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GATHERING OF EAGLES B-2 PAPER

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AIR FORCE TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
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UNITED STATES AIR FORCE

III. **B-2 (17 Jul 89):**

- (U//Dist. A) *Manufacturer / Specs:* Northrop Grumman Corp. During 1981, the U.S. Air Force completed plans to initiate development of an Advanced Technology Bomber (ATB), intended to complement—and perhaps eventually replace—the Rockwell B-1B as a low-level penetration bomber. After evaluation of design proposals from several manufacturers, the Air Force selected Northrop as the prime contractor for the ATB. (Northrop’s ATB had been under development since 1978.) Subsequently designated the B-2, the newest Northrop “flying wing” was the most sophisticated and most expensive aircraft yet developed.(USAF Fact Sheet, “B-2”)

(U//Dist. A) The B-2 was “point designed” in accordance with “stealth” (i.e., low-observable) principles, to minimize its chances of detection by enemy radar, and was of an all-wing configuration, following Northrop’s lengthy experience with this type of layout.⁴ Simply put, the bomber’s low observability was derived from a combination of reduced infrared, acoustic, electromagnetic, visual and radar signatures, making it difficult for even sophisticated defensive systems to detect, track, and engage the B-2. While many aspects of the low-observability process remain classified, the B-2’s composite materials, special coatings and flying-wing planform all contributed to its stealthiness. (*USAF Fact Sheet, “B-2”*)

(U//Dist. A) Designed to operate at high subsonic speeds, the acft was powered by four non-afterburning General Electric F-118-GE-100 turbofan engines, each rated at about 17,300 lb of thrust. The engines were semi-buried in the inner wing, with their intakes above the upper surface, alongside the central “fuselage,” which was fully blended into the wing. (The fuselage housed the two-man crew, the major mission avionics, and the acft’s weapons load, which included cruise missiles, conventional and nuclear ordance.) The trailing edge of the B-2 incorporated a radar-evasive, saw-tooth configuration. The acft also incorporated an automated, quadruple redundant, “fly-by-wire” flight control system that ensured stable and safe flight. (*Schwanborough; William W. Suit, In Search of the Ideal Airframe—USAF All-Wing Aircraft and the Development of Stealth*)

- (U) *Mission / Requirements:* The B-2 *Spirit* was designed as a *manned, multi-role penetrating bomber* capable of delivering both conventional and nuclear munitions. It’s low-observable characteristics gave it the unique ability to penetrate an enemy’s most sophisticated defenses and threaten its most valued, heavily defended targets. Simply put, the “global reach” of the B-2 provided the United States with perhaps its most potent deterrent capability. (*USAF Fact Sheet, “B-2”*)

- (U) *First Flight:* Following nearly a decade of development, on 22 Nov 88 the contractor and the Air Force conspicuously rolled out the first B-2 from its hangar at Air Force Plant 42 in Palmdale, affording the public its first view of the high technology bomber. The new “flying wing” had the same wingspan as the YB-49, 172 feet. The bomber had a length of 69 feet and a gross weight of approximately 350,000 lb. ((U) AFFTC History, 1 Oct 88 – 30 Sep 89, p 518) (U) Following months of planning and prep, the No. 1 B-2 (S/N **82-1066**) conducted a series of *low and high speed taxi tests* at Plant 42, which successfully concluded on 13 Jul 89. (The initial low-speed taxi tests had been performed on 10 Jul 89.) After an initial attempt at first flight had to be aborted on 15 Jul because of low fuel-pressure readings, the B-2 ***accomplished its maiden flight two days later, on 17 Jul 89***, with Northrop test pilot Bruce Hinds at the controls and Col Richard S. Couch serving as co-pilot. Hinds released the brakes on the B-2 and commenced his takeoff roll at 6:36 a.m. Twenty-one seconds after brake release, the nosewheel lifted off the ground and, less than two seconds later, at 6:37 a.m.,

⁴ (U) The Northrop B-2 design was based on the “flying wing” concept that John K. Northrop, the company’s founder, had pioneered with his N-1M and N-9M concept demonstrators and his XB-35 and YB-49 prototype bombers in the 1940s. In fact, as early as 1923, Northrop had postulated that optimum aerodynamic and structural efficiency could best be achieved by placing all of the elements of the airplane—its powerplant, flight controls, crew and cargo—within the confines of its airfoil. Ideally, virtually every exposed surface of such a design would contribute to lift, while parasite drag caused by non-lift producing structures would be eliminated. (U) *AFFTC History, 1 Oct 88 – 30 Sep 89, p 498.*

the B-2 became the *first flying wing to take to the skies over the Mojave Desert in nearly four decades*. Couch and Hinds had been planning for a takeoff role of between 4-- and 5000 feet but, as Couch later recalled, “we never got there.” Hinds had started easing back on the control column at about the 3500-foot mark, trying to establish a 7.5-degree takeoff pitch angle, but the airplane smoothly left the ground at about 6.5 degrees and, as Couch recalled, “climbed straight ahead, wings level.” “It just smoothly came off the ground,” he said. “We hardly even knew it.”

(U) After takeoff (which was made w/ the acft at a gross weight of 226,400 lb), the B-2 slowly climbed to a peak altitude of about 10,000 feet, where the test pilots completed the required landing approach test points to gain confidence should there be any need for an early touchdown. With the gear down throughout the flight, the airplane remained at speeds below 200 knots and both Hinds and Couch performed a variety of maneuvers to demonstrate the B-2's air worthiness, stability and control, and safe operation of its systems. Hinds later reported that the B-2 flew “like a real airplane” and that it was “very nimble.” Roll performance was particularly impressive. It also proved to be “well damped—very good directionally,” with only a single overshoot during yaw doublet maneuvers (YB-49 pilots would have been impressed with this). He characterized its pitch response to a longitudinal doublet as “almost deadbeat.”

(U) There were very few surprises during the flight. The B-2's flying characteristics matched very well with the computer simulations the pilots had previously “flown” on the ground. One of the few surprises came when the airplane was in ground effect; in that environment, Hinds reported that “we found the airplane worked a little better than the simulation.”

(U) At 0829L, one hour and 52 minutes after takeoff, the big flying wing touched down on the concrete surface of Runway 22 at Edwards AFB. The pitch attitude of the acft at touchdown was reportedly about seven degrees, substantially lower than the pair of F-16s flying safety chase overhead. The acft came to a stop less than 5000 feet from the point of touchdown and, after some engine checks, taxied slowly off the runway toward the Technical Support Facility and a waiting crowd of dignitaries and reporters. Afterwards, Bruce Hinds reported: “The acft was very stable; rock stable on final. It took very slight aft stick pressure—just held [the stick] aft and [the airplane] touched down very smoothly...It's going to be a very easy airplane to fly. It's a very simple aircraft aerodynamically.”

(U) Following the postflight congratulations and ceremonies, the acft was towed into Bay 1 of the Technical Support Facility, where maintenance personnel proceeded with their postflight activities. Impressively, there were *only 14 pilot-reported discrepancies noted during the B-2's maiden flight*. (Note: Account of first flight derived from, (U) *AFFTC History, 1 Oct 88 – 30 Sep 89, pp 538-543*)

(U) The airplane *completed its second flight on 16 Aug 89*. By November, the aircraft had logged 30 hours of flight time. Initial flight test results pleased both the contractor and the Air Force. The test pilots reported that the B-2 possessed excellent directional stability. Heavy buffeting during low-altitude gusting wind conditions did not occur as feared, minimized by the acft's *gust alleviation system* which utilized the elevons and an adjustable aft centerbody beavertail. After these preliminary flight tests, Northrop test pilots returned the bomber to Palmdale for a scheduled lay-up for maintenance and installation of subsystems. During this lay-up, Northrop technicians discovered *hairline cracks in the aft deck* near the engine exhausts. Northrop repaired the cracks and No. 1 B-2 resumed flight testing in Apr 90. (Note: No. 2 B-2 first *took to the air on 19 Oct 90*.) ((U) *AFFTC His, 1 Oct 88– 30 Sep 89, p 545; William Suit, In Search of the Ideal Airframe...*)

(U) Overall, the flight test acft experienced minor mechanical difficulties, such as landing gear that would not raise; the various tests revealed *two notable airframe flaws*; and the flight tests did not meet original schedule deadlines. However, the B-2 program did not experience anything comparable to the delays suffered by the B-35/49 program. After the No. 2 B-2 entered the test program, other acft soon followed. The third B-2 took flight in Jun 91; the fourth in Dec 91; the fifth in Oct 92; and the sixth in the Spring of 93. Northrop constructed two additional airframes for ground tests. (*Ibid.*)

- (U) *Significance*: Original plans had called for the USAF to procure 132 of the bombers; however, with the demise of the Soviet Union and the end of the Cold War, the requirement for such a large force was no longer justified. As a result, only 21 of the high tech bombers would be procured, with the first acft, the *Spirit of Missouri*, delivered to the 509th Bomb Wing at Whiteman AFB, MO, on 17 Dec 93. (All told, 20 B-2s have been delivered to Whiteman; the remaining acft serves as the B-2 developmental test (DT&E) acft assigned to the 419th Flight Test Squadron at Edwards AFB.) (USAF Fact Sheet, “B-2”)

(U) The B-2 stealth bomber *made its operational debut* during Operation *Allied Force*, when, on 24 Mar 99, two Spirits dropped 32 2,000 lb. satellite-guided GBU-31 Joint Direct Attack Munition (JDAM) bombs during a 31-hour, non-stop mission from Whiteman AFB. (The B-2 was the only operational acft used to delivery JDAMS during Operation *Allied Force*.) Over the course of *Allied Force*, **45 B-2 sorties** by a total of **six acft** delivered **656 JDAMs** on critical targets in the Federal Republic of Yugoslavia.⁵ The flights lasted up to 30 hours, with “no mission aborts and no system interface problems,” according to officials from the 509th Bomb Wing. (*Daniel Verton, “B-2 soars, proving report wrong,” in: Federal Computer Week, 5 Jul 99; USAF Fact Sheet, “B-2”.*)

(U//Dist. A) During Operation *Enduring Freedom* the B-2 flew a total of six missions on the first three days of the war. Each sortie took 70 hours, including the flight to Afghanistan, a turn-around at Diego Garcia for a new crew, and the flight back to Whiteman AFB. Of the 21 B-2s, a total of 55 percent were mission-capable (MC) when the bombing began on 7 Oct 2001. (www.globalsecurity.org)

- (U) *Technical Data*: Prime Contractor (Northrop Grumman Corp.); Power Plant (four GE F-118-GE-100 nonafterburning turbofans with 17,300 lbs thrust each); Length (69 feet); Height (17 feet); Wingspan (172 feet); Speed (high subsonic); Service Ceiling (50,000 feet); Unrefueled Range, nautical miles (6300 / with 37,300 lb. bomb load); Bomb Load (40,000+ lb. internal only, maximum capacity);⁶ Unit Cost (ca. \$1.157 billion in FY98 constant dollars); Inventory (21, including 1 test acft). (USAF Fact Sheet, “B-2”)

⁵ (U) The JDAM first saw combat during *Allied Force*. Of the more than 650 JDAMS dropped by the B-2s, 89 percent hit within 40 feet of their targets. *Scott Canon, “Missouri product puts U.S. on target,” in: The Kansas City Star, 12 Mar 02.*

⁶ (U) The B-2 carries all its wpns internally and is fitted with two separate wpns bays in the center of the acft. The acft can carry up to 40,000 lbs of wpns, including conventional and nuclear wpns, precision-guided munitions, gravity bombs, and a range of maritime wpns. Each wpns bay can be equipped w/ a rotary launcher or with a conventional or new “smart” bomb-rack assembly (BRA). In tests, the B-2 has successfully released B61 and B83 nuclear and Mk 84 conventional bombs from the rotary rocket launcher; and Mk 82 and CBU-87 conventional wpns from the bomb racks. The B61-11 is an earth-penetrating nuclear bomb for use against deeply buried and hardened targets; the B83 is a strategic free-fall nuclear bomb. The B-2 also carries the AGM-129 Advanced Cruise Missile and the GBU-31 JDAM (see above). (USAF Fact Sheet, “B-2”)

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