M] is what we have in our Tech[nical] Order [TO] and that's really the limit that I can tell you of our aircraft's capability. Anytime you go above 50,000 feet (you can look in any unclassified Air Force regulation), you need a full pressure suit. We do not fly with those. The TO limit that is unclassified – that we share even when we go on air shows – is 50,000 feet. You talked about the wing loading – that's an interesting thing. It has the lowest wing load of any aircraft and what that means is...if you are in turbulence, it'll be very bumpy because of the wing loading. In TF on a summer day it can be very bumpy downstairs and so it's very important to have been in the air recently. Then you're not as susceptible to stuff like being jostled around so much. I've had it so bumpy that as I went to touch the MDU [Multiple Display Unit], I couldn't even touch the buttons.

We have four of them in front of each pilot. I had to reach my hand up there, stabilize my hand, and then crawl my fingers over to the button I wanted to push.

Now, unlike the B-1 that has the canards that will smooth out the aircraft, is there...?

That's called SMCS – the Structural Mode Control System – and basically it was designed to increase airframe life by taking some of that loading off. It doesn't smooth it out. What smoothes it out is when the wings come back. The wing loading (like a B-1 and an F-111) is very high, so we could fly and even in what would be severe turbulence to another aircraft, it would be light turbulence to a B-1. The SMCS [small canards mounted on the B-1's nose – ed.] move at 200° per second and they're constantly adjusting. They give a better bombing platform and they also increase the structural life of the aircraft.

A B-2A (AV-6, 82-1071) flies with a Lockheed Martin F-117A Nighthawk over California's Mojave Desert. The strongest computing power available to the F-117's designers was the equivalent of a simple four-bit 8086 processor. The B-2's designers took advantage of the massive computing power available from super-fast mainframe computers. The earlier Nighthawk uses a faceted surface design, while the Spirit employs smooth blending of the airframe surface. (US Air Force)



There's a device called the Gust Load Alleviation System and that's what looks like the beaver tail. It moves to take away some of that rolling impact and increase the structural life of the aircraft. It's just another good design and it's there to help the ride for the pilots, the bombing platform, and the same reasons they have the SMCS on the B-1.

The beaver tail is what dampens some of the loads on the airframe in a high-turbulence, lowaltitude environment.

Interview with Brigadier General Tom Goslin, 509th Bomb Wing Commander, March of 1998

Note: Following this interview, Brigadier General Goslin was promoted to Major General. As of this writing, he is assigned to the Pentagon. (Goslin flush; author indented.)

When did you become involved in the B-2 program?

Originally I was briefed in late 1981, again before I moved up to the black roll office (before it was brought into existence – the XO-SP [Vice Commander Support Squadron] office). I was a bomber action officer and XO-XFS [Vice Commander Preliminary Mission Planning] (or the Air Force's plans office for bombers and ICBMs) and I was briefed into the B-2 program and the [AGM-129 Advanced Cruise Missile] ACM program late in 1981. Then my involvement there just carried over and I was selected to be the first bomber guy in the XO-SP office when

Brigadier General Tom Goslin, Commander of the 509th Bomb Wing, stands in front of a B-2A while speaking to the air show crowd gathered at Nellis AFB, Nevada. This was during the US Air Force's 50th Anniversary celebration in April of 1997. Goslin was later promoted to Major General. (Jim Goodall)



it was created about six months later.

From the initial conception of the B-2 in drawings to what we have today (the Block 30), did the design change dramatically? I know some of the mission profiles changed, but...

It changed a little bit but I wouldn't say dramatically. The plan for the aircraft looked a little bit different, but you would have recognized it instantaneously as the B-2 that we have today.

When did you become involved in the 509th?

I became involved in the 509th when General Joe Ralston (who in 1995 was the commander of Air Combat Command) fortunately selected me to become the Wing Commander and that was the first time that I started to have any direct involvement in the 509th. Now he also had hired me as his ADO [Assistant Director of Operations] at Air Combat Command in the summer of '95. So obviously I worked with the 509th like I worked with all the wings of Air Combat Command in taking care of different training and operational issues. When I found out that I was going to become the Wing Commander – that would have been in late '95. I also came out on the Brigadier General's list and that year the list was released just before Christmas, so I knew then for sure.

The B-2 is a very complicated system. All stealth systems are very complicated in that most

The B-2A SPIRIT OF PENNSYLVANIA (93-1087) taxis to the end of a runway at Whiteman AFB, Missouri. The auxiliary intake doors and split flaps are open and the 'beaver tail' is lowered. Despite the open and moved surfaces, the B-2 has a low Radar Cross-Section (RCS). Gen Larry Welch – Air Force Chief of Staff when the Spirit first flew in 1989 – said: "The B-2's RCS is in the insect category." (Jim Goodall)



of it is in the design, not necessarily in the coatings. The coatings are important, but most of it is in the design of the airframe. The coatings are the final products that really hone the overall LO [Low Observable] signature. The B-2 has many more coatings that are used on it and different materials used on it than other stealth aircraft. It was a very high-technology thing, a very complicated thing, and until we started to use the aircraft in a lot of different types of environments and operationally...that was when we first really started to understand the coatings and really started to press the coatings. At that time...the Block 10 showed a tendency for some of the strips of tape on the edges to start to come up in the rain.

What is involved from the 509th to deploy a number of B-2s to foreign soil?

The B-2 is such a special aircraft, a costly aircraft, that there are precautions from a security standpoint. When you deploy overseas, you do a lot of planning prior to that to ensure that you're going to a safe location. This is in order to prevent terrorist acts, local protest...

Are there contingencies in place...what if you had a B-2 where you had a mid-air collision with another aircraft – where you had to land it immediately, didn't lose the aircraft, and there was no loss of life but it's not necessarily in a secured location?

Again, there are plans that are put into place every time we move any type of military air-craft anyplace in the world so that if something occurs that is not in the primary plan – a divert for whatever reason – we have got plans to take care of that. The B-2 is no different. Some parts of the B-2 need to be protected from a technological standpoint, so that just means that we have a little more security than we normally would at other places.

Is it comparable with the F-117A or the B-1B?

Yes. When I was in the F-117 program, we had pictures of ourselves sitting in the cockpit with our names on our jets, but this was all top-secret – they were kept in a vault. We were talking about maintenance...this aircraft has much later technology than the B-1 and it was built to be very maintainable, or much easier to maintain. For instance, with the exception of working on certain areas underneath the aircraft up toward the leading edges of the surfaces, all the stuff underneath (the engines, bays, avionics bays and stuff like that) was all built to be accessible while you're standing on the ground. Big improvements. So in the traditional sense (engines, hydraulics, electronics, air, that type of thing), the aircraft is a very reliable aircraft. You're familiar with how we do phase¹ in an aircraft. Right now we have the longest time between phases of any combat aircraft in Air Combat Command. We're at 600 hours. That's longer than anybody else – fighters, bombers, whatever. The reason it's like that is because in terms of its basic flying abilities and its basic fighting abilities, the aircraft is a very, very good aircraft. We are more intensive in terms of the coverings because unlike all the other jets except the [F-]117s, our covering is a part of the reason that the jet works – versus an aluminum aircraft, which has either a nice covering or a camouflage covering.

What is the life expectancy of the B-2?

¹Phase refers here to an aircraft's time in between major inspections, when routine preventative maintenance is performed on the aircraft.

I don't know. Right now we make statements like it'll be here through 2030. The folks that work it – from the NCOs to the senior NCOs that have worked on a number of different aircraft, both bombers and fighters – they say this aircraft is probably the most solid-built aircraft they've ever worked on. In terms of its structure, this aircraft has much more in common with a fighter than it does with a bomber. It is a very strong, very rigid aircraft. It has a powerful airframe. Since it's mainly non-metal, we do corrosion control on the aircraft but the corrosion is not nearly the problem on composite aircraft as it is on aluminum aircraft.

Compared with the F-117, without giving the specifics, is the B-2 stealthier, the same...?

It's comparable. Both aircraft are the most survivable aircraft the United States has. Obviously, ICBMs [Intercontinental Ballistic Missiles] are probably the most survivable right now, but both aircraft have comparable survivability. Both aircraft are designed essentially to do the same thing, i.e., go into the most heavily defended areas and deliver precision weapons. Both aircraft can accomplish that. Where we differ most obviously is that the B-2 can do its mission from the heartland of America and come back to the heartland of America. That's our huge advantage nowadays. If we don't have to deploy thousands of tons of equipment forward and hundreds of people forward, number one: You don't have to have a place to put them. Number two: That many more people are not in harm's way. And number three: It is strictly a national thing. Whatever the national command authority wants, we can carry it out from right here in the United States. We're

the only aircraft in the US inventory and probably the only system in the US inventory that offers precision conventional attack through any type of weather, which is a big [plus]. Another thing is that like all bombers, we carry mass. We're talking about mass in terms of precision weapons with a single aircraft, putting only two people at risk. I can't get into it, but I can tell you from a weaponeering standpoint about the B-2's ability to independently target 16 weapons on a single site if need be, or across many sites – up to 16 sites. That's a huge advantage over the delivery systems we have right now.

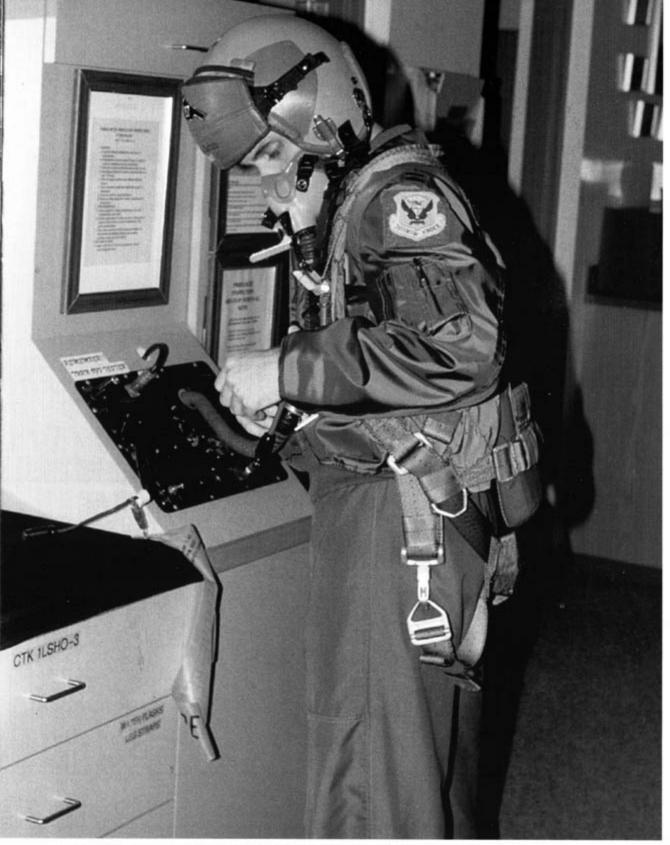
I think what's important for your readers to know is that as American taxpayers, they made a huge investment in this aircraft and a huge investment in this system. This system is combatready right now. This system can do its mission in a conventional or in a nuclear way, and we are tasked to do that. We have commitments throughout the spectrum of conflict that we can meet. We are able to meet our commitments while continuing to grow and train additional crews so that we will have a full crew force and a full maintenance and support force in place when we get all of our aircraft on board. I think that is really important to the American people.

The SPIRIT OF PENNSYLVANIA (93-1087) takes off on a cold, gray day in central Missouri. Auxiliary air intakes open to provide extra air for the engines for takeoffs and landings. Taxi and landing lights mounted on the landing gear struts are switched on for this cloudy day. (Jim Goodall)



B-2As are parked on the ramp at Whiteman AFB during an 'Open Skies' photo opportunity. The Spirits were photographed by an OC-135B assigned to the 55th Wing at Offutt AFB, Nebraska. 'Open Skies' events allow participating nations to request a fly over of any base in the United States with 24 hours' notice. An essential aspect of this exercise is that all assets are to be made visible to the over-flying aircraft. (509th BW/Public Affairs)





A B-2 pilot checks his breathing and oxygen system in the 509th BW's Life Support Facility. The Wing insignia is placed on the upper left sleeve of his flight jacket, while the captain's rank insignia appears above this patch. The pilot attaches the straps worn over his shoulder and waist to the ACES II ejection seat's parachute when he prepares for take-off. (Jim Goodall)



The 509th Bomb Wing's 325th and 393rd Bomb Squadrons share an operations building located in a secure area of Whiteman AFB. People entering the facility must pass through a series of gates staffed with Air Force security personnel. Personnel not wearing the proper identification badge are allowed access only with written permission and proper escort. 'Use of Deadly Force Authorized!' (Jim Goodall)

Six B-2s are parked on the Whiteman AFB ramp in preparation for a fly-over in support of the 'Open Skies' policy. This is done in accordance with the SALT (Strategic Arms Limitation Treaty) II agreement between the United States and Russia (succeeding the former Soviet Union). Spirits normally remain in their hangars between flights to protect the weather-sensitive Radar Absorbent Materials (RAMs). (509th Bomb Wing/Public Affairs)





Major Len Litton reviews the pre-flight checklist with the Spirit's Crew Chiefs. The B-2 support crew does all of the preflight work, just like with the now-retired SR-71 Blackbird 'spyplane.' When the Spirit's pilots arrive for a mission, they just climb the ladder, start the engines, confirm that everything is 'A-OK,' then taxi out of the hangar for takeoff. (Jim Goodall)

The open main landing gear doors give the B-2 directional stability at low speeds. Landing approach speed for the Spirit is 161 MPH (259.1 KMH). The 'beaver tail' on the aft center section is lowered. This assembly allows changes in the Angle of Attack (AOA) in both take-offs and landings. (Jim Goodall)





B-2 Mission Commander and Instructor Pilot Major Tony Monetti is strapped into the starboard seat. The Spirit uses the Boeing (formerly McDonnell Douglas) ACES (Advanced Concept Ejection Seat) II seat, which is fitted to most other current USAF aircraft. Monetti is ready to start the four General Electric F118-GE-100 engines. These are basically the same engines that power both the Rockwell B-1B and the Lockheed U-2S. The latter aircraft can reach altitudes above 80,000 feet (24,384 M). (Jim Goodall)



A B-2A makes a typical final approach to Andersen AFB, Guam during the GLOBAL POWER deployment from Whiteman AFB, Missouri in October of 1998. Split drag rudders on the wingtips provide yaw (left-right) control at all flight conditions. The Spirit approaches the runway at 161 MPH (259.1 KMH). (Northrop Grumman)

A B-2A completes its landing run at Andersen AFB during exercise GLOBAL POWER. The split drag rudders are fully opened on the outer wings to help slow down the aircraft. Auxiliary intake doors are open above the engine nacelles to supply additional air to the four engines. Landing and taxi lights on the nose and main landing gear struts are on for improved visibility. (Northrop Grumman)





The B-2A SPIRIT OF MISSOURI (AV-8, 88-0329) touches down at Andersen AFB, Guam on 13 October 1998. This Spirit and two other 509th Wing B-2s deployed from Whiteman AFB, Missouri to Andersen AFB for the GLOBAL POWER Operational Readiness Exercise (ORE). The successful exercise marked the B-2's first long-range deployment. (509th Bomb Wing's Website)

The SPIRIT OF MISSOURI arrives on the ramp at Andersen AFB following its flight from Missouri. Auxiliary intake doors atop the engine inlets are opened during ground taxi. Parked behind the B-2A are a Boeing KC-135E tanker in overall dark gray and a McDonnell Douglas C-9A Nightingale aeromedical transport. (Northrop Grumman)

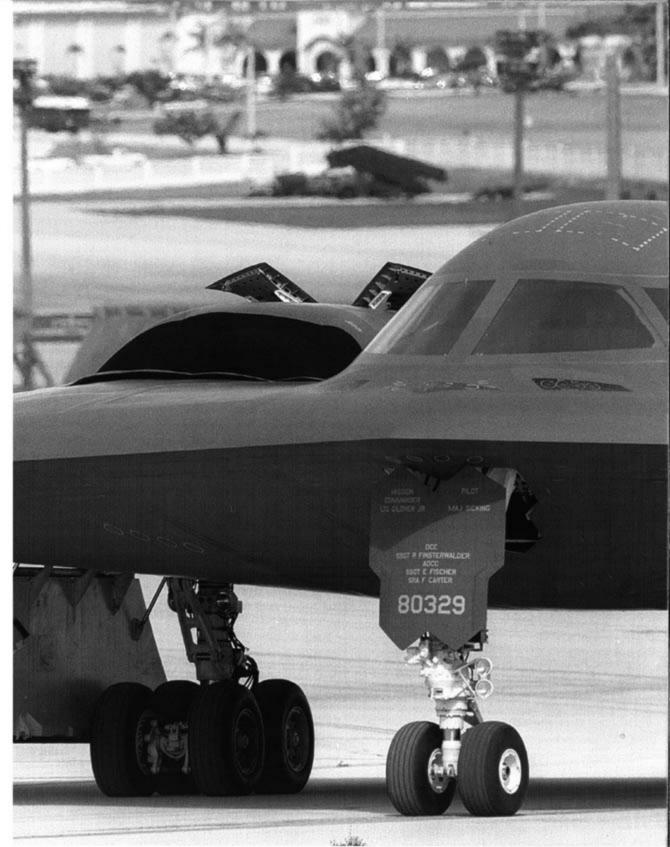




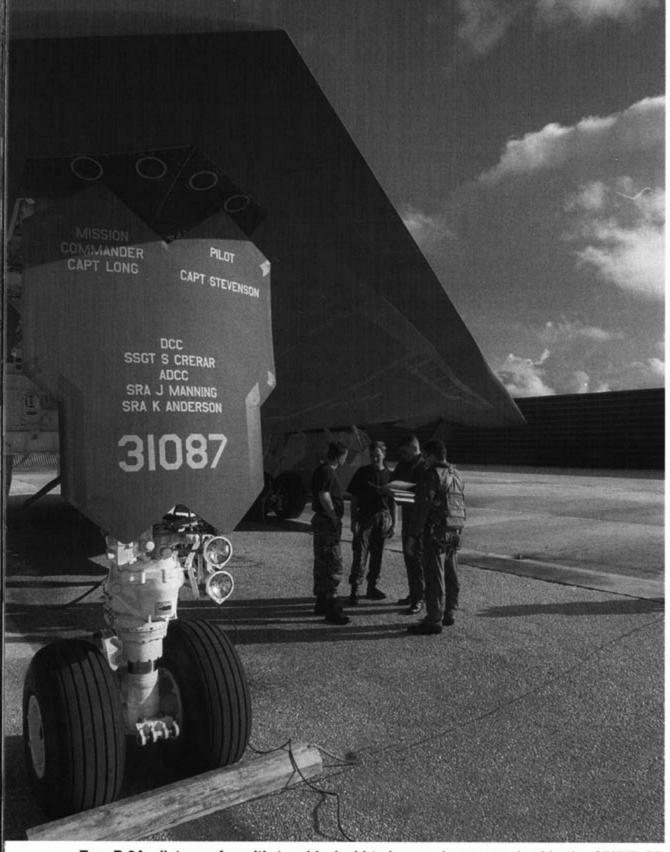
The two pilots of the SPIRIT OF MISSOURI (88-0329) taxi their B-2A at Andersen AFB after their arrival from Whiteman AFB, Missouri. The laminated acrylic windshield panels enclose a fine gold mesh layer to keep out radar waves. Large windshield panels are necessary due to the seats' positions well aft of the windshield. (Northrop Grumman)

Ground crewmen tow the B-2A SPIRIT OF PENNSYLVANIA back to its parking area at Andersen AFB, Guam in October of 1998. The Spirit required a main landing gear tire change while participating in the GLOBAL POWER ORE. The tow bar from the tractor is connected to the nose landing gear axle. (Northrop Grumman)





The SPIRIT OF MISSOURI (AV-8, 88-0329) taxis to its parking ramp after landing at Andersen AFB. The B-2's rear nose landing gear door is closed and opens only when the power is off or during gear retraction or extension. Two taxi and landing lights are mounted on the nose gear strut's port side. (Northrop Grumman)



Two B-2A pilots confer with two black-shirted ground crewman beside the SPIRIT OF PENNSYLVANIA (93-1087). Four flush-mounted static sensors are mounted above the open nose landing gear door. The wing leading edge is swept back at a 33° angle. No leading edge flaps or slots for additional low speed lift are fitted to the Spirit. (Northrop Grumman)



Ground crewmen attend to the SPIRIT OF MISSOURI (88-0329) during its deployment to Guam for the GLOBAL POWER exercise in October of 1998. The crew access door is opened and the ladder is lowered. The nose landing gear door is opened to starboard for gear bay servicing. External air hoses and electrical cables lead from trailers to the B-2A's nose gear bay and cockpit access, respectively. (Northrop Grumman)

A ground crewman checks the starboard engine access panels on a B-2A Spirit deployed to Guam in October of 1998. Each of the four F118 engines is accessed through an outboard-hinged door on the aircraft undersurface, between the main landing gear and weapons bays. All undersurface doors have serrated front edges to minimize radar returns. (Northrop Grumman)



Operation ALLIED FORCE

On 24 March 1999, following the initial cruise missile strikes, the B-2 became the first manned aircraft to engage in hostilities during Operation ALLIED FORCE. This was the North Atlantic Treaty Organization (NATO) air campaign against Yugoslavia. The operation was in reply to the Serbs' brutal conflict with ethnic Albanians in the Serb province of Kosovo. Two Spirits attacked targets in Serbia, with each aircraft dropping 16 2000 pound (907.2 kg) GBU-32 JDAMs after a 16-hour flight from Whiteman AFB, Missouri.

In its first taste of combat, the B-2 bomber defeated not only the Serbian air defense system, but also the naysayers who for years had insisted it would not work as advertised or would never be risked in a real war situation.

The B-2s of the 509th Bomb Wing at Whiteman AFB flew less than one percent of the total sorties flown by NATO aircraft in Operation ALLIED FORCE, but they accounted for 11 percent of the bomb load dropped in that conflict.

Flying 30-hour-long, nonstop missions from Whiteman to Yugoslavia and back, USAF B-2s attacked heavily defended targets in all weather conditions. All returned without a scratch. The stealth aircraft maintained a high readiness rate, given the small number of aircraft available. B-2s participated in 34 of the 53 total Air Tasking Orders¹ in the conflict. Only one mission was scrubbed because of mechanical problems and that B-2 was fixed and ready to go in less than 30 minutes.

The B-2s of ALLIED FORCE put 90 percent of their bombs well within the prescribed 30 feet (9.1 m) range from target. Most of the B-2's bombs hit the bull's-eye, and the rest fell only a short distance beyond. Spirits dropped over 650 JDAMs (primarily 2000 pound bombs) and four 4700 pound (2131.9 kg) GBU-37/B 'bunker buster' weapons during the conflict.

The B-2s operated exclusively at night, sometimes in a two-ship mission but usually as a lone Spirit. While they did not fly 'arm-in-arm' with other NATO assets as part of a strike package, the B-2s stuck to carefully scripted timing for their arrival in and departure from the target area. Spirits sometimes served as the opening round of a multi-pronged assault.

For example, B-2s were sometimes used to precisely crater intersections of runways and taxiways on airfields. Thus boxed in on those airfields and prevented from escaping, the Serb aircraft were later destroyed by non-stealthy B-52 or B-1B bombers that dropped large numbers of unguided 'iron' bombs. In one instance, a single B-2 destroyed two airfields on the same mission. The operation demonstrated that the B-2 can be folded in (in a seamless fashion) with other assets in-theater.

The B-2s took advantage of 'jammers' (Electronic Countermeasures aircraft) that were operating in the area. This tactic was driven more by a desire to provide extra protection for the crews than by a critical operational need.

During a post-ALLIED FORCE interview, then Brigadier General LeRoy Barnidge (509th Bomb Wing Commander) said that he frequently receives questions about whether stealth aircraft need electronic countermeasures support. "The answer is no," he asserted. It was "beneficial and useful to have EA-6B Prowlers and other jammers in the area, but we operated in an autonomous fashion. As the Operation ALLIED FORCE campaign wore on, mission planners became increasingly confident about sending B-2s against targets without any EW [Electronic Warfare] support.

"Operation ALLIED FORCE proved that the B-2 is a ready asset that could easily become the first weapon called on in a crisis. In a future conflict, it is possible that the United States might have to prepare for battle in a foreign area without the benefit of forward-based forces. This situation could result from a number of factors such as strategic surprise, space constraints, and political constraints (to name just a few). In such a situation, the United States would still have a powerful military option in the B-2.

"We have validated that we can reach out from the continental US and begin to prosecute the air campaign while other assets are flowing into the theater," Barnidge said. "That's a pretty big deal. I think people have fundamentally changed – broadened – their perspective of the capability of American airpower. And certainly the B-2 is an American asset, instead of just an Air Force asset."

The Balkan conflict also yielded positive results on another important issue – pilot endurance. At the start of the action, even the B-2 pilots themselves had concerns about being able to continue the long Missouri–Yugoslavia round-trip flights beyond a couple of weeks. They found themselves convinced when the 78-day conflict ended on 19 June 1999 that they could have kept up the bombing campaign longer – as long as might have been necessary.

Fifty-one pilots flew the B-2 in combat. Most of them flew one mission, a handful flew two, and one pilot flew three times. The desired goal was for pilots to get at least three days of rest between missions, but when the pilots landed, they appeared to be alert and were ready to get back in the rotation for their next mission.

The B-2's mission capability rate during ALLIED FORCE (not counting low-observable maintenance) averaged approximately 75 percent. When such maintenance is included, the figure becomes approximately 60 percent; however, not a single B-2 mission started late and only

Ground crewmen pull the SPIRIT OF TEXAS (AV-7, 88-0328) from its hangar at Whiteman AFB prior to a mission over the former Yugoslavia during Operation ALLIED FORCE. AV-7 was nicknamed THE PIRATE SHIP during early flight test at Edwards AFB, California. This Spirit was loaned to Northrop for electromagnetic compatibility and emission security testing during 1993. (Northrop Grumman)



¹Air Tasking Order: A plan which coordinates all activities of fighter, attack, bomber, tanker, electronic warfare, and search and rescue aircraft for a given mission.



Armorers prepare 2000 pound (907.2 kg) GBU-31 Joint Direct Attack Munitions (JDAMs) for loading onto a B-2A at Whiteman AFB. The weapons are transported on a trailer to the individual Spirit's hangar. Strakes attached to the bomb body stabilize the JDAM while it is steered to its target by the tail fins. (Northrop Grumman)

A B-2A sits outside its hangar on 'Night One' at Whiteman AFB, prior to the first combat mission in support of Operation ALLIED FORCE. Another Spirit is parked just inside a hangar. During ALLIED FORCE in 1999, B-2s were usually sent on single-aircraft missions to attack targets in Yugoslavia. Occasional two-ship missions were also flown during the North Atlantic Treaty Organization (NATO) air campaign. (Northrop Grumman)



one aircraft had to abort its mission for an in-flight mechanical problem. Once that aircraft landed, a repair was made and it was ready to go again in just 15 minutes. Two other missions were canceled after take-off because NATO partners withdrew permission to attack the intended targets.

During ALLIED FORCE, the 509th BW had nine operational B-2 bombers on the ramp at Whiteman. The USAF assigned eight B-2s to combat missions; six were available at any given time. The bombers not in action were used to continue training of new B-2 pilots, conduct aircraft tests, or carry out mandatory inspections.

On 'Day One' of the operation, the 509th carried out the preflight inspection and final mission planning for the B-2s going into action. These tasks were conducted by other team members on behalf of the pilots who were in crew rest and not to be disturbed until just before the flight. When it was time to go, the assigned crews got into their aircraft, taxied, and took off.

Even if they were headed for targets in entirely different parts of Yugoslavia, the B-2s taking off on the same night usually flew together from Whiteman across the Atlantic, their goal being to provide mutual support on the long trans-Atlantic trip. They refueled twice en route – once over the Atlantic and again just before entering Yugoslavian airspace.

During the flight, crew members reviewed their checklists, studied imagery of the target, got weather updates, and monitored the health of the aircraft, endeavoring to make sure everything was perfect on the first pass. They slept in shifts.

These 'power naps' were actually factored into the mission planning. A crewmember took his snooze on a beach lounge purchased at the local Wal-Mart store. This particular lounge model just happened to fit perfectly in the space behind the Aircraft Commander's station. Other techniques for freshening up included wet-toweling, changing clothes, and eating warm meals.

Upon entering the war zone, crewmembers went through a ritual of getting ready for combat by putting on 'long johns' (thermal underwear), winter-weight flight jackets, survival vests, and other gear not necessary during other portions of the mission. The final element in preparation was the powering up of the weapons and ensuring that the computer was communicating correctly with the bombs.

On approach to the designated target area, the B-2 generated a synthetic aperture radar picture almost photographic in detail and quality. This was then checked against intelligence photos and the target was identified. Next, the GPS coordinates were verified via the B-2's unique GPS-Aided Targeting System (GATS) equipment that permitted the B-2's Mission Commander to choose aim-points on the target – even if clouds, darkness or weather obscured it.

The coordinates were then updated, if necessary, and fed into the JDAM weapon via an electronic umbilical cord. At the appropriate moment (once for each bomb), the bomb bay doors would open, a JDAM would drop clear of the aircraft, and the weapon would then steer itself to the target.

Each B-2 could (and in some cases did) attack 16 different target locations per mission. Pilots reported that apparently they were never detected. One said that moments after touching down at Whiteman, he was intrigued to see a Serb leader on television, standing in a crater, complaining about NATO's use of cruise missiles. "It wasn't a cruise missile," the pilot said, "It was us! That showed they never knew we were there."

"The JDAMs proved outstandingly reliable and accurate," remarked one lead pilot. Barnidge said that the reliability of the JDAM was well above 95 percent, adding that, "There were no stupid munitions dropped by the B-2."

Interview with Major Tony Monetti and Major Harry Foster, 4 August 2000

Note: Major Monetti and Major Foster each flew two B-2A combat missions during Operation ALLIED FORCE.

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Did both of you gentlemen fly during ALLIED FORCE?

Yes. I led 'Night Two' [25 March 1999] and Tony, I don't know when.... I don't remember what night I flew either, but I did fly.

When things were starting to heat up in the Balkans, did you think they were going to use the B-2?

Prior to that we were in for two years here. We had been on everyone's drawing board to use. There was a cadre of guys who were always in what we call continual spin-up, working up contingency plans...they were brought in and told, 'This is a your eyes only'-type of operation. That had gone on for approximately two years here, so when this began – I don't want to say we view any of these things skeptically – we weren't anticipating that anything would become of this. The negotiations were ongoing in France, we were watching the news, and Congress seemed not really interested in our getting involved in this. So when we were first brought together and told that we were being considered in a plan – 'You guys are going to be the first eight guys' – we all said, okay, here we go again. As it grew closer, about two weeks from the actual operation, the indicators were that things were heating up and getting more serious. When we actually got to a point where we had never been before and when we got the war warning (a piece of paper on the base), then we were all pretty sure that hey, this might happen.

That's when it started getting exciting?

That's right. From the beginning we were thinking that maybe this was just a two-day type of affair and so it was kept to a very small group of people initially. Then as we got very short, we realized that this might in fact be an air campaign, and so that set off another level of spin and got everybody on the base excited about it.

We got everyone in the B-2 program combat experience and that was a masterstroke from the leadership here. They recognized that they had hired a cadre of very experienced fighter and bomber pilots. Instead of trying to limit this to a few people or a few IPs [Instructor Pilots], they spread the wealth amongst everybody – and I think that's going to pay the B-2 dividends in the long run.

From 24 hours before the mission, what was your schedule like? Or 48 hours, what ever the proper...?

I was spare on 'Night One' [24 March 1999]. That night we had two prime aircraft and two spare aircraft. Forty-eight hours out, we came in, sat around the table, and sort of walked through the mission with the OG [Operational Group] and the Wing Commander. We were try-

ing to walk through what could go wrong and if it did go wrong, what were we going to do. We walked through those contingencies and we were briefed on the mission and then we went home. Because of the length of the B-2 missions that we fly, we rely heavily on the mission-planning cell to do the mission plan. When you walk in as a crewmember, essentially you are handed a package and you go execute it. We did have the 'Night One' targets well in advance, so 48 hours out we were looking at those. And then we went home. At about the 36-hour point before take-off, we stayed in crew rest. We came in about five hours before take-off and essentially just briefed it and stepped into the aircraft. We had pretty much done all we could do. It was time to go and do the mission and that's what we did.

What I thought was unique was how here at Whiteman, we train the way we fight and fight the way we train – so this was not something completely foreign to us. We'd come in and get an idea of where we might be going, what the threat picture looked like, then we'd go home. Some of us had flown combat missions prior where you're deployed somewhere, you go into this little room by yourself and then you go launch. Well, in this case, you go home. And that's what was unique about it. You went home and you had dinner. And my kids started picking up that something was different because I always wear this watch right here. My son had an idea that something was up. I told them, 'Well, I'll see you in a couple days.'

Then you'd come in and you'd go do your mission. You'd get your spin-up on where you're going, what the threat picture looked like, you'd launch, and then you'd come back after striking. You would have been up for, I don't know, two days, flying 30 hours, and then you'd come home. And you'd watch your BDA [Bomb Damage Assessment] on CNN [Cable News Network]. It was a completely unique situation. 'Surreal' is the term that was used in the past and it still holds true today.

The SPIRIT OF MISSOURI (AV-8, 88-0329) runs its engines while waiting on the ramp between hangars at Whiteman AFB. The B-2A awaited the go-ahead to begin its 30-hour mission to attack key Yugoslav targets in support of Operation ALLIED FORCE in March of 1999. This was the NATO air campaign against Yugoslavia, whose Serbs were fighting ethnic Albanians in Kosovo. (Northrop Grumman)



The CNN effect is something to comment about. We watched this thing spin up and we were very concerned here about [being] upset and providing operational cover for what we were doing at the base. We went to great lengths to do it and I will tell you that right before I came in to be spare that night, one of my neighbors showed up with cookies at the door and said good luck. Was that chance or what? But it had been reported on CNN and it was widely suspected the B-2 would be used. The American people aren't dumb and it opened my eyes to how difficult it is to cover something like this, what with CNN and everything being live.

What was your feeling when you rolled out of the hangar and started your take-off?

First of all, I have to tell you the feeling on 'Night One' – the feeling as a spare on 'Night One' – was that I was fired up and ready to go. I just knew I was going to go but the aircraft both worked. We saw incredible maintenance reliability during the war. I mean, it was just phenomenal. There was a big letdown after 'Night One,' being spare and not getting to go. 'Night Two,' we went back home to crew rest and through this whole thing again – go right to sleep, come back in, and then get up for the next night's sortie! So pulling out there on 'Night Two' was a different feeling because then you were praying that your aircraft wouldn't break. Again, our maintenance reliability throughout the war was phenomenal. It was nearly 100 percent in terms of reliability and pulling out of the hangar. To get to your question, it was just a great feeling. You walked out there, the Crew Chiefs had done their job, everything was coming together, you'd take-off and it was great. Right after we got airborne there was a lot of letdown ... okay, a lot of adrenaline. I'd flown fighters before and you get very intense for about

¹ A sortie is one operational mission flown by one aircraft.

A shift supervisor and bomb loading team go over their checklist prior to loading JDAMs into the B-2A SPIRIT OF MISSISSIPPI (AV-6, 82-1071). Each B-2 stationed at Whiteman AFB, Missouri is assigned its own individual hangar, where all maintenance, servicing, and weapons loading takes place. (Northrop Grumman)



a two or three-hour sortie. Well, this was a 30-hour sortie so now you had to calm yourself down and think okay, it's still 15 hours to the target. As soon as we got airborne, I went back and went to sleep for about four hours before we hit the first tanker. We were sleeping on the floor in the early sorties. Later somebody had the idea to go to Wal-Mart and buy lawn chairs, but we were sleeping on an air mattress on the floor, which I didn't mind. That was the thing that I learned that was difficult about a long-duration flight: you're going to combat but it's a long way away and you can't get yourself caught up in the moment. So that was different from when an F-117 guy flew an eight-hour sortie in DESERT STORM [1991 Persian Gulf War]. He was up taxiing out of the barn and airborne for what he was about to do. For us, you're up but you can't get too high up because this is a marathon, not a sprint.

I can honestly say that I felt completely comfortable in the B-2. For one thing, I knew the people that were behind this whole operation. You couldn't forget the Northrop Company and all the little manufacturers that are out there that put this plane together and took a lot of pride in each little piece. And you took into account...the maintenance staff, the air traffic controllers and the medics. I mean, it's all this whole team effort. And then us, of course – trained in and then there we were, about to go do it. There is no other aircraft in the world I'd have wanted to be in when I was going into combat – one that gives us this incredible range to get there, the payload (sixteen 2000 pound [907.2 KG] near-precision weapons), the stealth to penetrate the enemy air defenses – you can't beat it! You combine all of these strengths together and you've got yourself one heck of a fighting machine. And then there we were, employing this weapons system for the first time – not a training mission but a combat mission – and I felt completely comfortable. I mean, all of us did. There's no other weapons system I'd want to be in.

What went through your mind just prior to your first weapons release? Did you drop all 16 weapons at the same time or...?

Generally we were dropping eight a pass. And what went through my mind was I guess the pilot's prayer: 'Don't let me screw up.' We were double-checking switches. Okay, we've done everything we can. It was really ... I'd have to say it was more like a training mission. It really was more like flying over Kansas. I expected to see triple A [Anti-Aircraft Artillery] over the target, a lot of things that I had seen flying SOUTHERN WATCH [patrolling the southern Iraq no-fly zone], and it wasn't there. It was like flying over a moonlit night in Kansas.

I remember I had images of what combat would be like, from my experiences in Baghdad. I went to Baghdad a couple times and remember seeing triple A and the missile launches and hearing the radio chatter. Then there we were, over this country... We had just two aircraft – two B-2s and that's it. There was no other package; there were no other aircraft flying that night. They had canceled the air war due to weather, but they still sent two B-2s and there we were. You didn't hear anybody on the radios; you didn't see a thing. There was bad weather beneath us but we were just flying and we released our weapons and came home. And we hit every target. It was a completely unique situation that we were in – and the weapons system works.

Part of it was just listening. They were jamming the guard radio or it was interference or something – I don't know. We were listening to some bad Italian opera singer as we were dropping the things. But that's what was coming in over the guard [reserved emergency radio] frequency – some opera. It was sort of surreal, all of that.

I think he hit the nail on the head also when he said it was like a training mission. I mean,

we were all strapped in. That's one thing I remember that was unique – it took us so much time to strap in because you had to get all this gear that you normally don't train with. That time we were putting everything on and it took you about a half-hour to strap in. And okay then, we were going to really go and do what we'd been trained to do. And there you were, over enemy territory, and you were just doing what you'd been training to do – you got your switches up, you aimed where you needed to aim, and you let the weapons fly and let the weapons do the trick.

Did you get a physical impact when you were releasing the eight 2000 pound bombs?

It was a mild thump. They bumped as they came out. The aircraft decelerated while the doors were open and you felt the doors close and that was it. The aircraft didn't shudder, it didn't fly up – it was just very stable. You added a little power to maintain speed while the bombs were coming out.

And the other kind of feeling you got besides the actual touch-and-feel was the feeling that you knew that these weapons were going to go where you told them to go. You know what I'm saying? I had confidence that this weapons system...that when we put the cursor on the target, it was going to go hit that target. And that's a tremendous feeling.

Is that when the weapons were actually programmed in the cockpit?

We already had certain target coordinates of where we were going to go bomb. We had the ability with the B-2 to use our synthetic aperture radar. We took a couple pictures with the radar and looked to make sure that was where we were going to hit. And now, say if collateral damage might have been even an issue – then we would make sure we were exactly...where we were going – otherwise we wouldn't drop. See? So it depends... There are certain rules of engagement. That's what was great about the B-2 – I was able to take my radar shot and confirm where I was going to hit. Then I put the cursor where I wanted it to go, designated, and then it sent the new, updated coordinates to the weapons. The weapons came out and the GPS [Global Positioning System] did the rest as far as maneuvering the weapons to achieve their kill.

I wasn't thinking about it at the time, really, but the GPS-aided weapon is where we're headed... It was a lot more than just the B-2 going out there carrying a load. There was [Air Force] Space Command doing their job with the GPS satellites and I'll tell you, the coordinates we got were very, very accurate. I delivered seven weapons that first night on coordinates alone because the targets...were heavily treed and I couldn't quite make them out. But we knew we had good coordinates. So I had confidence enough in the coordinates to just let the bombs go. And the bombs went right where we asked them to go and we killed a MiG-29 and a MiG-21

The Explosive Ordinance Disposal (EOD) team of the 509th Bomb Wing loads 2000 pound (907.2 κ G) Boeing GBU-32 JDAMs onto a cart for transport to the individual B-2 hangars. The JDAM is a Global Positioning System (GPS)-guided kit that can be installed on 'dumb' bombs weighing 500 pounds (226.8 κ G), 1000 pounds (453.6 κ G), 2000 pounds, or 4700 pounds (2131.9 κ G). The tail assembly has movable fins, whereas the center body unit gives the JDAM-modified weapon directional stability following its release from the aircraft. The body also gives the JDAM a degree of lift that enables the weapon to hit targets as much as six to ten miles (9.7 to 16.1 κ M) on either side of the B-2's flight path. (Northrop Grumman)

and that was what we could see.

Can you put a MiG kill on your B-2...?

You can't do that. They weren't in the air. The Navy saw it and they put a **Tomahawk** [BGM-109 cruise missile] onto it just to make sure it was dead. Then they tried to take credit for our kill, but that's okay.

Is the radar resolution fine enough that you can determine specific buildings and locations?

Yes. We can't go into the specifics of how good it is. Suffice to say it's of photo quality and it has enough detail to make out...with high confidence what we're aiming at.

During your total of four missions, did you feel that you were detected at any time? Other than after things started going boom, did they know you were there?

Our Wing Commander said that the B-2 was undetected and as far as we know, there never was any indication that they saw us ... detected us in any way.

So in your opinion, the B-2 performed as advertised?

The B-2 did better than advertised. Here's what I have for anyone who's a critic of the B-2: Yes, it is an expensive piece of hardware, but look at what America got for its investment. In the development cost of the B-2 were materials that are going to pay dividends to this country for years to come. The F-22 and the JSF [Joint Strike Fighter], from a materials point of view, have seen direct benefit from that. Additionally, the facilities that we built to test stealth air-



craft...no one else in the world has anything like it and the B-2 program paid for that. To have an aircraft you can launch from the Continental United States, fly it halfway around the world to Europe, drop precision bombs within literally feet of their targets, and return that bomber home – after going into the middle of a very advanced integrated air defense system... I'm sorry for the American taxpayer, for anyone who thinks they didn't get their money's worth. I would have a serious debate with them about that fact.

I'm just glad that we're the ones that got the B-2 and not someone else.

That's correct because the technology, while expensive, works as advertised. And that's not just a propaganda statement. I believe that from my heart and from my soul. We are saving lives and we do have a capability that no other country in the world possesses. It's unique and the United States has it. It's the B-2 bomber and it's here at Whiteman Air Force Base.

An incredible piece of equipment... What was the ride back like after your first mission?

I mentioned to a friend of mine this story: I was coming back and I remember seeing the East Coast of America. I was trying to get a clearance to go to the United States and the radios were kind of garbled. I remember hearing a good old-fashioned New Yorker over the radio and he said, "Hey, you guys just got back, didn't you?" I said, "Yeah," and he said, "What do you want?" I said, "I want to climb to this altitude and I want direct to Whiteman" and he said, "You've got it! You can have whatever you want!" And it was just a nice feeling, hearing a New York voice and a welcome back home. It was a great feeling, knowing that we had accomplished our mission and accomplished it safely and now we were returning home to get the jet back to our guys so we could turn it and fly it again the next day.



Once you were back on the ground and you went to your post-flight, did you feel drained?

No. I was still pretty fired up. I mean, we both took a catnap or two. I slept maybe two hours in my mission. I didn't sleep much.

I slept nine.

So it depends. The fighter guys are a little weaker on their sleep needs ... no, I'm just kidding!

My 'Night Two' was a little bit different. It's not every combat sortie where the Chief of Staff

meets you at the bottom of the ladder when you're done. The question was, "Would you guys like to go be on [CNN host] Larry King?" "No, thank you." Everyone was very pleased in the early nights that the aircraft was performing so well. When the BDA began coming in, the B-2 was a totally untested weapons system. When we took off on 'Night Two,' the guys from 'Night One' were just on their targets as we were launching, so we had no idea if they were going to get shot at. We had no idea. We passed them in the mid-Atlantic and talked to them a little bit on the radio, just to sort of see what they had for us. So coming back after 'Night Two,' we had four data points now that the aircraft was working very, very well. We had four data points that the Joint Direct Attack Munition (which had undergone some criticism from the small aircraft communities) was giving us a better CEP [Circular Error of Probability2] than they had seen in tests. That happened on 'Night Three.' On 'Night Four,' we began getting on a roll. We were there when other aircraft weren't there, so in the early nights it was sort of ... everyone was just very happy that the aircraft was doing so well. After approximately the first two weeks...as [Lt.] General [Michael C.] Short [NATO's air component commander] said, the B-2 carried the mail. We were there - the guys were there night after night in all weather, never minding that the weather in Italy was bad. We were there and we were on the target as Tony said, alone and unafraid in some cases. And we were hauling the mail for that particular conflict.

As I said, it's like the aircraft knew that they were needed. We were operating with only six aircraft. I wish we were doing it today with 16 B-2s. Again, I come from a small aircraft world so I have to hear it from fighter pilots all the time: "Yeah, the B-2...we'll just park all our aircraft and the B-2 will replace the United States Air Force." We're not saying that, but I will say that with two aircraft we were delivering the equivalent of an entire F-16 squadron's production. We were doing it much more accurately than they could and we were doing it compressed and risking fewer lives than they were. Today, with four or five B-2s across the target, I could match an aircraft carrier's production for one cycle of the deck. And the aircraft is very reliable. We began this with a question about maintenance, but the aircraft works. It does. It's highly reliable and when we show up in numbers – four or five of us – we can really bring a lot of punch. It takes a whole lot of aircraft in other contexts...

During ALLIED FORCE, what was the most unusual type of target?

²Circular Error of Probability: The radius of a circle centered at the desired point of impact, which contains 50 percent of the projectiles independently aimed to hit that point.

Ready for 'the big one,' the SPIRIT OF MISSISSIPPI is loaded with sixteen 2000 pound (907.2 kg) GBU-32s. In preparation for loading a B-2, the weapons team assembles each weapons bay bomb load on the respective side of the Spirit. Each weapons bay holds up to eight GBU-32s, which are mounted on Advanced Applications Rotary Launchers (AARLs). (Northrop Grumman)

We put six JDAM 84s into a 40-foot by 40-foot [12.2 by 12.2 m] box on the center span of a bridge that the small aircraft community could not bring down. We figured we had put enough there but because we weren't quite sure what it was made of, we put two more on the northern span just because we could and we had a couple left over. Those were spread about 15 feet [4.6 m] apart and the result was what you see here. Incidentally, the history behind why the B-2 hit this bridge is that an F-15 came by with [2510 pound/1138.5 KG] GBU-15s and put two of them on it. Nothing happened, and that's their bridge-dropping weapon! Then F-117s came by. They put a couple of things on it (two [2000 pound] BLU-109s). Nothing happened to the bridge – still there! Then the B-2 came by...

I will say, there was some neat SCI [Sensitive Compartmental Information]-level message traffic about what they thought of us after we dropped the bridge!

This particular bridge looked exactly like that. You could see the center span under the water. You could see the main spans of the bridge. You could see the land/water contrast and you could see the roads coming in.

I think the best way to describe it is 'near picture-perfect quality.'

And it is presented like a picture. I mean, you would see something like that and then of course resolutions and... Specific details are what I can't get into.

All I can say is near picture-perfect quality and we can expand to refine.

What is your typical weapons load?

Our weapons load? You're talking up to eighty 500 pound [226.8 kG] 'dumb bombs,' up to sixteen 2000 pound precision weapons, and up to eight close-to-near 5000 pound [2268 kG] weapons – 'bunker busters.' That's a tremendous punch that each B-2 can give you. Now can you imagine four, eight, twelve of these aircraft over the target area?

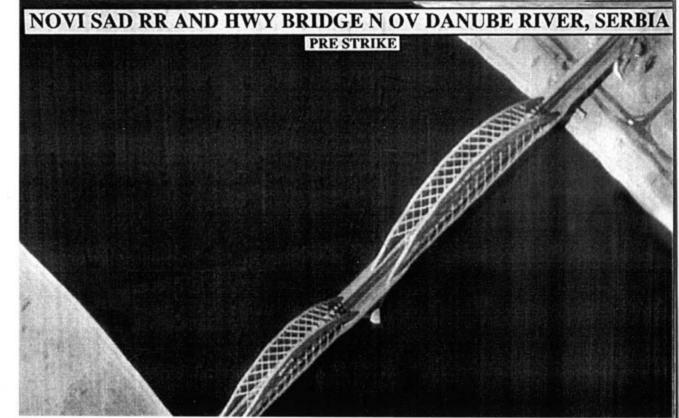
Unfortunately they are only 21 of them [B-2s].

In some of the scenarios that were looked at during ALLIED FORCE, did you ever consider launching from here, flying to target, recovering somewhere in Europe (we'll say Fairford [England] – it could have been Mildenhall [England] or wherever), re-arming, new crew, return to target, and then back to Whiteman?

I'll give you a reason why not, why that was impractical. When we began the thing, there were approximately 600 JDAMs [Joint Direct Attack Munitions] in the world. The [Boeing] JDAM factory is in St. Charles, Missouri, right up the road. Nice and close. It would have been more effort to have gotten the JDAMs – and all the JDAMs, by the way, had been moved to Whiteman in anticipation of doing this – so the logistics train to move the bombs really was the thing that drove us to operate out of here.

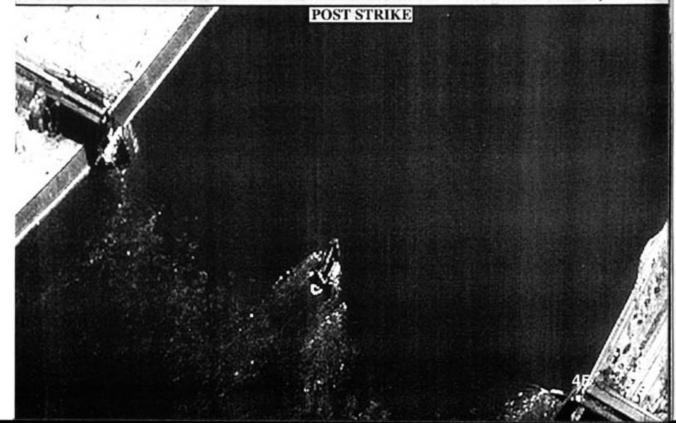
The leadership's answer to that...and it was a simple answer...was, "This was the best way to fight this particular contingency." Certainly you weighed various options, but the decision was made that this was the best way to do it. What were all the exact reasons and so forth? They haven't said and I don't know, but their short answer was that they decided this was the

Major Monetti's B-2A recorded the post-strike image of the Novi Sad bridge after his Spirit attacked it with eight GBU-32s. Six of the 2000 pound (907.2 κg) weapons were targeted on the larger center span, with the other two aimed at the north span's end. All eight GBU-32s hit their targets, successfully disabling the bridge. Major Monetti said this same bridge had been unsuccessfully attacked by an F-15E Strike Eagle and an F-117A Nighthawk before his B-2A arrived. (USAF via Jim Goodall)



This is the pre-strike image of the Novi Sad railroad and highway bridge across the Danube River in Serbia. The image was taken using the B-2A's Hughes (now Raytheon) AN/ALQ-181 low-probability-of-intercept radar from 40,000 feet (12,192 M). The author asked Majors Tony Monetti and Harry Foster about the clarity of radar images, and they replied that these were of "photographic quality." This and other AN/ALQ-181 images were downgraded in quality prior to public release, to prevent adversaries from discerning the radar's true capabilities. (USAF via Jim Goodall)

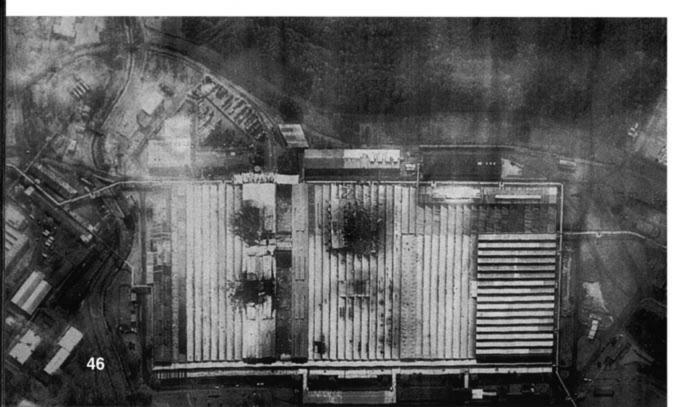
NOVI SAD RR AND HWY BRIDGE N OV DANUBE RIVER, SERBI





A B-2A's AN/ALQ-181 recorded this Bomb Damage Assessment (BDA) image of a Serbian support base near Kirvovo. Arrows are placed on the image to facilitate viewers. One or two bomb craters are found on each of the four clusters of buildings on the base. (Jim Goodall)

This BDA image shows the result of a B-2A strike against the Kragjevac armament and motor vehicle plant in Crvena Zastava, Serbia. A Spirit dropped at least three bombs which hit the plant. During Operation ALLIED FORCE, the B-2s dropped 90 percent of their bombs within a 30-feet (9.1 m) range from the intended target. (Jim Goodall)



best option to press for, "Why are you fighting from here?" His words were, "For this particular contingency, this is the best way to do it." Something that simple.

There has been some speculation that the Air Force is looking at forward deploying two or three B-2s.

That wouldn't surprise me. We are working on a contingency. It's in the open press that we are developing deployable shelters to maintain our stealth coatings... You can't sit outside in driving rain, apply this stuff, and expect it to cure properly. You've got to get it out of the environment. That doesn't mean that we can't fly in rain – that's not what I said. I said to maintain it, you've got to be in a dry environment. The stuff is put on here with, I don't know – it's Elmer's glue for lack of a better comparison. Now imagine trying to do that in standing water. That would be difficult to do. So we're developing these deployable shelters. Once they are developed and paid for – when they're online and they're here – this aircraft will have the ability to move forward. And when we do get the ability to move forward, you will see our ability to produce sorties go up, what with being closer to the fight. One disadvantage of sitting in the Continental United States and doing battle in Europe is that it is a long transit time. But that also gives you unique capability. If the forward area says no, you can't use our base, well, we have a base right here in Missouri that we can use if the President wants us to. But the closer we can get to the fight, the better – because that would allow us to produce more sorties and that's what we're in business to do.

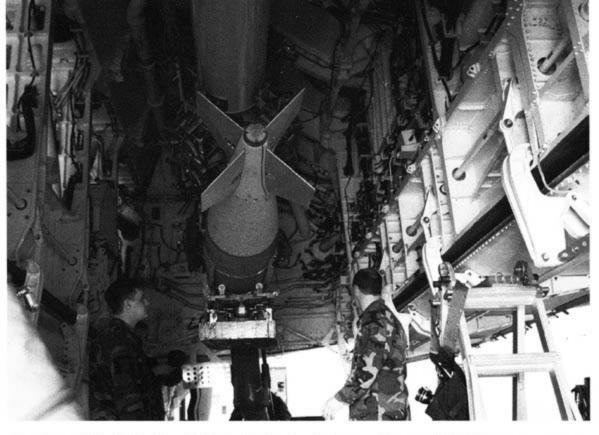
What Harry said is exactly right. Certainly, the deployable shelters will give us the capability to forward-deploy to many, many locations.

In the FY02 [Fiscal Year 2002, 1 October 2001 to 30 September 2002] budget, there's 56 million dollars appropriated for the B-2 using the 500 pound JDAM, designation GBU-31. In approximately two and a half years, we will have the ability with this aircraft to fly over a target and drop 80 precision-guided, GBU-31 500 pound bombs. Think about that for a moment.

That's incredible!

It will be a remarkable capability and we haven't figured out the crew side because they would have to be the one to find 80 targets. I can't even fathom... It's a concept the Intel[ligence] community hasn't thought about yet. Where do you put eighty 500 pound bombs in a pass? Because soon we'll have the ability to do it.

I want to caveat on that. It's important that we understand that this whole team effort thing... I already mentioned some of the maintainers and the other people and the employees of Northrop. But look at some of the pilots they picked for this program. You've got a bunch of fighter guys and bomber guys who've come from their own worlds of how they do business. Now you've combined them together, and together we've matured this weapons system beyond what I believe they were even thinking about. You get some brilliant people that have these ideas and they make these ideas happen. You take into account Space Command and the benefits of space and GPS with these weapons and our stealth... You combine all that together with these pilots that like to think outside the box sometimes, and you've got yourself one heck of a fighting force with the B-2.



Members of the 509th Bomb Wing's Explosive Ordnance Disposal (EOD) team use a standard Air Force weapons loading cart to mount a 2000 pound bomb with relative ease. Loading the 4700 pound (2131.9 κg) GBU-37/B requires additional caution as it can be slightly unwieldy! Weapons bay doors are swung out to be parallel to the aircraft undersurface during weapons loading. (Northrop Grumman)

A KC-10A Extender refuels a B-2A over the California desert during a test flight. Spirits required four mid-air refuelings – two outbound and two inbound – during their 30-hour missions against Yugoslav targets in 1999. A boom operator on both KC-10 and KC-135 tanker aircraft 'flies' the refueling boom into the receptacle. (USAF via G. Phillips)





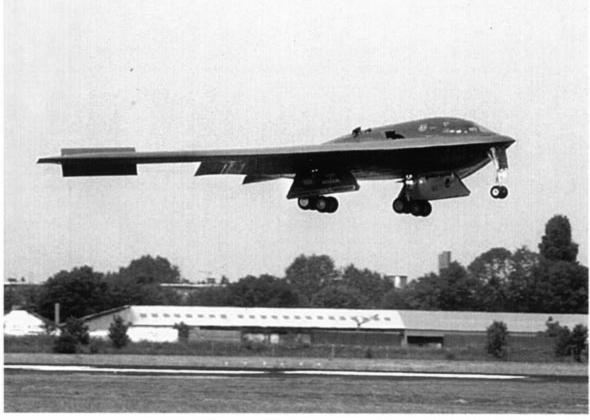
It must feel a bit unnerving to have 20,000 pounds (9072 kg) of bombs hanging over your head, but the dedicated men and women of the 509th Bomb Wing show no fear as they go about their work. Two armorers secure GBU-32s to the Spirit's bomb rack. (Northrop Grumman)

Three Spirits are parked in their hangars one night at Whiteman, awaiting their next missions against Yugoslavia. Each hangar's aft doors open to allow the B-2s to start their engines from within the shelter. ALLIED FORCE missions were timed to put the Spirits over their targets at night. (Northrop Grumman)





The SPIRIT OF GEORGIA (AV-14, 89-0129) flies over the Sierra Nevada Mountains near Edwards AFB, California during a test flight. This was the eighth B-2A assigned to the 509th BW, arriving at Whiteman AFB on 17 November 1995. The Spirit has proven to be a key asset for USAF planners, seeing service over Iraq, Yugoslavia, and – more recently – Afghanistan. (USAF)



A B-2A prepares to land at Le Bourget Airport near Paris, France in 1995. The Spirit was completing a flight demonstration at the 41st Paris Air Show. The elevons fully open for low speed control in all axes – pitch, roll, and yaw. (USAF via G. Phillips)

The B-2A SPIRIT OF OKLAHOMA (AV-18, 93-1085) is displayed at Tinker AFB, Oklahoma. This Spirit was christened in a ceremony at Tinker on 15 May 1996. The aircraft was the 11th operational B-2A assigned to the 509th BW. (USAF via G. Phillips)



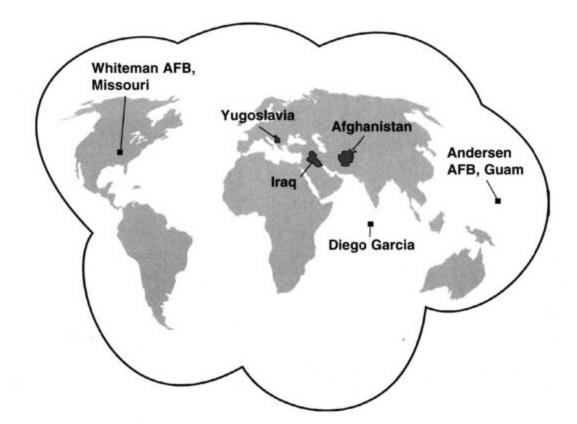
Operation ENDURING FREEDOM

The unthinkable happened on 11 September 2001, when a group of Islamic fundamentalist suicide bombers attacked the United States. The terrorists hijacked four American-built Boeing commercial airliners, with two of the aircraft flown into the twin towers of New York City's World Trade Center. The towers burned and later collapsed, burying thousands of people in the rubble. A third airliner hit the Pentagon, the Department of Defense headquarters in Washington, while a fourth – intended for either the White House or the Capitol in Washington – was flown into a field in western Pennsylvania. Following the tragic death of over 3500 innocent victims, the destruction of the World Trade Center's twin towers, and a direct hit on the Pentagon, America quickly transformed from a somewhat fractured, disinterested populous into a nation united.

US authorities soon found evidence linking the terrorist network al-Qaeda – led by Saudiborn terror mastermind Osama bin Laden – to the 11 September attacks. Afghanistan's fundamentalist Taliban regime provided sanctuary to bin Laden and his organization. The US armed forces prepared a campaign code named Operation ENDURING FREEDOM to bring down the Taliban government and to destroy al-Qaeda.

Operation ENDURING FREEDOM technically began on 5 October 2001 just after 1100 hours Eastern Standard Time (EST) – nearly two hours before President George W. Bush spoke to the nation from the Treaty Room at the White House. Four American cruisers, a US submarine, and a British submarine began firing salvos of cruise missiles towards al-Qaeda and Taliban targets in Afghanistan. Afghan sources reported the initial blasts occurring at 1227 hours EST (2057 hours local Afghan time).

Range of B-2 with One Inflight Refueling (From Whiteman AFB, Diego Garcia, and Andersen AFB)



Early on 5 November, six 509th Bomb Wing (BW) B-2As left Whiteman Air Force Base (AFB), Missouri for the 7500-mile (12,069.8 km) non-stop flight to Afghanistan. At approximately 1230 hours EST on 6 October (24 hours after the initial cruise missile strikes), the B-2s crossed the Afghan border and began attacking Taliban and al-Qaeda installations. The Spirits bombed their targets from 50,000 feet (15,240 m) using 2000 pound (907.2 kg) GBU-36/B satellite-guided munitions.

The weapons-loading teams at Whiteman sent poignant messages from America to the terrorists. "NYPD1," "FDNY2," and "Don't Tread On Me" were written on a good number of the Guided Bomb Units (GBUs) loaded aboard the B-2 bombers. These messages were in memory of the many police officers, firefighters, rescue workers, and military personnel killed in the attacks on the World Trade Center and the Pentagon.

The flight from Whiteman AFB to Afghanistan required six aerial refuelings. Following completion of their bombing missions over Afghanistan, the B-2s landed – approximately 40 hours after takeoff – at the British/US military facility on Diego Garcia in the central Indian Ocean. There, the two-man crews were rotated, the toilets emptied, and then relief crews piloted the B-2s on their 30-hour return flight back to Whiteman. According to the 509th Bomb Wing Commander, Brig. Gen. Anthony F. Przybyslawski, the aircraft returned home 'Code One' with no maintenance write-ups. This meant the aircraft were mechanically sound and ready to fly again. "The fact these aircraft never shut down their engines for more than 70 hours highlights the durability and reliability of this weapons system," Przybyslawski stated.

Przybyslawski declared that the Spirits had met no resistance while flying over Afghanistan. "Four simple words describe our mission: global strike, precision engagement. The B-2's combination of stealth technology, long range, large payload, and precise munitions makes it the world's most capable long-range bomber," he said. "But the B-2 is just an aircraft until you add people. We have America's best, flying, maintaining and supporting this aircraft. I couldn't be prouder of these people."

Where is Diego Garcia?

Diego Garcia is part of the British Indian Ocean Territory (BIOT) established in 1965. It is one of 56 islands in the Chagos Archipelago, which extends over an area of 22,000 square miles (56,975.6 km²) in the heart of the Indian Ocean, south of India and between Africa and Indonesia.

This tropical island is a narrow coral atoll with a land area of approximately 11 square miles (28.5 km²), nearly enclosing a lagoon. Its configuration is like that of a 'V' drawn by a shaky hand, stretching 34 miles (54.7 km) in length with the opening facing north-northwest. Three small islands dot the mouth of the lagoon, which is approximately 13 miles (20.9 km) long and spreads up to six miles (9.7 km) in width. The water's depth ranges from 60 to 100 feet (18.3 to 30.5 m) and is scattered with coral heads. Shallow reefs surround the island on the ocean side as well as protect the lagoon itself. Diego Garcia's mean height above sea level is a mere four feet (1.2 m).

¹NYPD: New York Police Department ²FDNY: Fire Department of New York



(Above) The first B-2A (82-1066) flies above the Mojave Desert near Edwards Air Force Base (AFB), California. Early Spirits had black leading edges, replaced on Block 30 aircraft with leading edges finished in Dark Gunship Gray to match the rest of the airframe. The B-2A prototype was named SPIRIT OF AMERICA in 1999.

(Below) AV-13 (89-0128) takes off from Offutt AFB, Nebraska during the base open house on 4 September 1995. Split rudders mounted on the wing trailing edge open for low-speed control. This B-2A was christened SPIRIT OF NEBRASKA at a ceremony held during the open house. Auxiliary engine inlet doors provide extra air during takeoff, landing, and taxiing.

