Boeing NB-52B *Stratofortress* Mothership

By Brian Lockett

NASA's Boeing NB-52B Stratofortress Mothership *takes off on its last research flight with the third X-43A Hyper-X stack on November 16, 2004. (Author's photo)*

Introduction

The oldest flying B-52, the NB-52B, carrying Air Force serial 52-0008, has just been retired following the conclusion of the X-43A Hyper-X project at the NASA Dryden Flight Research Center at Edwards AFB. The NB-52B and its sister ship, the NB-52A, 52-0003, were diverted to the mission of launching the North American X-15 hypersonic research airplane in 1958. The NB-52A was retired in October 1969, but the NB-52B continued to serve as the mothership for a multitude of projects over forty-five years. It accumulated less flight time than any currently operational B-52.

While the two *Stratofortresses* were engaged in the task of launching the three X-15 rocket planes, a series of rocket-powered lifting bodies were developed that utilized the existing air launch capability. At the conclusion of manned, rocket research aircraft testing in 1975, the NB-52B was almost retired, but a series of remotely piloted research vehicles required its support for their flight programs. A variety of parachute recovery system tests and unmanned rocket launches were also conducted with the *Stratofortress* mothership.

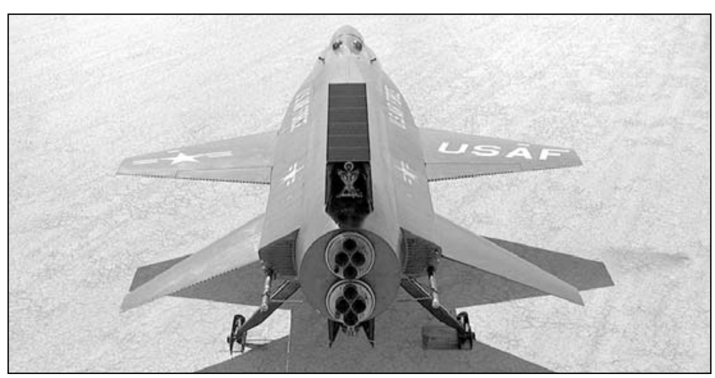
The NB-52B launched the three X-15 hypersonic rocket planes and the Northrop HL-10, Northrop M2-F2/F3, Martin Marietta X-24A and Martin Marietta X-24B lifting bodies. It simulated the steep, power-off approach to landing used by the Space Shuttles. It assisted in the collection of data about wake turbulence from large aircraft. It served as an air-to-air gunnery target. It launched 3/8-scale F-15 Remotely Piloted Research Vehicles (RPRV), a Ryan Firebee II drone, Ryan Firebee-based Drones for Aeroelastic Structures Testing (DAST), and the Highly Maneuverable Aircraft Technology (HiMAT) RPRVs. It dropped the 48,000-pound Space Shuttle Reusable Booster Drop Test Vehicle (SRB/DTV) and it released a simulated F-111 crew module from its bomb bay to evaluate new parachute recovery systems. It was the first airplane to launch a satellite into orbit on the Orbital Sciences Pegasus booster. It tested the drag chute used to decelerate Space Shuttle Orbiters. It tested pollution reducing fuel additives with a pair of jet engines mounted under its bomb bay. It launched the X-38 Space Station Crew Return Vehicles and the X-43A Hyper-X Supersonic Combustion Ramjet.

North American X-15 Rocket Plane

The North American X-15 was designed as a research vehicle for the investigation of (1) hypersonic aerodynamics, (2) structural characteristics under high aerodynamic heating conditions, (3) effectiveness of reaction type controls in regions where conventional aerodynamic controls are ineffective, and (4) psychological and physiological piloting problems associated with "weightlessness" conditions of space flight.[1]

The X-15 was designed to be air-launched. Like the X-2, the X-15 was equipped with a skid landing gear, which did not allow take-off from the ground. The initial configuration of the X-15 weighed 14,500 pounds at launch for a glide flight and 34,400 pounds for powered flights.

The intended powerplant for the X-15 was the throttleable Reaction Motors XLR-99. The X-15 pilot could select from a



X-15-1 equipped with a pair of Reaction Motors XLR-11 engines sits on Rogers Dry Lake in 1960. (NASA photo E-5256) range of thrust levels up to 58,000 pounds. The rocket engine burned anhydrous ammonia and used liquid oxygen (LOX) as the oxidizer.

The development of the XLR-99 engine took longer than had been anticipated. Due to delays in the development of the XLR-99 rocket engine, program managers decided to substitute a pair of XLR-11 rockets to allow initial flight tests. These were the same engines that had been used in the X-1 program. They were refurbished for use in the first two X-15s.

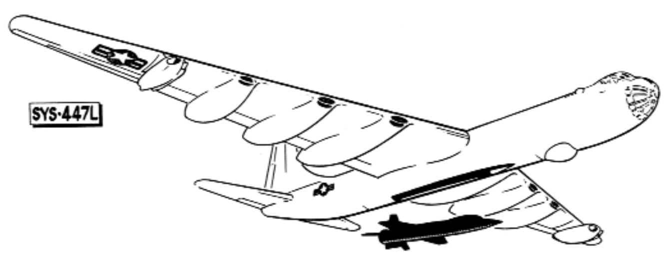
Each XLR-11 rocket engine was equipped with four thrust chambers. The pilot controlled the power output of the engines by switching individual combustion chambers on or off. The eight chambers of the XLR-11 engines provided thrust in 2,000 pound increments, up to 16,000-pounds of thrust. The fuel used by the XLR-11 rocket engines was ethyl alcohol mixed with water.

Selection of the B-52 *Stratofortress*

At first, the mothership for the X-15 was expected to be the Convair RB-36. The X-15 would have been mounted in the bomb bay of the B-36. The performance of the B-36 would have allowed the X-15 to be launched at an altitude of 35,000 feet and Mach 0.7.[2]

In 1957, The National Advisory Committee for Aeronautics (NACA) directed North American Aviation to change the mothership from the B-36 to the B-52 *Stratofortress*. The B-36 fleet was going to be phased out of service at about the time that the X-15 began flying.

The X-15 could not be mounted in the bomb bay of the B-52. It would be mounted on a pylon under the wing of the *Stratofortress* between the fuselage and the inboard engine



Proposed B-36 Carrier for X-15. (From AFFTC/HO)

nacelle. This introduced a number of complications. The X-15 pilot would have to board the rocket plane before take-off. The B-52 flaps could not be used on take-off or landing. There were no windows on the B-52 that provided a view of the X-15 on the pylon.

There were concerns that the noise from the B-52 engine pod might damage the X-15. Technicians mounted a dummy model of the X-15 on a B-52 wing and ran the engines for ten hours. Concrete ballast representing the X-15 was hung on a B-52 wing and dropped to see what effect it would have.

The improvement in performance conferred by the 72,000-pounds of thrust from the eight J57-19 jet engines of the B-52 raised the launch altitude to 45,000 feet and the speed up to Mach 0.9. It also allowed the weight of the X-15 to be increased.[3]

B-52A-1-BO, 52-0003, and RB-52B-10-BO, 52-0008, were sent to North American for modification in 1958. Aircraft 52-0008 was manufactured at Seattle. It was equipped to carry a pressurized crew module in the bomb bay for aerial photography. It was accepted by the Air Force on March 22, 1955, but its first flight was not flown until June 11. RB-52B, 52-0008, was assigned to Edwards AFB in September 1955 for bomb/navigation systems testing.

In late 1955, the designation of 52-0008 was changed to JRB-52B and then to JB-52B. The new designation indicated that the bomber had been modified for flight test and that its reconnaissance capability was no longer supported.

The Air Materiel Command received JB-52B, 52-0008, on July 3, 1958. Instrumentation recording equipment was removed. A spare VHF communication radio and a spare OMNI navigation radio were left aboard the airplane. The AJA-1 True Heading Computer System, the AN/ASB-9 Bombing Navigation System, and the AN/APN-89 Radar System were removed. Equipment related to operations of standard bombers was left inoperable on the JB-52B. The ALE-1 chaff dispenser was not installed. The wing and tail surface de-icing system was deactivated. The K-38 camera was not installed. The windshield wiper motor was disabled, and the wiper blades and arms were removed. [4]

Aircraft 52-0008 was delivered to the Aeronautical Systems Center on December 12, 1958.[5] It arrived at Plant 42 on December 13, 1958, and was moved into the North American hangar on January 6, 1959.[6] It had flown 110 times and accumulated 533 flight hours.

Modifications to the NB-52B

The NB-52B was modified as follows:

- A pylon weighing 1,170 pounds was added under the right wing, inboard of the engine nacelles and capable of supporting 50,000 pounds. The pylon was equipped with three shackles to support the X-15. Umbilical attachments supplied the X-15 with liquid oxygen, nitrogen gas for pressurizing the cockpit, breathing oxygen, and electrical power. The nitrogen source for cockpit pressurization was a forty-gallon liquid nitrogen tank in the pylon. Three release mechanisms ensured that the X-15 could be released from the pylon. The primary release mechanism was hydraulic, powered by an accumulator mounted in the pylon. The secondary mechanism was pneumatic with its high-pressure nitrogen gas bottles located in the bomb bay of the B-52. A mechanical release was provided as backup. The design of the pylon placed the cockpit of the X-15 in front of the leading edge of the wing of the B-52 so that the X-15 pilot could eject while it was still attached to the B-52.
- A 1,500-gallon liquid oxygen tank was installed in the bomb bay. It was divided into a climb tank and a cruise tank. The climb tank was sealed to prevent evaporation of the liquid oxygen. The cruise tank was vented to the atmosphere to allow evaporation of the liquid oxygen in that tank, which would cool the liquid oxygen and increase its density. In the minutes before launch, the launch panel operator would switch from the climb tank to the cruise tank to maximize the amount of oxidizer in the X-15. The tanks were equipped with a jettison line and two vents that extended out the left side of the fuselage.
- Ten vents were installed on each side of the fuselage to prevent the accumulation of fumes in the bomb bay.

- Closed circuit television, a film motion picture camera, and lights were installed on the starboard side of the fuselage. Two sets of television cameras were installed, one forward of the X-15 and another aft of the wing. A motion picture camera was installed near the aft television camera.
- An AN/APN-81 navigation computing radar system was installed to provide input to the stable platform system. The stable platform established the position and direction of flight of the NB-52 and fed that information into the inertial navigation system of the X-15 in the moments before launch.
- A notch was cut into the trailing edge and inboard flap of the starboard wing to accommodate the vertical stabilizer of the X-15. The inboard flaps were disabled. The outboard flaps remained functional, but were not used in flight.
- 395 pounds of stiffeners, channels, ribs, rollers, and angles were added to the wing structure.
- The No. 3 main fuel tank located in the wing above the pylon and the two cells of the mid-body fuel tank were removed.
- Eighteen nitrogen bottles and nine helium bottles were installed in place of the mid-body fuel tank. The helium gas was used to pressurize the liquid oxygen top-off system. The nitrogen gas was used to operate the valves of the top-off system.[7]
- A launch panel was installed on the upper deck of the B-52 at the Electronic Counter-Measures operator's station. The launch panel fed altitude and velocity data to the X-15 inertial guidance computer until launch. A pair of television monitors allowed the launch panel operator to observe the liquid oxygen top-off overflow and check the function of the X-15 flight control surfaces.
- A Plexiglas astrodome was installed on the right side of the upper deck to provide the launch panel operator with a direct view of the X-15.
- A panel of five launch indicator lights was installed above the pilot's instrument panel to coordinate the pilots of the B-52 and X-15. Three lights confirmed that the pylon hooks had securely engaged the X-15. An amber "ready to launch" light and a green "launch" light were controlled by the pilot of the X-15. The "ready to launch" light indicated that the X-15 systems had been configured for launch. The "launch" light indicated that the X-15 pilot was ready to begin the final portion of the launch countdown.
- The right-hand crew station on the lower deck was removed.[8]
- The tail gun turret and tip tanks were removed. One the ways of distinguishing the NB-52A from the NB-52B was that the fairings for the tail-gunners sighting mechanisms were not removed from the NB-52A.
- Wheels, tires and brakes designed for higher speeds were installed, raising the ground speed limit from 180 knots to 217 knots.

The designation of 52-0008 was changed to NB-52B to indicate that it was so extensively modified that it could not be returned to stock configuration.

Over the years, numerous systems aboard the NB-52B have been replaced with systems from later models of the *Stratofortress*. Gauges in the fuel system are from the B-52C. The ejection seats are from the B-52D. The drag chute accepts the parachutes used in the B-52G, and the landing gear and brakes are the type used on the B-52H.[9]

First X-15 Operations

In early November 1959, the X-15-1, 56-6670, was mated to the NB-52B for the first time to conduct tests of the X-15 LOX tank liquid level sensing probe and B-52 top-off control amplifiers of the Acoutica Associates automatic top-off liquid level control system. Automatic top-off cycles were accomplished from both the climb and cruise tanks in the NB-52B.

The NB-52B first carried an X-15 in flight on December 16,

X-15-1 on the pylon of the NB-52B in late 1959. (NASA photo E5087)

1959, in an attempt to launch Scott Crossfield on the second flight of the X-15-1, 56-6670, which would be its first rocket-powered flight. Captain Charles Kuyk piloted the NB-52B and Major Jack Allavie was the co-pilot. A failure of the LOX tank pressurization system resulted in a mission abort.

The NB-52B first launched an X-15 on January 23, 1960. Telemetering difficulties delayed the take-off. An airplane crashed on the base and closed the main runway. Major Fitzhugh Fulton and Captain Kuyk launched Scott Crossfield at an altitude of 45,000 feet over Rosamond Dry Lake. The XLR-11 rockets of the X-15-1 propelled it to Mach 2.53 (1,669 mph) and 66,844 feet altitude. The only pilots to have flown faster were Pete Everest and Mel Apt in the X-2.[10]

North American repaired and strengthened the fuselage of the X-15-2, 56-6671, after it broke its back during an emergency landing on Rosamond Dry Lake on November 5, 1959. It returned to Edwards AFB in January 1960.

The X-15-2 was mated to the NB-52B for a powered flight attempt on February 4. There were numerous systems problems on the X-15. The cockpit would not pressurize. The radio failed. The bearings of one of the Auxiliary Power Units (APU) seized. The

The NB-52B made its first public appearance at the May 17, 1960, Edwards AFB open house with the X-15-1 mounted under its wing. The X-15-2, 56-6671 was displayed on the left side of the NB-52B. (Photo by Richard Lockett)

The NB-52B carries the X-15-1 in September 1960. The Day-Glo orange has been stripped from the vertical stabilizer. (Photo by Tony Panopolis)

pressure of the water alcohol fuel tank sagged, and the jettison failed to completely empty the tanks of the X-15. The mission was aborted, and the dead weight on the pylon was much greater than usual when the NB-52B landed.[11]

The NB-52B carried the X-15-2 aloft again on February 11. Captain Jack Allavie was at the controls of the mothership, and Major Fulton was the co-pilot. The XLR-11 engines propelled the X-15 to an altitude of 88,116 feet. Crossfield leveled out and accelerated to Mach 2.22 (1,466 mph).[12]

The NB-52B launched the X-15-2 six times before it was sent to North American for its XLR-99 engine. It launched the X-15-2 on its last flight with the smaller XLR-11 engines on May 26, 1960. Captain Charles Bock, Jr. and Major Allavie launched Scott Crossfield on a flight that reached the modest altitude of 51, 282 feet.

The NB-52B launched the X-15-1 eleven times with the interim XLR-11 engines. The NB-52B launched the X-15-1 on the last flight with the smaller XLR-11 engines on February 7, 1961. Major Fulton and Captain Robert Mosley launched Major Robert White on a flight that reached a new speed record of Mach 3.50 (2,275 mph).

NB-52B carries Major Robert White in the X-15-2 equipped with the XLR-99 engine on an aborted attempt to launch the first flight with the "hot nose" on February 21, 1961. Nose art depicts an Eagle dropping an X-15 and the name "Challenger." (NASA photo E8698)

In order to perform airborne system tests of the B-52 without an X-15 mated to the *Stratofortress*, a pod was developed that fit on the X-15 pylon and simulated the systems of the X-15. The pod was made from an external fuel tank left over from the North American F-107 *Ultrasabre* program. Seven pod flights were flown between March 1 and December 22, 1961. Pod flights were indicated by a special symbol painted on the fuselage of the NB-52B in front of the leading edge of the right wing.

Introduction of XLR-99 Rocket Engine

The NB-52B first launched an X-15 with the XLR-99 engine on March 7, 1961. Captain Charles Kuyk and Major Frank Cole launched Major Robert White in the X-15-2 on a flight that set a new speed record of Mach 4.43 (2,905 mph).

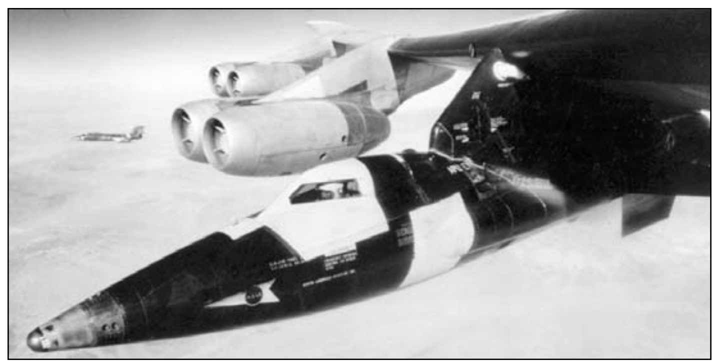
In March 1961 the ARA-25 radio in the NB-52B was returned to working order. If the X-15 pilot were to eject in the desert, the ARA-25 would allow the mothership to home in on the X-15 pilot's rescue beacon. The NB-52B could relay the position of the X-15 pilot to the high range stations on the telemetry frequency.[13]

On March 30, 1961, Major Fulton and Captain Kuyk launched Joe Walker from the NB-52B in the X-15-2 on a flight that set a new altitude record of 169,600 feet.

Captain Jack Allavie and Captain Emil Sturmthol flew the NB-52B at the Edwards AFB open house on May 20 and May 22, 1961.

On September 28, 1961, recently promoted Air Force Major Jack Allavie and Royal Air Force Squadron Leader Harry Archer launched Navy Commander Forrest Petersen in the X-15-2 on a flight that set a new speed record of Mach 5.30 (3,600 mph).

On November 9, 1961, Major Allavie and Squadron Leader Archer launched Captain Robert White from the NB-52B in the X-15-2 on the first flight to exceed Mach 6. Mission 2-21-37 achieved Mach 6.04 (4,093 mph) and an altitude of 101,600 feet. Mach 6 would not be exceeded by the X-15 again for over two years.



Captain Robert White in the X-15-2 shortly before launch on the first Mach 6 flight on November 9, 1961. (North American Rockwell photo)

On January 2, 1962, Major Frank Cole and Captain Sturmthal flew the NB-52B to Boeing at Wichita, Kansas, for periodic maintenance. At the conclusion of the maintenance, Captain Scharon and Major Kuyk flew the NB-52B back to Edwards AFB on March 21.

The NB-52B first launched the X-15-3 on April 20, 1962. It was the fourth flight of the X-15-3. Major Allavie and Major Russell Bement launched Neil Armstrong from the NB-52B on a flight that reached a speed of Mach 5.31 (3,789 mph) and an altitude of 207,500 feet.

The NB-52B first launched the X-15-1 after the installation of its XLR-99 engine on April 30, 1962. Major Allavie and Major Bement launched Joe Walker on a flight that set a new altitude record of 247,000 feet.

Major Allavie and Squadron Leader Archer flew the NB-52B at the Edwards AFB open house on May 19, 1962. Major Miles Burganheim replaced Squadron Leader Archer in the copilot's seat for the flyby on May 20.

Major Russell Bement and Alvin White flew the NB-52B past the Palmdale Airshow on October 28, 1962.

X-15-2 Landing Accident

The X-15-2 was involved in a serious accident on its thirty-first flight on November 9, 1962. Major Bement and Lt. Col. Kenneth Lewis launched Jack McKay in the X-15-2 from the NB-52B over Mud Dry Lake. It was the fourteenth flight of the X-15-2 that was launched from the NB-52B since the installation of its XLR-99 engine. The XLR-99 engine throttle stuck at 30 percent thrust. Jack McKay had to make an emergency landing on the lakebed. McKay was unable to jettison all of the propellants before landing and the flaps failed to deploy. His landing speed was 296 miles per hour instead of the usual 230. Just after touch-down, the left main landing gear failed. The left wingtip dug in and flipped the X-15 onto its back, seriously injuring McKay.

The X-15-2 lies on its back on Mud Dry Lake following Jack McKay's landing accident on November 9, 1962. (Photo from AAFTC/HO)

While the X-15-2 was being repaired, the opportunity was taken to modify it for even higher speeds. By raising the top speed of the X-15 to over Mach 7, it would become possible to use it to test supersonic combustion ramjets. To accomplish this mission, it would need additional fuel for a longer engine burn time, and tanks and fixtures to support the operation of the ramjet. The most apparent modification was the addition of large external fuel and oxidizer tanks. The fuselage of the X-15A-2 was stretched by twenty-nine inches. The stretch of the fuselage of the X-15A-2 and the addition of the external tanks increased its launch weight from 31,000 pounds to over 50,000 pounds. The heaviest payload ever carried by the NB-52B was the X-15A-2, weighing 53,100 pounds.

Major Bement and Major Gayland Jones flew the NB-52B past the Palmdale Airshow on November 9, 1963.

On January 8, 1964, Captain Joe Engle was preparing to be launched from the NB-52B by Lt. Col. Fulton and Lt. Col. Lewis on the forty-third flight of the X-15-1. Fifteen seconds before launch, the outboard engine of the nacelle next to the X-15 failed. Both engines in that nacelle were shut down, and the launch was conducted successfully on the remaining six engines.[14]

After the completion of the rework of the X-15-2 by North American in El Segundo, the spaceplane was trucked back out the Sierra Highway to Edwards AFB on February 18, 1964.[15] To reflect the modified status of the high-speed variant of the X-15, it was re-designated X-15A-2.

The pylon of the NB-52B was modified to carry the heavier X-15A-2. The modifications were completed in April 1964. On April 17, Major Bement and RAF Flight Leader David Cretney flew the NB-52B to Tinker AFB in Oklahoma for Inspection and Repair as Necessary (IRAN).[16]

IRAN for the NB-52B was completed a month ahead of schedule. Major Bement and Major Saunders flew a local maintenance check flight at Tinker AFB on July 22, 1964. Major Bement and Major Bock flew the NB-52B back to Edwards AFB the following day.

The NB-52B first launched the modified X-15A-2 on September 29, 1964. It was the third flight of the X-15A-2 in its new configuration. On its previous flight, flown on August 14, the nose landing gear deployed at a speed of Mach 4.4. Aerodynamic heating cause the fuselage to grow longer, pulling on the landing gear release lanyard. Despite a redesign of key linkages in the nose gear, the small door in the center of the nose gear door popped open during the September 29 flight.

The NB-52B made appearances at both days of the 1964 Pt. Mugu Naval Weapons Center airshow. Col. Joseph Cotton piloted the NB-52B on both days. Major Jones flew as copilot on October 17, and Major Bock accompanied Col. Cotton on October 18.

Two weeks later, on November 1, Major Bement and Major Jones flew the NB-52B past the Palmdale Airshow.

Jack McKay returned to the cockpit of the X-15A-2 during two captive-carry flights on the NB-52B in November 1964. Lt. Col. Fulton and Major Bock piloted a captive mission flown on November 6. Major Bement and Col. Cotton piloted the mission flown on November 16.

Major Bement and Major Bock launched Jack McKay from the NB-52B in the X-15A-2 on November 30, 1964. McKay's first flight in the modified rocket was limited to Mach 4.66 to check out the modifications that had been made to the nose gear door.[17]

Col. Cotton and Major Bement flew the NB-52B at the Edwards AFB open house on May 16, 1965.

NB-52B carries the X-15-3 in 1965. (Photo from AAFTC/HO)

Northrop Lifting Bodies

Northrop designed a pair of rocket-propelled, lifting body vehicles that took advantage of the air-launch capability provided by the *Stratofortress* motherships. The Northrop M2-F2, N803NA and HL-10, N804NA were delivered to Edwards AFB in 1965 and 1966.

The Northrop lifting bodies required an adapter to attach them to the X-15 pylon. Northrop Norair manufactured a twenty-two foot long steel frame adapter to hold either the M2-F2 or HL-10 and to supply electrical power, fluids, and gases to the lifting body. The X-15 pylon was modified in February 1967 with a pair of attachment hooks a little behind the forward X-15 attachment hook to provide four-point attachment for the lifting body adapters.[18]

Northrop Norair lifting body adapter on NB-52B pylon on September 23, 1965. (NASA photo E13837)

Lt. Col. Fulton and Captain Charles Doryland piloted the NB-52B as it made two unmanned captive-carry flights of the M2-F2 on October 21, 1965. On these flights, the NB-52B took off and landed straight ahead on the lakebed runway.[19]

Each lifting body design was tested first in a series of glide flights. The B-52 climbed to an altitude of 45,000 feet and adopted a heading toward the northeast along a line east of Rogers Dry Lake. Following launch, the lifting body descended at a rate of 10,000 to 15,000 feet a minute for about four minutes. The pilot of the lifting body steered the vehicle through a left turn onto the base leg of the approach to landing. The pilot aimed at the landing target on Runway 17 or Runway 18 and initiated the flare at an altitude of about 1,500 feet and a speed of about 300 knots. After the flare, the airspeed of the lifting body decreased rapidly and the landing gear was extended several seconds before touchdown at a speed of about 200 knots. Following touchdown, steering was by differential braking because there was no nose-wheel steering capability.

On January 27, 1966, Major Bock and Major Gayland Jones flew the NB-52B to Tinker AFB, Oklahoma, for IRAN.[20] At that time the last of the Day-Glo orange was removed from the airplane, and the engine nacelles were painted gray. Major Bock and Major Doryland flew the NB-52B back to Edwards AFB on April 8, 1966.

Following its return from Tinker AFB the NB-52B underwent five weeks of pylon modification to accept the increased weight of the X-15A-2 with its external tanks.[21] The last launch conducted from the NB-52B had been the sixty-second flight of the X-15-1 on November 4, 1965.

Northrop M2-F2 hangs from the Northrop Norair adapter on the pylon of the NB-52B. (NASA photo E13868)

After over half a year of maintenance and modification, Lt. Col. Fulton and Major Doryland piloted the NB-52B as it carried the M2-F2 on a captive carry mission on June 7, 1966. Lt. Col. Fulton and Captain Jerry Bowline piloted the NB-52B as it carried the M2-F2 on a second captive carry flight on July 6.[22] Milton Thompson occupied the cockpit of the M2-F2 on both captive carry flights.

The first captive carry flight of the X-15A-2 with full external tanks was made on June 27, 1966. Lt. Col. Fulton and Major Doryland were at the controls of the NB-52B. Col. Robert Rushworth occupied the cockpit of the X-15A-2. The right outrigger landing gear of the *Stratofortress* stuck in the down position. It was the heaviest payload that had been suspended from the pylon to that date. A test of the propellant jettison system was a primary objective of this flight.

NB-52B carries Col. Robert Rushworth in the X-15A-2 with full external fuel tanks on June 27, 1966. (Photo from AAFTC/HO)

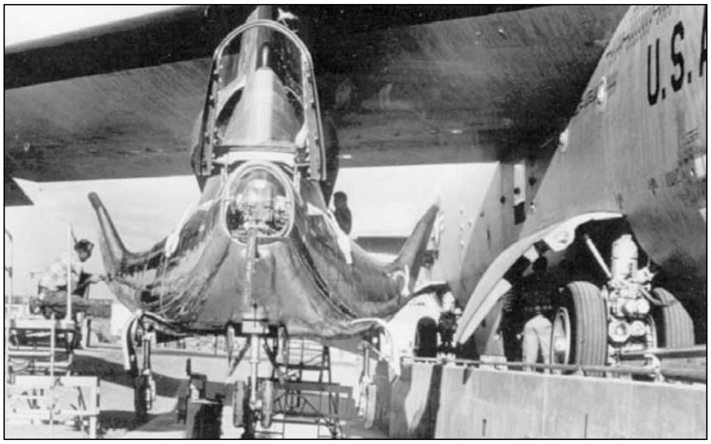
The X-15A-2 with full external tanks was launched for the first time from the NB-52B over Mud Dry Lake on July 1, 1966. Lt. Col. Fulton and Major Doryland were at the controls of the NB-52B. After launch, Col. Rushworth received an indication that the ammonia was not flowing from the external fuel tank, a situation that required him to abort the flight. Rushworth successfully glided the X-15A-2 to a landing on Mud Dry Lake in Nevada.[23] It was Col. Rushworth's last X-15 flight.

The first glide flight of the M2-F2 was scheduled for July 11, 1966. Lt. Col. Fulton and Major Doryland were taxiing the NB-52B out that morning when a Lockheed F-104 *Starfighter* blew a tire while landing on the main runway. The M2-F2 glide flight was postponed for a day. Milton Thompson was successfully launched on the first heavyweight lifting body flight on July 12, 1966.[24]

NB-52B takes off with Bruce Peterson in the M2-F2 on September 22, 1966. (NASA photo E15788)

The Northrop HL-10 was first mated to the NB-52B on November 12, 1966. The first captive-carry flight of the HL-10 was recorded in the flight log but never flown. The HL-10 was de-mated from the NB-52B, and the M2-F2 was mated for its fourteenth glide flight. Col. Cotton and Fitzhugh Fulton launched Captain Jerry Gentry in the M2-F2 on November 21.

The NB-52B carried the HL-10 on its first captive-carry flight on December 20, 1966. Major Reschke and Major Sturmthal piloted the *Stratofortress*. Bruce Peterson occupied the cockpit of the



HL-10 mated to the NB-52B on November 12, 1966. (Photo from NASA)

HL-10. The collection of test data was so successful that another captive-carry flight was cancelled.

Col. Cotton and Major Reschke launched Bruce Peterson from the NB-52B in the HL-10 on its first glide flight on December 22, 1966. Immediately after launch the HL-10 started vibrating. The yaw axis of the stability augmentation system entered a limit rate cycle. The flight control system commanded the control surfaces to move faster than they were able to. Peterson reduced the gain of the yaw channel of the stability augmentation system and eliminated the vibration. The pitch channel of the stability augmentation system also entered a limit rate cycle and Peterson reduced the gain of that channel several times. The HL-10 touched down at 280 knots instead of the expected 200 knots. It bounced and became airborne for some distance before settling on the lakebed.[25] The stability of the HL-10 was so poor that it did not fly again until March 15, 1968, after it had been modified to improve its flight characteristics.

Bruce Peterson flares the Northrop HL-10 just before landing on December 22, 1966. (NASA photo E661598)

Each lifting body eventually had an XLR-11 rocket engine installed. Lifting body flights were of shorter duration and lower speed than X-15 flights, so they were conducted in the vicinity of Edwards AFB. Flights were launched no farther away than Cuddeback Dry Lake. Following launch, the lifting body pilot ignited two to four of the thrust chambers of the rocket engine. On a typical flight, he climbed under power for something over two minutes. At about 70,000 feet altitude, after the appropriate amount of burn time, the pilot shut off the engine or allowed it to shutdown when the fuel was exhausted. The flight data relevant to lifting body reentry was collected primarily after engine shutdown. The approach and landing were essentially the same as for the glide flights.[26]

The M2-F2 was mated to the NB-52B for an attempt to launch Jerry Gentry on its fifteenth flight on April 20. The XLR-11 rocket engine had just been installed in the M2-F2 in preparation for a series of powered flights. The attempt was aborted and the M2-F2 was de-mated from the NB-52B, so that the X-15-3 could be mated for its fifty-eighth flight on April 26.

Col. Cotton and Major Bowline launched Pete Knight from the NB-52B in the X-15A-2 with the dummy ramjet on the ventral fin for the first time on May 8, 1967. The test shape was intended to examine the aerodynamic impact that an air-breathing ramjet would impose on the X-15, and it had no internal airflow.

M2-F2 Landing Accident

The M2-F2 was severely damaged in a landing accident during its sixteenth glide flight on May 10, 1967. Col. Cotton and Major Bowline launched Bruce Peterson from the NB-52B. As Peterson turned to line up with the runway, he dropped the nose of the lifting body slightly to keep it pointed at the pre-flare aim point. At the reduced angle of attack, the M2-F2 became unstable about its roll axis and entered a "Dutch roll." Peterson recovered from the Dutch roll, but the M2-F2 was no longer pointed at the normal landing runway on the lakebed. A Piasecki CH-22 *Workhorse* rescue helicopter hovering over the lakebed distracted Peterson in the moments before landing. The area on the lakebed where Peterson touched down lacked runway markings, making it difficult to estimate height above the featureless surface. The M2-F2 touched down on the lakebed before Peterson hit the landing gear switch. The flight ended in a spectacular rolling, flipping crash, film of which was used in the opening sequence of *The Six Million Dollar Man* television series. Bruce Peterson was badly injured in the accident and lost his sight in one eye.

Sixteen glide flights of the original Northrop M2-F2 configuration were flown from July 12, 1966, to May 10, 1967. The NB-52B had launched the M2-F2 twelve times. Following Bruce Peterson's accident, the M2-F2 was rebuilt to fly again in a modified configuration.

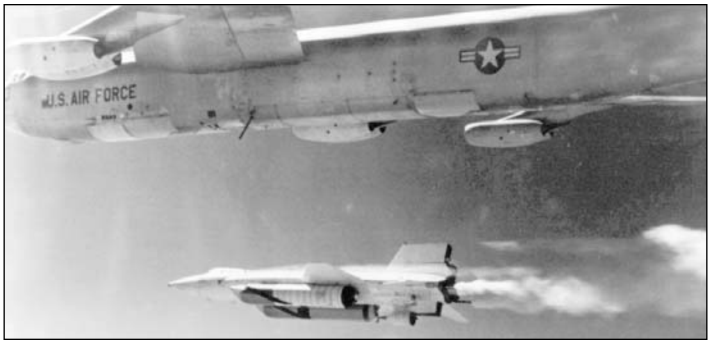
The NB-52B was displayed at the May 21, 1967, Edwards AFB Open House with the X-15-1 sitting on the ground under the pylon on the right wing. The Northrop HL-10 was on static display on the left side the NB-52B. The NB-52B's eagle nose art had been replaced with the cartoon of a B-52 throwing an X-15 that it still wears today.

X-15A-2 Fastest Flight

In order for the X-15A-2 to survive the higher temperatures generated by flight at speeds above Mach 7, the entire spaceplane was coated with spray-on, ablative thermal protection material. The pink ablative material was covered by a white sealant.

The NB-52B first launched the X-15A-2 with its white coating on August 21, 1967. After two aborted launch attempts, Col. Joe Cotton and Major Reschke launched Pete Knight in the X-15A-2 over Hidden Hills Lake. The supersonic combustion ramjet test shape was mounted on the ventral fin, but it was not carrying the external fuel tanks. The X-15A-2 reached a speed of Mach 4.94 (3,368 mph) and an altitude of 91,000 feet.

Nb-52B carries the X-15A-2 in the all-up configuration on a captive carry flight on August 7, 1967. (Photo from AAFTC/HO)



NB-52B launches Pete Knight in the X-15A-2 on the fastest flight of the program on October 3, 1967. (NASA photo EC88-180-10)

The NB-52B launched the X-15A-2 on its only flight in the "full-up" configuration on October 3, 1967. It carried the ablative coating, external tanks, and the ramjet test shape. Col. Cotton and Major Reschke launched Pete Knight from the NB-52B in the X-15A-2 over Mud Lake in Nevada at an altitude of 45,000 feet. The X-15A-2 achieved the highest speed ever attained by any manned aircraft other than the space shuttles, Mach 6.70 (4520 mph).

As the X-15A-2 crossed Death Valley, shock waves streaming from the dummy ramjet mounted on the ventral stabilizer superimposed themselves in unexpected ways, creating hot spots that burned holes into the nickel-iron skin of the ventral fin. Superheated air flowed into the stabilizer and the rear fuselage of the X-15A-2, burning through the plumbing and wiring within. Three of the four explosive bolts holding the dummy ramjet cooked off. The single remaining bolt eventually failed and the dummy ramjet fell off of the X-15A-2 as it approached the lakebed.

The damage to the X-15A-2 was subsequently repaired, but the next year funding for the program was discontinued. The X-15A-2 was never flown again and the first supersonic combustion ramjet flight had to wait for the X-43A Hyper-X program to be flown twenty-seven years later. The X-15A-2 is displayed at the National Museum of the Air Force.

The scorched X-15A-2 following the all-up flight in October 1967. (NASA photo EC1834)

Loss of Mike Adams and the X-15-3

The X-15-3 was lost and its pilot, Mike Adams, was killed following launch from the NB-52B on November 15, 1967. It was Adams' seventh flight in the X-15 and the one hundred ninety-first flight of the program. The third X-15 was equipped with the Minneapolis-Honeywell MH-96 adaptive-gain flight control system that automatically blended the aerodynamic flight controls with the reaction control thrusters as the X-15 transitioned from the atmosphere to the vacuum of space and then re-entered the atmosphere.

Col. Joe Cotton and Squadron Leader John Miller launched Mike Adams from the NB-52B on the sixty-fifth flight of the X-15-3 at 10:30 in the morning over Delamar Dry Lake in Nevada at an altitude of 45,000 feet. Adams accelerated for 82 seconds to a speed of Mach 5.20. The X-15-3 ascended on a ballistic trajectory to 266,000 feet. By exceeding an altitude of fifty miles, Adams earned his U. S. Air Force astronaut wings.

Mike Adams. (North American Rockwell photo)

An electrical disturbance from an experiment package on the wing tip caused the automatic reaction control thrusters to shut down. It also caused errors in the presentation of the attitude of the X-15 on the cockpit displays. Electrical disturbances disengaged the pitch and roll stability dampers.

As the X-15-3 started to descend, Adams switched to the manual reaction controls. It is believed that he was suffering from vertigo. He made control inputs in the wrong direction, causing the X-15 to yaw farther from the direction of flight. The X-15 spun completely around at 3,500 mph as it re-entered the atmosphere over Death Valley.

As the X-15-3 descended through 120,000 feet, Adams recovered from the spin, but at that point the adaptive flight control system drove the elevators into a rate-limit cycle. This drove the X-15 into violent pitch and roll oscillations. Mike Adams was tossed up and down inside the cockpit of the X-15 with thirteen times the force of gravity. He was unable to initiate the ejection sequence. The G-load on the X-15 caused its nickel-steel structure to break into many pieces at an altitude of about 60,000 feet over the Panamint Mountains. Mike Adams was killed when the cockpit section hit the ground near the town of Johannesburg in the Mojave Desert, five minutes and fifty seconds after he had been launched from the NB-52B.

HL-10 flights resumed with a captive flight on the NB-52B, piloted by Lt. Col. William Reschke and Squadron Leader Miller, on February 29, 1968. Captain Jerauld Gentry occupied the cockpit of the HL-10. Lt. Col. Reschke and Col. Cotton launched Captain Gentry from the NB-52B in the HL-10 on its second flight on March 15.

The wreckage of the cockpit of the X-15-3 lies in the desert after Mike Adams fatal crash. (NASA photo E17873)

The NB-52B last launched an X-15 on June 12, 1968. Lt. Col. Reschke and Col. Cotton launched Bill Dana in the X-15-1 on its seventy-seventh flight. Jack Russell manned the launch panel operator's station.

The NB-52B launched the X-15-1 twenty-six times, the X-15-2 fourteen times in its original configuration and fifteen times as the X-15A-2, and the X-15-3 thirty-four times.

Bill Dana piloted the last X-15 flight on October 24, 1968. He was launched from the NB-52A, 52-0003, in the X-15-1. The X-15-1 is displayed in the Milestones of Flight Gallery of the National Air and Space Museum.

The NB-52B launched the first powered flight of a lifting body on November 13, 1968. Fitzhugh Fulton and Captain Edward McDowell launched John Manke in the HL-10 on its third flight. Victor Horton manned the launch panel operator's station. Manke fired two of the XLR-11 engine's thrust chambers for 186 seconds. The HL-10 reached a speed of Mach 0.84 (524 mph) and an altitude of 42,650 feet.

Martin-Marietta X-24A

A third lifting body joined the program in 1969. Martin-Marietta created the X-24A based on the shape of the SV-5. The X-23 was a sub-scale SV-5 that was lofted into sub-orbital flight by a rocket. It demonstrated the behavior of the shape during flight at high Mach numbers. The X-24A was intended to evaluate its flight behavior during the transition from supersonic to subsonic flight and at landing.

The X-24A hangs from its adapter on the pylon of the NB-52B on May 8, 1969. (NASA photo EC69-2196)

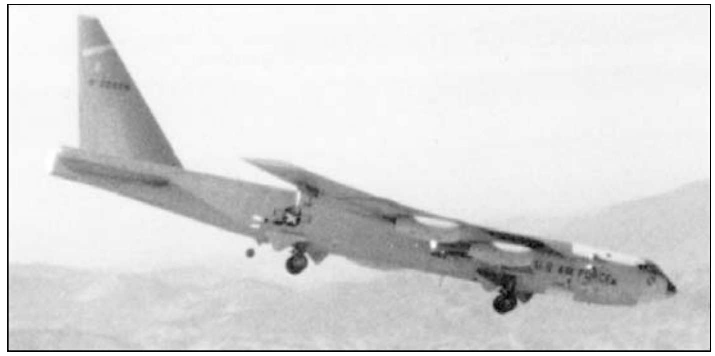
The NB-52B carried the Martin-Marietta X-24A on its first captive-carry flight on April 4, 1969. Lt. Col. Sturmthal and Major Jerry Bowline piloted the *Stratofortress*. Captain Jerauld Gentry occupied the cockpit of the X-24A. Victor Horton manned the launch panel operator's station.

The severely damaged M2-F2 was repaired, modified and re-designated M2-F3. The most obvious difference was the addition of a central fin that acted as a splitter.[27] The rebuilt M2-F3 was delivered to the NASA Flight Research Center in July 1969.

The NB-52B's sister ship, NB-52A, 52-0003 was retired to the Military Aircraft Storage and Disposition Center (MASDC) at Davis Monthan AFB near Tucson, Arizona, on October 19, 1969. This left the NB-52B as the sole mothership for the lifting body projects. The NB-52A survives in the Pima Air Museum near Tucson.

Simulating the Space Shuttle's Approach to Landing

In the first half of 1970, the NB-52B was used as an in-flight simulator of the proposed Space Shuttle. The NB-52B made steep approaches to the runways on Rogers Dry Lake, simulating the approach to be used by the Shuttle Orbiters. The pilots throttled six of the engines down to idle and set the remaining two engines to 75 percent thrust to provide power for the aircraft systems. The air brakes on the top of the wings were fully extended, to the "six" position. The NB-52B achieved lift-over-drag ratios as low as 3.2 in this configuration. The pilots pulled one and a half Gs during the flare for landing.


The NB-52B simulates the diving approach of the Space Shuttle in early 1970. (NASA photo E21203)

Six pilots flew fourteen straight-in approaches to the lakebed runways. The descents were started at 10,000 feet altitude. Eight overhead circling approaches were made, some full circles, others just three-quarters of a circle. The bank angle flown in the over-head approaches averaged forty-five degrees and reached as high as sixty-five. Touchdown speeds varied between 185 mph and 205 mph.

Ground controlled approaches (GCA) were flown with the pilots of the NB-52B wearing hoods to restrict their view to the instruments inside the cockpit and taking instructions from the ground controller. Three pilots flew steep angle GCA approaches from 18,000 feet altitude, initiating the flare about 500 to 800 feet above the lakebed. Four such approaches were flown. The rate of descent on these approaches was so high that the vertical speed indicator was pegged at the maximum descent rate, denying rate of descent information to the pilots. The pilots judged that the task was not much more demanding than a standard ground controlled approach. These tests contributed to the conclusion that the jet engines should be removed from the Shuttle Orbiters, substantially increased the payload of the Space Transportation System.[28]

Powered Lifting Body Flights

The NB-52B launched the HL-10 on the fastest lifting body flight on February 18, 1970. Captain Nicholas Fritz and Squadron Leader Allen Fisher launched Major Peter Hoag in the HL-10 on its thirty-fourth flight, which achieved a top speed of Mach 1.86 (1228 mph). Victor Horton manned the launch panel operator's station.

The NB-52B launched the HL-10 on the highest altitude lifting body flight on February 27, 1970. Major Bowline and Captain George Larson launched Bill Dana in the HL-10 on its thirty-fifth


The NB-52B launches the X-24A on a rocket-powered flight in 1970. (NASA photo ECN2511)

flight, which attained an altitude of 90,303 feet. Jack Russell manned the launch panel operator‘s station.

The NB-52B launched the X-24A on its first XLR-11 rocket-powered flight on March 19, 1970. Lt. Col. Sturmthal and Major Bowline piloted the *Stratofortress*. Victor Horton manned the launch panel operator‘s station. Captain Jerauld Entry occupied the cockpit of the X-24A.

The Martin Marietta X-24A, serial 66-13551, was displayed with the NB-52B at the May 19, 1970, Edwards AFB Open House. The X-15 mission marks had been removed from the fuselage of the NB-52B, and a new series of profiles of the M2-F2, HL-10 and X-24A had been started.

The NB-52B first carried the M2-F3 on a captive-carry flight on May 22, 1970. Major Bowline and Squadron Leader Fisher piloted the mothership. Victor Horton manned the launch panel operator‘s station. Bill Dana occupied the cockpit of the M2-F3.

The NB-52B first launched the M2-F3 on June 2, 1970. Squadron Leader Fisher and Captain Fritz launched Bill Dana from the NB-52B in the M2-F3 for its first glide flight since Bruce Peterson’s accident on May 10, 1967. Victor Horton manned the launch panel operator‘s station.

The HL-10 made the last of its thirty-seven flights when Major Fornell and Major Bowline launched Major Hoag from the NB-52B on July 17, 1970. Jack Russell manned the launch panel operator‘s station. The NB-52B launched the HL-10 twenty-three times. The HL-10 survives on a pylon in front of the NASA Dryden Flight Research Center at Edwards AFB.

The NB-52B launched the X-24A on its highest altitude flight on October 27, 1970. Lt. Col. Reidenauer and Squadron Leader Fisher launched John Manke on the nineteenth flight of the X-24A, which achieved an altitude of 71, 400 feet. Victor Horton manned the launch panel operator‘s station.

The NB-52B launched the X-24A on its fastest flight on March 29, 1971. Major Edward McDowell and Squadron Leader Fisher launched John Manke on the twenty-fifth flight of the X-24A, which achieved a speed of Mach 1.60 (1,036 mph). Victor Horton manned the launch panel operator‘s station.

The NB-52B launched the X-24A on its last flight in its original configuration on June 4, 1971. Major McDowell and Major Ranz launched John Manke on a flight that reached a speed of Mach 0.817 and an altitude of 54,400 feet. Jack Russell manned the launch panel operator‘s station. The X-24A was launched from the NB-52B on twenty-seven of its twenty-eight flights.

The Northrop HL-10 was displayed next to the NB-52B at the May 17, 1972, Edwards AFB Open House, which marked the twenty-fifth anniversary of the Air Force. All mission marks had been removed from the NB-52B fuselage. The buff colored chin radome of the NB-52B had been replaced with a black radome.

The M2-F3 falls away from the NB-52B in a 1972 launch. (NASA photo ECN3334)

The NB-52B launched the M2-F3 on its fastest flight on December 13, 1972. Major George Luck and Captain Michael King launched Bill Dana in the M2-F3 on its twenty-sixth flight, which achieved a top speed of Mach 1.613 (1064 mph). Victor Horton manned the launch panel operator‘s station.

The NB-52B launched the M2-F3 on its highest altitude flight on December 20, 1972. Major George Luck and Major Frederick Feidler launched John Manke in the M2-F3 on its twenty-seventh flight, which reached a peak altitude of 71,500 feet. It was the final M2-F3 flight. Jack Russell manned the launch panel operator‘s station. The M2-F3 is displayed in the National Air and Space Museum.

Martin-Marietta X-24B

The Air Force Flight Dynamics Library came up with an idea for using the X-24A as the basis for a lifting body with an entirely new shape. The airframe of the X-24A was sheathed in an aluminum glove that gave it a flat bottom, a long-pointed nose and stub wings. The flatiron shape was expected to provide greater controllability at hypersonic airspeed. It was re-designated X-24B. The X-24B was the first lifting body to be equipped with nose-gear steering. The newly configured X-24B returned to Edwards AFB in early 1973.

The X-24B was first displayed to the public next to the NB-52B at the May 16, 1973, Edwards AFB Open House. The HL-10 was displayed next to the M2-F3 some distance down the flightline. The NB-52B mission marks for the X-15, M2-F2, HL-10, and X-24A had been reduced to a single silhouette of each with the number of flights launched. New profiles for the flights of the M2-F3 had been added.

NB-52B carries the Martin-Marietta X-24B in 1973. (Photo from AAFTC/HO)

The NB-52B first carried the X-24B aloft after its modification on July 19, 1973. Lt. Col. Dale Ranz and Captain Thomas Higgins piloted the NB-52B. Victor Horton manned the launch panel operator‘s station. John Manke occupied the cockpit of the X-24B.

The NB-52B first launched the X-24B on August 1, 1973. Lt. Col. Ranz and Captain Higgins launched John Manke in the X-24B on its first glide flight. Victor Horton manned the launch panel operator’s station.

F-15 Remotely Piloted Research Vehicles

A new experimental flight research technique was introduced in the early 1970s: Remotely Piloted Research Vehicles. RPRVs were promoted as a less expensive and safer alternative to manned flight-testing. The lightness and small size of an RPRV, compared with a full-scale airplane, allowed its construction to be quicker and less expensive. Placing the pilot in a control cockpit on the ground eliminated the risk to human life posed by full-scale testing.[29]

The first RPRVs were three 3/8-scale models of the McDonnell-Douglas F-15 *Eagle*. The models investigated the stall, departure, and spin characteristics of the F-15 without placing a pilot at risk. A typical F-15 RPRV mission began with launch from the NB-52B at an altitude of 50,000 feet and a speed of Mach 0.7. Test maneuvers were conducted for approximately five minutes during the unpowered glide. Approximately 10 stability and control maneuvers were conducted on a typical flight. These maneuvers were performed at several angles of attack to determine the RPRV's stability, control, and damping characteristics.

The 3/8-scale F-15 RPRV hangs from its adapter on the NB-52B pylon in April 1973. (NASA photo EC3644)

Recovery of the RPRV by a Mid-Air Retrieval System (MARS) helicopter was the standard method of operation for the first 16 flights of the program. The MARS helicopter snagged the drone as it descended under its parachute.

The NB-52B first carried an F-15 RPRV on a captive-carry flight on October 1, 1973. Captain Higgins and Major Michael King piloted the NB-52B. The NB-52B first launched an F-15 RPRV on October 12. Captain Higgins and Captain Francis Scobee piloted the NB-52B.

NB-52B carries an F-15 RPRV in October 1973. (NASA photo ECN-3804)

The NB-52B launched the X-24B on its fastest flight on October 26, 1974. Major Luck and Captain Paul Skabo launched Mike Love in the X-24B on its sixteenth flight. The X-24B reached a maximum speed of Mach 1.76 (1,163 mph) on that flight.

The NB-52B appeared at the December 1, 1974, Edwards AFB Open House with the X-24B parked under the pylon. The rear fuselage of the X-24B had been painted white.

On two occasions the MARS helicopter failed to retrieve the F-15 RPRV as it descended under its parachute. The first time, the drone landed using the main parachute, but sustained extensive damage. On the sixteenth flight, flown on January 16, 1975, the MARS helicopter failed to retrieve the RPRV. Tom McMurtry belly-landed the RPRV on Rogers Dry Lakebed. After McMurtry had demonstrated the feasibility of landing the RPRV horizontally like an airplane, landing gear skids were installed on the drones. On subsequent flights the pilot flew the RPRV to a landing on the dry lakebed.

Conclusion of X-24B Program

The NB-52B launched the X-24B on its highest altitude flight on May 22, 1975. Major Luck and Captain Paul Skabo launched John Make in the X-24B on its twenty-third flight. Jack Russell manned the launch panel operator's station. The X-24B reached a maximum altitude of 74,130 feet on that flight.

The NB-52B launched the first lifting body mission to land on the concrete runway at Edwards AFB on August 5, 1975. Fitzhugh Fulton and Capt. Thomas Higgins launched John Manke from the NB-52B in the X-24B over Cuddeback Lake. The precision of the approach of the X-24B was more than adequate to prove the feasibility of landing a space shuttle within the confined area of a runway. [30]

The NB-52B launched the last rocket propelled lifting body flight on September 23, 1975. Major Higgins launched Bill Dana in the X-24B on a flight that reached a speed of Mach 1.157 and an altitude of 56,800 feet. It was Dana's last rocket flight and also the last flight powered by one of the four-chambered XLR-11 rocket engines that had powered the X-1s in 1947. It was not just the same engine design; it was the same engine, still in use after twenty-eight years.

The NB-52B was again accompanied by the X-24B at the November 16, 1975, Edwards AFB Open House. The X-24B had been painted white with a blue stripe along the leading edge.

The NB-52B launched the last lifting body flight on November 26, 1975. Major Higgins and Fitzhugh Fulton launched

The NB-52B was accompanied by the X-24B at the November 16, 1975, Edwards AFB Open House. (Author's photo)

The X-24B falls away from the NB52B in 1975. (Photo by Bob Dorr via Greg Spahr)

Tom McMurtry in the X-24B on a glide flight. Six pilots had flown the X-24B on twelve glide flights and twenty-four powered flights.[31] The X-24B is displayed in the National Museum of the Air Force.

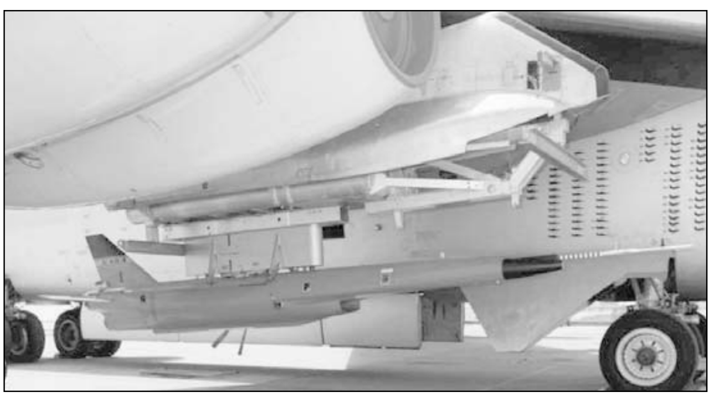
The NB-52B launched 127 lifting body flights in all. The NB-52A launched a further 17 lifting body flights.

Firebee II

The NASA Firebee II program was intended to demonstrate the feasibility of using the airframe as the basis for a low-cost research vehicle. Unlike the F-15 RPRV, the Firebee II was powered by a jet engine. It was capable of operating at a greater distance from the ground control station.

The NB-52B first carried the Firebee II on a captive-carry flight on November 25, 1975. A second captive flight was scheduled for December 19. Problems with the command and control systems on the F-104 that was used for emergency control of the drone in flight caused that mission to be aborted.

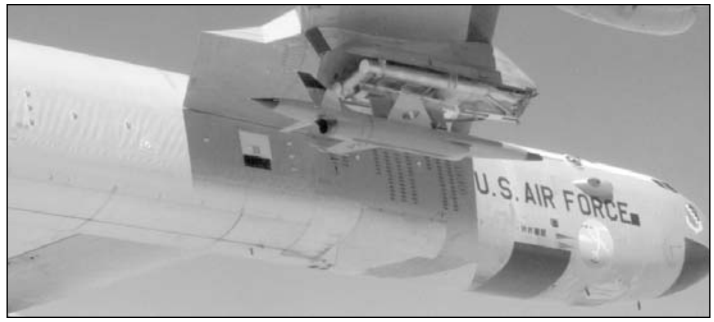
The NB-52B last launched an F-15 RPRV on December 17, 1975. Major Higgins and Captain Scobee piloted the



Firebee II drone hangs from the NB-52B pylon in 1977. (NASA photo EC7401)

Stratofortress and Ray Young manned the launch panel. Einer Enevoldson piloted the F-15 RPRV from the ground station. The three F-15 RPRVs flew a total of twenty-seven times.

The Air Force planned to retire the NB-52B once the lifting body programs were concluded in 1975. Some consideration was given to retiring the *Stratofortress* mothership to MASDC at Davis Monthan AFB. NASA had a continuing need for the NB-52B to launch RPRVs and parachute test systems, so the NB-52B was loaned from the Air Force to NASA on April 26, 1976. NASA



NB-52B carries the Firebee II drone in 1977. (NASA photo EC8114)

added a yellow tail band with black stripes and the word NASA to the vertical stabilizer of the *Stratofortress*.

The NB-52B was flown to Tinker AFB, Okla.,, for IRAN on July 7, 1976. It returned to Edwards AFB on September 22, 1976.

The third captive flight of the Firebee II was flown on July 22, 1977. The NB-52B launched the Firebee II on July 28, 1977. Bill Dana controlled the flight of the drone from the ground.

Space Shuttle Solid Rocket Booster Drop Test Vehicle I

The parachutes used to recover Space Shuttle Solid Fuel Boosters were tested in drops from the NB-52B. Marshall Space Flight Center contracted with Martin-Marietta to build a 48,000-pound Space Shuttle Solid Rocket Booster Drop Test Vehicle (SRB/DTV) to fit the X-15 pylon.

The NB-52B made the first two captive-carry flights with the SRB/DTV on June 10, 1977. The first drop of the SRB/DTV was flown on June 15, 1977. Fitzhugh Fulton and Don Mallick piloted the NB-52B and Victor Horton manned the launch panel.

The Shuttle Reusable Booster Drop Test Vehicle hangs from the pylon of the NB-52B on June 17, 1977. (NASA photo EC7515)

Six drops were made in the first series of tests of the SRB/DTV. The last drop of the series was flown on September 12, 1978.

Wake Vortex Testing

The Air Force Weapons Lab conducted a study of B-52 wake properties with the NB-52B in 1977. To make the wingtip vortices of the NB-52B visible, a smoke system was installed to stream smoke from the its left wingtip. In September and October 1977, plumbing and valves, a tank, and a service panel for the smoke system were installed.[32] A smoke control panel and a control panel for a tail-mounted camera were fabricated at the same time.[33] An SCSG-1 smoke generator was installed in the left wingtip and a 16mm camera was installed in the tail gunner's compartment in September 1977.[34] An immersion heater was installed in the wingtip smoke generator in November 1977.[35]

Wake vortex tests were conducted near Idaho Falls. The NB-52B flew past a tower fitted with wind speed and direction sensors at several levels. The *Stratofortress* made eight passes by the tower on a flight flown during the week of October 17 and twenty-two passes on a flight flown on December 6.

Spin Research Vehicle

The F-15 RPRVs served as the basis for the Spin Research Vehicles (SRV). A variety of nose configurations and anti-spin parachutes were tested on the SRV. SRV launch panel circuitry for the NB-52B was fabricated in August 1977.[36] The NB-52B first launched an SRV on November 29, 1977. A Spin Research Vehicle was displayed on the pylon of the NB-52B on static display at the November 12, 1978, Edwards AFB Open House.

The NB-52B launched the last flight of the SRV on July 15, 1981. Fitzhugh Fulton and Brian O'Hara piloted the *Stratofortress*. Ray Young manned the launch panel and Mike Swan controlled the SRV from the ground. The Spin Research Vehicles flew twenty-six flights.

The NB-52B was accompanied by the X-24B at the November 16, 1975, Edwards AFB Open House. (Author's photo)

Blue Streak

In 1979, the Instrumented Standard Wing was attached to the Firebee II. It had a blue stripe painted along its span and was referred to as the "Blue Streak" wing. The NB-52B made a captive-carry flight of the *Blue Streak* on March 7, 1979. Fitzhugh Fulton and Donald Mallick piloted the *Stratofortress* and Ray Young manned the launch panel.

The NB-52B launched the *Blue Streak* only once, on March 9, 1979. Donald Mallick and Thomas LeBeau piloted the *Stratofortress* and Ray Young manned the launch panel. Tom McMurtry piloted the *Blue Streak* from the ground station.

Drone for Aeroelastic Structure Testing

The Drone for Aeroelastic Structure Testing (DAST) was based on the airframe of the Ryan Firebee II drone. It was equipped with smooth surfaced Aeroelastic Research Wings with flexible skins and internal actuators instead of traditional hinged, fixed-contour flight control surfaces. The intent was to delay the onset of stall by eliminating discontinuities in the surface contour of the wing, and to provide complete control over wing camber to

Blue Streak drone equipped with white Instrumented Standard Wing hangs from the NB-52B pylon in March 1979. (NASA photo ECN-10247)

provide optimal lift at all speeds, altitudes, and maneuvering conditions.

In preparation for the DAST program, a series of modifications were performed to the NB-52B. Wiring for the drone was routed from the bomb bay to the launch panel operator's station and installed from the pylon to the bomb bay through the liquid

Drone for Aeroelastic Structures Testing hangs from the NB-52B pylon in 1979. (NASA photo EC11859)

NB-52B carries DAST in the company of NASA TF-104G, N824NA, in 1980. (NASA photo EC14095)

oxygen plumbing on January 13, 1977.[37] A Firebee system console was installed at the launch panel operator's station on February 16, 1977.[38]

A Firebee II drone was fitted with Aeroelastic Research Wing No. 1 (ARW-1) in 1979. In this configuration the Firebee II became known as DAST. The first captive-carry flight of DAST was flown on September 14, 1979. The first launch of DAST from the NB-52B was flown on October 2, 1979.

The third flight of DAST was flown on June 12, 1980. Fitzhugh Fulton and Donald Mallick piloted the NB-52B. Ray Young manned the launch panel and Tom McMurtry flew the

DAST from the ground. At a speed of Mach 0.825, the right wing of DAST fluttered and separated from the drone.

DAST II

A second Aeroelastic Research Wing (ARW-2) was manufactured, and DAST II was prepared for flight in 1982. The first captive-carry flight of DAST II by the NB-52B was flown on October 29, 1982. The NB-52B launched the DAST II one time on November 3, 1982. Fitzhugh Fulton and Donald Mallick piloted the NB-52B. Ray Young manned the launch panel and Tom McMurtry flew the DAST II from the ground. Flights of the DAST II were attempted on January 20 and February 10, 1983, but both of the attempts were aborted before the DAST II was launched.

All subsequent DAST II launches were conducted from U. S. Navy DC-130A drone control *Hercules*.

NB-52B carries DAST II in October 1982. (NASA photo E20785)

F-111 Crew Module Parachute Test Vehicle

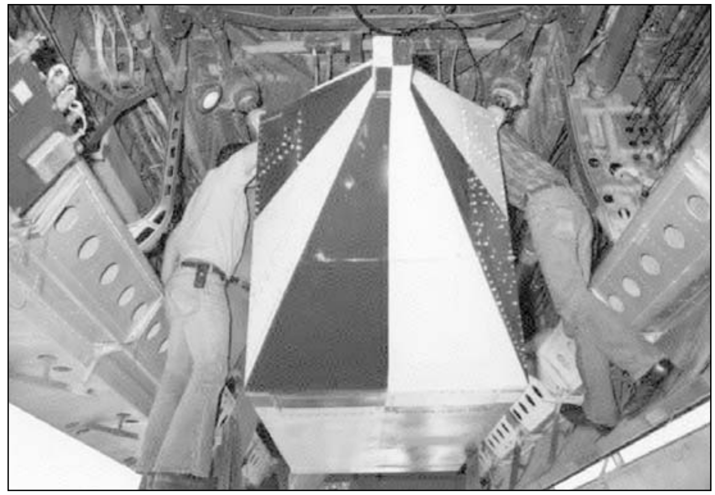
Over the operational history of the F-111, new equipment was frequently added to the cockpit. This increased the weight of the crew escape module. As a result, the rate of descent under the original seventy-foot diameter ring-sail parachute had increased, as had the risk of injury to a crew forced to eject from a disabled F-111. New parachute recovery systems were designed for the escape module of the F-111.

The Parachute Test Vehicle (PTV) was developed in the sixties during the development of the original parachute system. The design of the PTV allowed it to be suspended in the bomb bay of a conventional B-52. In the late1970s, the NB-52B was the only remaining *Stratofortress* with a bomb bay configured to drop the PTV. The PTV was ten feet long and four feet wide with a compartment for the test parachute installation and a second compartment for a safety parachute system. It was pointed in front and had a drag parachute mounted on the back end to stabilize the vehicle until the test parachute deployed. It was painted bright red.

The installation of the equipment used to drop the PTV in the bomb bay of the NB-52B required the removal of the X-15 LOX top off tank. The tank and its associated cradle were removed on January 23, 1979.[39] An H-frame supporting a standard MAU-12 bomb rack was installed in the bomb bay in February 1979.[40]

The NB-52B first dropped the PTV on February 17, 1979. Eight drops were conducted in the first PTV test series. The drops were conducted over the Tonopah Test Range in Nevada. The last drop of the first test series was flown in August 1979.

A second test series of eleven PTV drops was conducted in 1982. The first drop of the second test series was flown on March



The Parachute Test Vehicle suspended in the bomb bay of the NB-52B in 1988. (NASA photo ECN18234)

3, 1982. The last drop of the second test series was flown in November 1982. A third series of twelve PTV drops was conducted from July 7, 1987, to November 9, 1988.[41] A fourth series of eleven PTV drops began in May 1989. The last drop of the fourth test series was flown in February 1990.

A new 85-foot diameter ring sail parachute system was developed for the F-111 crew module. A series of four drops of the PTV were flown to test the new parachute in February and March 1991. A sixth series of ten drops was conducted from June 1991 to November 1991. A seventh series of five drops began in March 1992.

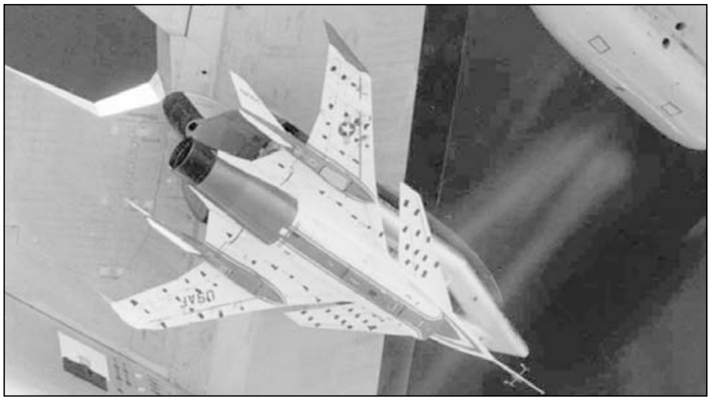
On some of the PTV test flights, the NB-52B tested a ground speed sensor to be used on the Convair 990 Landing Systems Research Aircraft (LSRA).

PTV drops from the bomb bay of the Nb-52B in 1988. (NASA photo EC88-0032-03)

Highly Maneuverable Aircraft Technology

The Highly Maneuverable Aircraft Technology (HiMAT) research vehicles were designed to investigate methods of improving the maneuverability of fighter aircraft. They were designed specifically for launch from the NB-52B. Novel aerodynamic features of the HiMAT drones included close-coupled canards and winglets. Rockwell International designed a full-scale maneuverability demonstrator and then scaled it down to forty-four percent of its original size. Two HiMAT drones were built.

The empty weight of the HiMAT drones was 2,840 pounds. Fully fueled for launched they weighed 3,500 pounds. They were



NB-52B carrying HIMAT #1 in 1979. (NASA photo EC11643)

designed for a maximum speed of Mach 1.6. They were built to withstand twelve positive Gs and six negative Gs. A General Electric J85-21 turbojet engine powered each of the drones.

The M2-F3 pylon adapter was modified to support the HiMAT drones for launch from the NB-52B. The main structural tubing of the adapter was converted to contain 230 gallons of jet fuel to replace the fuel burned by the HiMAT before launch. The HiMAT was mounted on the adapter in a 2-degree nose down attitude to ensure that it would separate cleanly from the NB-52B at launch.

Two hooks on the adapter attached to pins on the centerline of the upper fuselage of the drones. Sway braces on the adapter prevented the drone from swinging from side to side. The pilot of the NB-52B controlled the release of the hooks. Compressed nitrogen gas drove the hook release mechanism.

Initial modifications to HiMAT panel wiring were made to the NB-52B in March 1978.[42] Additional wiring and a Volt-Amp monitor panel were installed in May.[43] Panel boxes, a T/M J-box, camera brackets, antennae, and a pneumatic launch system monitor were installed in January 1979.[44,45] A relay was installed to shut down power switching during pyrotechnic payload loading.[46] The B-52 power distribution was expanded for the HiMAT mission in April 1979.[47] At the same time, power kill circuitry was added to the electrical back-up launch system.[48] Circuitry associated with the fuel tank, camera, and power kill system was installed at the launch panel operator's station in May.[49] The fuel top-off tank was equipped with a pressure sensor and a fuel pressure gauge was installed on the launch panel operator's instrument panel.[50]

The HiMAT engine was started on the ground before the NB-52B began to taxi to the runway. The NB-52B carried the HiMAT drone to an altitude of 45,000 feet for launch over Edwards AFB.

The NB-52B was displayed with a HIMAT drone attached to the pylon at the November 8, 1987, Edwards AFB Open House. (Author's photo)

At the conclusion of each test flight, the drone was flown to a horizontal landing on skids on Rogers Dry Lake.

The NB-52B made the first captive-carry flight of HiMAT #1 on July 11, 1979. Fitzhugh Fulton and Donald Mallick piloted the *Stratofortress*. Ray Young manned the launch panel operator's station. Bill Dana operated the HiMAT drone systems from the ground. The NB-52B first launched HiMAT #1 on July 27, 1979. The crew was the same as for the captive carry flight, except Tomas LeBeau was the copilot of the NB-52B.

The NB-52B appeared with the Highly Maneuverable Aircraft Technology (HiMAT) adapter on the X-15 pylon at the October 5, 1980, Edwards AFB Open House.

The NB-52B made the first captive-carry flight of HiMAT #2 on June 25, 1981. The crew was the same as for the first captive-carry flight of HiMAT #1. The NB-52B first launched HiMAT #2 on July 24, 1981. The crew was the same as for the captive carry flight, except Major Daniel Vanderhorst was the pilot of the NB-52B.

The last flight of HiMAT #1 was flown on August 27, 1982. Fitzhugh Fulton and Donald Mallick piloted the *Stratofortress*. Ray Young manned the launch panel operator's station. Steven Ishmael controlled the HiMAT drone from the ground. The NB-52B launched the HiMAT #1 fourteen times.

The last flight of HiMAT #2 was flown on January 12, 1983. Fitzhugh Fulton and Donald Mallick piloted the *Stratofortress*. Harold O'Brien manned the launch panel operator's station. Einer Enevoldson controlled the HiMAT drone from the ground. The NB-52B launched the HiMAT #2 twelve times.

Space Shuttle Solid Rocket Booster Drop Test Vehicle II

A second series of drop tests of the SRB/DTV was scheduled to begin on February 23, 1983. The flight was cancelled due to adverse weather. As the NB-52B taxied back to the flightline, the rear hooks supporting the SRB/DTV failed. The resulting damage put the NB-52B pylon out of commission until September.

The first drop of the second test series was flown on September 16, 1983. Eight drops were conducted. The last drop of the second SRB/DTV test series was flown on March 20, 1985.

The SRB/DTV rest on the ground after the failure of the NB-52B pylon hooks on February 23, 1983. (NASA photo EC22788)

The SRB/DTV falls away from the NB-52B on July 19, 1984. (NASA photo EC90-0111-2)

During the course of one test, the parachute separated from the SRB/DTV, which impacted the desert at high speed. There is a special mission mark on the fuselage showing the unit stuck in the ground and flanked by Joshua trees.

Orbital Sciences *Pegasus*

Under contract to the Defense Advanced Research Projects Agency (DARPA), Orbital Sciences Corporation designed their *Pegasus* booster to be air-launched from the NB-52B. The three-stage Pegasus booster weighed over 41,000 pounds.

The NB-52B first launched the Orbital Sciences *Pegasus* booster over the Pacific Ocean, about 60 miles southwest of Monterey, Calif., on April 5, 1990. Gordon Fullerton and Jim Smolka piloted the NB-52B.[51] It was the first time a payload had been put into earth orbit by a commercial rocket. The NB-52B launched the second *Pegasus* on July 17, 1991, using the same drop point off the California coast.

The NB-52B was displayed with a *Pegasus* satellite launcher at the October 6, 1990, Edwards AFB Open House.

NB-52B carries Orbital Sciences Pegasus. *(NASA photo EC89-0309-3)*

The NB-52B first launched a commercial satellite on the third *Pegasus* on Feb. 9, 1993. That launch was conducted off the coast of Florida.

The fourth, fifth, and sixth *Pegasus* missions were launched off the California coast. A total of seventeen satellites were placed in orbit by the six *Pegasus* launches. The NB-52B launched its final *Pegasus* mission on Aug. 3, 1994. *Pegasus* launches are now conducted from Orbital Sciences' Lockheed L-1011, N140SC *Stargazer*.

Space Shuttle Drag Chute Tests

The NB-52B tested the Space Shuttle Drag Chute in a series of eight high-speed taxi tests in 1990. NASA's Johnson Space Center contracted with Rockwell Space Systems to construct a mechanism to test the drag chute intended for use to decelerate landing Space Shuttle Orbiters. A boxy structure was installed under the empennage of the *Stratofortress* to hold the drag chute mechanism.

The first drag chute test was conducted on Rogers Dry Lake on July 20, 1990. The drag chute was deployed at an air speed of 150 mph. Three additional tests were conducted on the lakebed in July and August.

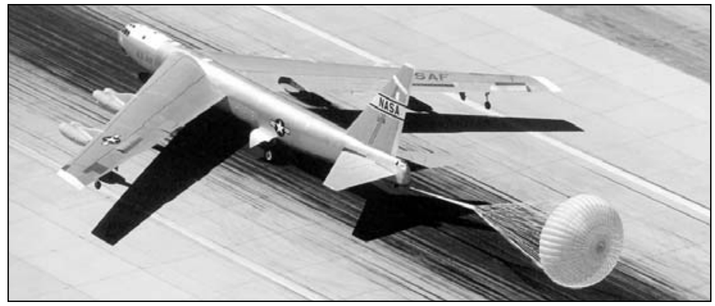
The NB-52B first tested the drag chute on the concrete runway on September 12, 1990. Gordon Fullerton and Ed Schneider were at the controls of the NB-52B. Four tests were conducted on the concrete runway in September and October.

The highest speed at which the NB-52B deployed the chute was 192 knots on the sixth test, conducted on September 21. The drag chute remained reefed to prevent it from separating from the *Stratofortress*.

The Space Shuttle *Endeavor* made the first use of the drag chute on May 16, 1992.

Supersonic Supercruise

In 1994 and 1995, the NB-52B carried a pair of J85 jet engines and tanks of fuel additives on a pallet in its bomb bay. It was reported that it was collecting data about the effectiveness of the additives in reducing emissions of oxides of nitrogen from the proposed High Speed Civil Transport.



NB-52B tests the Space Shuttle drag chute on the concrete runway on September 27, 1990. (NASA photo EC90-262-27)

The 1,170-pound X-15 pylon was removed on September 15, 1994, to eliminate the asymmetric flow field around the B-52. On October 7, 1994, a close-out structure was installed in the slot in the trailing edge of the wing that had been installed to accommodate the tail of the X-15.

The NB-52B tests fuel additives with a pair of J85 jet engines mounted on a pallet in its bomb bay on June 30, 1995. (Author's photo)

X-38 Space Station Crew Return Vehicle Parachute Test-bed

The NB-52B conducted a series of seven drops of NASA's X-38 Space Station Crew Return Vehicle parachute test-bed. The X-38 was a technology demonstrator for the proposed crew return vehicle that was designed as an autonomous "lifeboat" for the International Space Station. NASA planned to use the crew return vehicle to return the Space Station crew to Earth if an Orbiter was unavailable or if the Space Station became disabled.

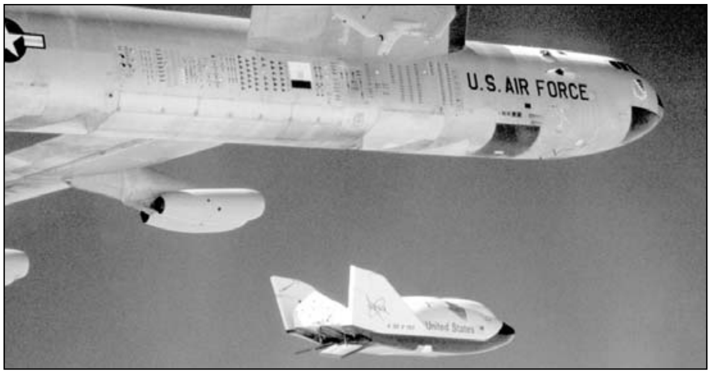
A new pylon was manufactured to carry the X-38 under the wing of the NB-52B. The new pylon weighed 3,000 pounds.

The original X-38 shape was derived directly from the Martin-Marietta X-24A. Its flying characteristics had already been thoroughly explored. Unlike the X-24A, which landed at over 200 mph, the X-38 landed gently under a large, wing-shaped parachute.

The X-38 conducted tests of the last phases of the landing of the proposed Crew Return Vehicle. After launch from the NB-52B it demonstrated the behavior of the lifting body shape in gliding flight at subsonic velocity, then it deployed a large parafoil for the final descent, landing very slowly on its skids on Rogers Dry Lake.

Two X-38 vehicles were constructed. V-131 was initially intended to make short glide flights, so it lacked movable flight controls. V-132 was equipped with functional flight control surfaces, which allowed it to perform extended glides before deploying the 5,000-square foot parafoil.

The NB-52B first carried X-38 V-131 on a captive-carry flight on August 2, 1997. The NB-52B appeared with X-38 V-131 mounted on its new pylon at the 1997 Open House. The Open House ran for two days, October 18 and 19.



The X-38 V-132 falls away from the NB-52B on July 9, 1999. (NASA photo EC99-45080-25)

The first parachute drop test of X-38 V-131 was conducted on March 12, 1998. The unanticipated behavior of the parafoil as it deployed prompted a ten-month hiatus in X-38 flight tests while the parafoil was tested at Yuma Marine Corps Air Station. V-131 was dropped from the NB-52B for the second time on February 6, 1999. V-131 was subsequently modified by Scaled Composites to more closely represent the configuration of the orbital V-201 Crew Return Vehicle. After modification, its designation was changed to V-131R. It tested a larger 7,500-square foot parafoil intended for the full-scale vehicle.

X-38 V-131 sat on its trailer on static display next to the NB-52B at the 1998 Open House. The X-38 pylon had been removed from the NB-52B.

The NB-52B first launched X-38 V-132 on March 5, 1999. V-132 made its second flight on July 9, 1999, and its third flight on March 30, 2000.

X-38 V-132 sat on its trailer on static display next to the NB-52B at the 1999 Open House, which was held on October 9 and 10.

The NB-52B first launched X-38 V-131R with the larger parafoil on November 2, 2000. The *Stratofortress* launched the last X-38 flight on December 13, 2001. The Space Station Crew Return Vehicle and the X-38 flight test program were cancelled in late 2001. X-38 V-132 has been placed on static display at the Johnson Space Center.

NB-52B takes off with X-38 V131R on November 2, 2000. (Author's photo)

Hyper-X

The NB-52B launched three X-43A Hyper-X stacks to investigate Supersonic Combustion Ramjet technology. The twelve foot long X-43A was mounted on the first stage of a Pegasus booster and dropped from the NB-52B. After launch the Pegasus pitched up into a climb as it does on a typical satellite launch, but then it pitched over to level flight at about 100,000 feet altitude and accelerated to the desired launch speed. The X-43A separated from the booster and successfully demonstrated the operation of a supersonic combustion ramjet at a speed approaching Mach 10.

The X-43A and its Pegasus booster were mated to the NB-52B for the first time on March 13, 2001. The X-15 pylon was re-installed on the wing of the *Stratofortress* for the Hyper-X program. The NB-52B first carried an X–43A Hyper-X stack on a captive-carry flight on April 28, 2001.

The first X-43A Hyper-X mission was launched on June 2, 2001. In order to fly the Pegasus booster with a full load of propellant, the stack was dropped at an altitude of 20,000 feet. The increase in dynamic pressure relative to the normal Pegasus launch altitude of 40,000 feet resulted in the failure of the rudder actuator. The vehicle yawed out of control and had to be destroyed by range safety control.

After a lengthy accident investigation, the second X-43A Hyper-X was launched on March 27, 2004. The Pegasus booster was modified by the removal of 3,300 pounds of excess propellant to allow the NB-52B to launch it at an altitude of 40,000 feet. The second X-43A demonstrated that an air-breathing engine could propel a vehicle at Mach 7. It was the first flight of an integrated supersonic combustion ramjet powered vehicle and shattered all previous records for the speed of a vehicle propelled by an air-breathing engine. The X-43A accelerated in a climb at a speed more than twice as fast as the Lockheed SR-71A *Blackbird*.

The final research flight by the NB-52B was the launch of the third X-43A Hyper-X on November 16, 2004. Former Space Shuttle pilot C. Gordon Fullerton piloted the *Stratofortress* mothership. The copilot was Frank Batteas. Orbital Sciences employee Brian Minnick manned the launch panel and NASA Dryden's Brad Neal monitored the X-43A systems aboard the NB-52B.

NB-52B takes off with the first X-43A Hyper-X stack on June 2, 2001. (Author's photo)

The Pegasus booster climbed to 110,000 feet and accelerated to Mach 9.8 in about 90 seconds and then released the X-43A. Once it was established that the X-43A was in stable flight, the engine cowl doors opened. Hydrogen fuel was injected into the combustion chamber and ignited with Silane. Combustion was maintained in the airflow going faster than the speed of sound through the engine. The thrust of the engine was approximately equal to the drag of the vehicle, simulating cruise flight, for ten seconds. The X-43A flew twenty miles in those ten seconds.

It is anticipated that the NB-52B *Stratofortress* mothership will be placed on display at Edwards AFB.

NB-52B takes off with the second X-43A Hyper-X stack on March 27, 2004. (Author's photo)

The NB-52B makes a pass over the NASA Dryden Flight Research Center following the last X-43A Hyper-X mission on November 16, 2004. (Author's photo)

Editor's Note: This article is an excerpt of Brian's soon to be published book, Balls Eight: A Pictorial History of the Boeing NB-52B Stratofortress Mothership. *The book is illustrated with many full color photos of every project that the NB-52B has supported.*

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