NASA Facts

National Aeronautics and
Space Administration

Dryden Flight Research Center
P.O. Box 273
Edwards, California 93523
Voice 661-276-3449
FAX 661-276-3566
pao@dfrc.nasa.gov

FS-1998-05-011-DFRC

The Lifting Bodies

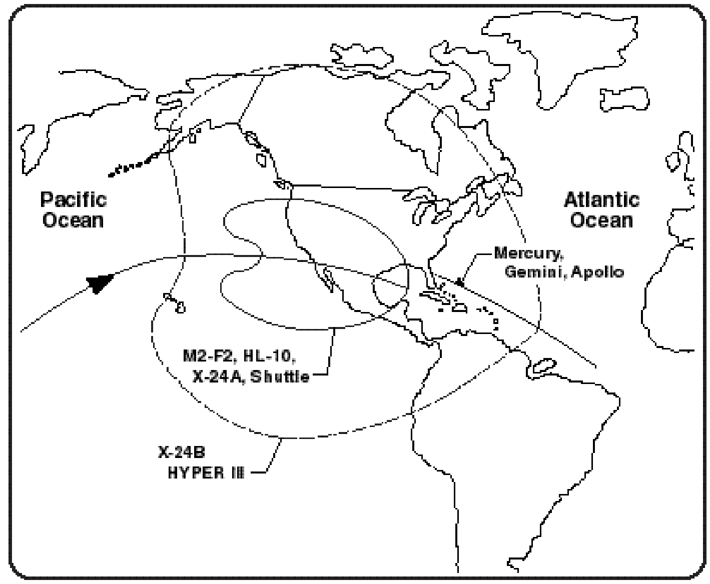
Three of the five heavyweights--X-24A (L), M2-F3 (C), & HL-10 (R) *E21115*

A fleet of lifting bodies flown at the NASA Flight Research Center (FRC), Edwards, Calif., from 1963 to l975 demonstrated the ability of pilots to maneuver (in the atmosphere) and safely land a wingless vehicle. These lifting bodies were basically designed so they could fly back to Earth from space and be landed like an aircraft at a pre-determined site. (In 1976 NASA renamed the FRC as the NASA Dryden Flight Research Center in honor of Hugh L. Dryden.)

These unique research vehicles, with their unconventional aerodynamic shapes, were the M2-F1, M2-F2, M2-F3, HL-10, X-24A, and the X-24B. The information the lifting body program generated contributed to the data base that led to development of today's space shuttle program as well as the X-33 and X-38 technology demonstrators. Lockheed Martin's X-33 features a lifting-body design, while the X-38 vehicles get their configuration from the X-24A.

Aerodynamic lift—essential to flight in the atmosphere—was obtained from the shape of the vehicles rather than from wings on a normal aircraft. The addition of fins and control surfaces allowed the pilots to stabilize and control the vehicles and regulate their flight paths.

All but the M2-F1 were powered by the same type of XLR-11 rocket engine used in the famed Bell X-1—first aircraft to fly faster than the speed of sound. The M2-F1, a lightweight prototype, was unpowered.

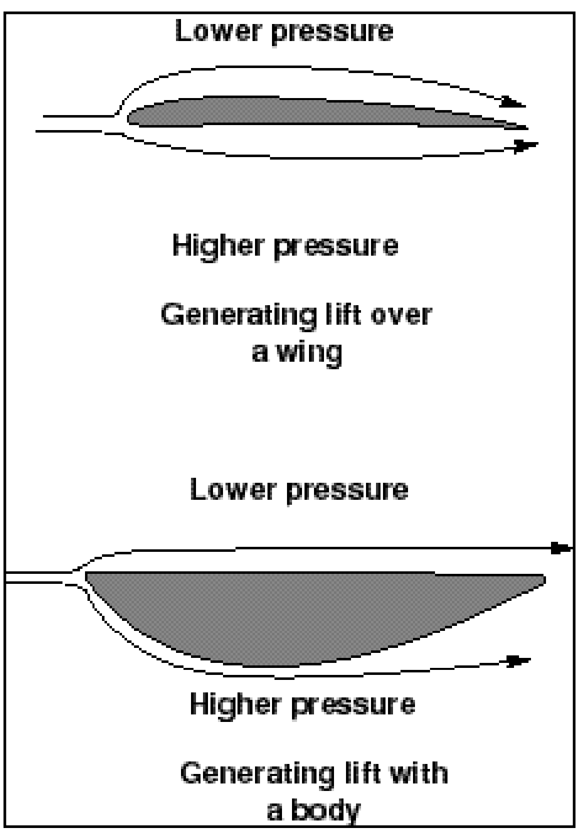


Orbital entry footprints (lateral and longitudial maneuverability) of lifting bodies and spacecraft. (Note the very small area for the Mercury, Gemini, and Apollo capsules as compared with the lifting bodies and the Space Shuttle.)

Background

The original idea of lifting bodies was conceived about 1957 by Dr. Alfred J. Eggers Jr., then the assistant director for Research and Development Analysis and Planning at what later became the NASA Ames Research Center, Moffett Field, Calif. (then called the Ames Aeronautical Laboratory).

NASA had earlier been investigating the problems associated with reentry of missile nose cones. H. Julian Allen, another Ames engineer, determined that a blunt nose cone was a desirable shape to survive the aerodynamic heating associated with reentry from space. Eggers found that by slightly modifying a symmetrical nose cone shape, aerodynamic lift could be produced. This lift would enable the modified shape to fly back from space rather than plunge to earth in a ballistic trajectory.



These studies by Eggers, Allen, and their associates led to the design known as the M-2, a modified half-cone, rounded on the bottom and flat on top, with a blunt, rounded nose and twin tail-fins. This configuration and those of the later lifting bodies allowed them to be maneuvered both in a lateral and a longitudinal direction so they could be landed on a runway rather than simply parachuting into the ocean as did the contemporary ballistic capsules used in the Mercury, Gemini, and Apollo programs.

The Pioneering M2-F1

In 1962, FRC Director Paul Bikle approved a program to build a lightweight, unpowered lifting body as a prototype to flight test the wingless concept. It would look like a "flying bathtub," and was designated the M2-F1. It featured a plywood shell, built by Gus Briegleb, a sailplane builder from El Mirage, Calif., placed over a tubular steel frame crafted at the FRC. Construction was completed in 1963.

The first flight tests were over Rogers Dry Lake at the end of a tow rope attached to a hopped-up Pontiac convertible driven at speeds up to about 120 mph. These initial

E 10962 ***M2-F1 towed aloft by C-47***

tests produced enough flight data about the M2-F1 to proceed with flights behind a NASA R4D tow plane at greater altitudes. The R4D (Navy version of the C-47) took the craft to an altitude of 12,000 ft. where free flights back to Rogers Dry Lake began. NASA research pilot Milt Thompson flew the M2-F1 during the first series of tests.

Typical glide flights with the M2-F1 lasted several minutes and reached speeds of 110 to l20 mph.

More than 400 ground tows and 77 aircraft tow flights were carried out with the M2-F1 before it was retired and gave way to more advanced versions of lifting bodies. A historical artifact belonging to the Smithsonian's National Air and Space Museum, the M2-F1 is located at Dryden where it has been restored to a flight-like condition.

The Heavyweights

The success of Dryden's M2-F1 program led to NASA's development and construction of two heavyweight lifting bodies based on studies at NASA's Ames and Langley research centers—the M2-F2 and the HL-10, both built by the Northrop Corporation. The "M" refers to "manned" and "F" refers to "flight" version. "HL" comes from "horizontal landing" and "10" is for the tenth lifting body model to be investigated by Langley.

The Air Force later became interested in lifting body research and had a third design concept, the X-24A, built by the Martin Company. It was later modified into the X-24B and both configurations were flown in the joint NASA-Air Force lifting body program located at Dryden.

M2-F2

The first flight of the M2-F2—which looked much like the M2-F1—occurred on July 12, 1966.
Thompson was the pilot. By then, the same B-52 used to air launch the famed X-15 rocket research aircraft had been modified to also carry the lifting bodies into the air and Thompson was dropped from the B-52's wing pylon mount at an altitude of 45,000 feet on that maiden glide flight.
The M2-F2 weighed 4,620 pounds without ballast, was roughly 22 feet long, and had a width of about 10 feet.

ECN 1567 ***M2-F2 and F-104 chase aircraft.***

On May 10, 1967, during the sixteenth glide flight leading up to powered flight, a landing accident severely damaged the vehicle and seriously injured the NASA pilot, Bruce Peterson.

M2-F3

NASA pilots said the M2-F2 had lateral control problems, even though it had a stability augmentation control system. When the M2-F2 was rebuilt at Dryden and redesignated the M2-F3, it was modified with an additional third vertical fin—centered between the tip fins—to improve control characteristics.

The first flight of the M2-F3, with NASA pilot Bill Dana at the controls, was on June 2, 1970. It was a glide flight to evaluate changes in the vehicle's performance due to the modifications. The modified vehicle exhibited much better lateral stability and control characteristics than had the M2-F2.

Over the next 26 missions, the M2-F3 reached a top speed of l,064 mph (Mach 1.6). Bill Dana was the pilot, and the high-speed flight took place on Dec. 13, 1972. The highest altitude reached by the vehicle was 71,500 feet on Dec. 20, 1972, the date of its last flight, with NASA pilot John Manke at the controls.

A reaction jet control system, similar to thrusters used on orbiting spacecraft, was also installed to obtain research data about their effectiveness for vehicle control. As the M2-F3's portion of the lifting body program neared an end, it evaluated a rate command augmentation control system, and a side-arm control stick similar to side-arm controllers now used on many modern aircraft.

The M2-F3 is now on display in the National Air and Space Museum, Washington, D. C.

HL-10

The HL-10 was delivered to the FRC by Northrop in January 1966. Its first flight was on Dec. 22 of the same year. The pilot was Bruce Peterson, before he was injured in the M2-F2 accident.

The HL-10 was flown 37 times and it set several program records. On Feb. 18, 1970, Air Force test pilot Maj. Peter Hoag flew it to 1,228 mph (Mach 1.86), fastest speed of any of the lifting bodies. Nine days later, NASA's Bill Dana flew the HL-10 to 90,303 feet, the highest altitude reached by any of the lifting body vehicles. The HL-10 was also the first lifting body to fly supersonically—on May 9, 1969, with Manke at the controls.

The HL-10 featured a flat bottom and rounded top —much like an airfoil—and it had a delta planform. In its final configuration, three vertical fins, two of them canted outwards from the body and a tall center fin, gave the craft directional control. A flush canopy blended into the smooth rounded nose.

It was about 21 feet long, with a span of 13.6 feet. Its glide-flight weight was 6,473 lbs. and its maximum gross weight was over 10,000 lbs.

Flights with the HL-10 contributed substantially to the decision to design the space shuttles without air-breathing engines that would have been used for landings. Its final flight was on July 17, 1970.

The HL-10 is now on public display at Dryden.

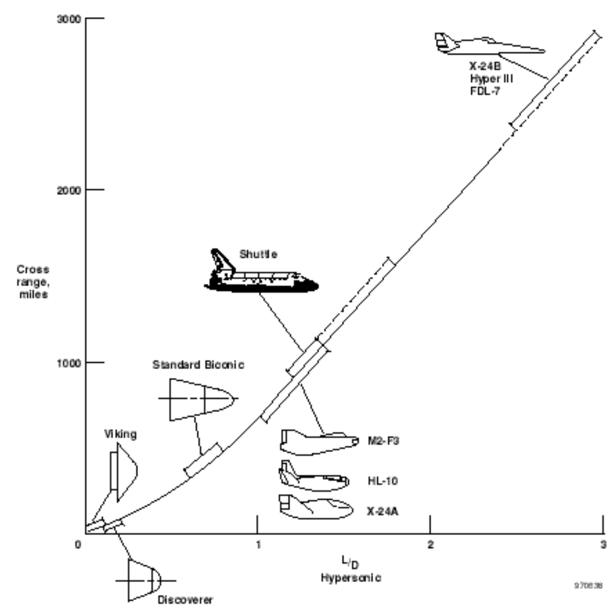
X-24A

Built for the Air Force by Martin, the X-24A was a bulbous vehicle shaped like a teardrop, with three vertical fins at the rear for directional control. It weighed 6,270 pounds without propellants, was just over 24 feet long, and had a width of nearly 14 feet.

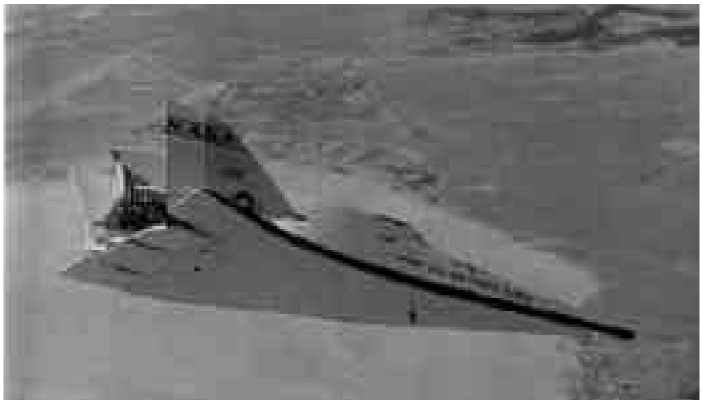
The first unpowered glide flight of the X-24A was on April 17, 1969. The pilot was Air Force Maj. Jerauld Gentry. Gentry also piloted the vehicle on its first powered flight Mar. 19, 1970.

It was flown 28 times in a program which, like that of the HL-10, helped validate the concept that a space shuttle vehicle could be landed unpowered. Subsequently, the X-38 program managers elected to use the X-24A design to save money, since the existing X-24A aerodynamic database was complete. This limited the number of wind tunnel tests that would have been required for a totally new design.

Fastest speed in the X-24A was 1,036 mph (Mach 1.6). The



Graph showing
cross-range distances in miles the vehicles could fly perpendicular to the re-entry path plotted against hypersonic lift over drag for several vehicles returning from orbit. Notice that the sleeker vehicles such as the X-24B and Hyper III have the greatest cross-range capability—around 2,500 miles, whereas the more blunt-nosed lifting bodies has cross-range capabilities more comparable to that of the Space Shuttle.



Launch and flight sequence for a powered lifting body, showing the X-24B as an illustration of a general pattern.

pilot was John Manke, who also reached the highest altitude in the vehicle, 71,400 feet. He was the pilot on its final flight June 4, 1971.

X-24B

ECN 4643 ***X-24B on an approach to a lakebed landing.***

The X-24B's design evolved from a family of potential reentry shapes, each with higher lift-to-drag ratios, proposed by the Air Force Flight Dynamics Laboratory.

To reduce the costs of constructing a research vehicle, the Air Force returned the X-24A to Martin for modifications that converted its bulbous shape into one resembling a "flying flatiron"—rounded top, flat bottom, and a double delta planform that ended in a pointed nose.

First to fly the X-24B was Manke, a glide flight on Aug. 1, 1973. He was also the pilot on the first powered mission Nov. 15, 1973.

Among the final flights with the X-24B were two precise landings on the main concrete runway at Edwards, which showed that accurate unpowered reentry vehicle landings were operationally feasible. These missions were flown by Manke and Air Force Maj. Mike Love and represented the final milestone in a program that helped write the flight plan for today's space shuttle program.

After launch from the B-52 "mothership" at an altitude of about 45,000 feet, the XLR-11 rocket engine was ignited and the vehicle accelerated to speeds of more than 1,100 mph and to altitudes of 60,000 to 70,000 feet. After the rocket engine was shut down, the pilots began steep glides towards the Edwards runway. As the pilots entered the final approach leg, they increased their rate of descent to build up speed and used this energy to perform a "flare out" maneuver and slow their landing speed to about 200 mph—the same basic approach pattern and landing speed of today's space shuttles.

The final powered flight with the X-24B was on Sept. 23, l975. The pilot was Bill Dana, and it was also the last rocket-powered flight flown at Dryden. It was Dana who also flew the last X-15 mission about seven years earlier.

Top speed reached with the X-24B was 1,164 mph (Mach 1.75) by Love on October 25, 1974. The highest altitude reached was 74,100 feet, by Manke on May 22, 1975.

The X-24B is on public display at the Air Force Museum, Wright-Patterson AFB, Ohio.