Smithsonian
National Air and Space Museum

X-15

THE WORLD'S FASTEST ROCKET PLANE AND THE PILOTS WHO USHERED IN THE SPACE AGE

JOHN ANDERSON AND RICHARD PASSMAN

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X-15 nestled under the wing of its B-52 mother ship. *USAF, Air Force Flight Test Center History Office, Edwards Air Force Base*

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PREFACE

The X-15 is exciting, even on paper. A rocket-powered airplane, the X-15 carries only 90 seconds' worth of fuel. It must be taken aloft under the wing of a B-52 bomber to an altitude of 45,000 feet, then dropped at a Mach number of 0.8. Falling at the acceleration of gravity (32.2 feet per second, every second), the X-15 pilot must engage the engine. Then, using his limited fuel supply, he climbs to a maximum altitude of 352,400 feet or accelerates to Mach 6.7 (6.7 times the speed of sound). He returns to Edwards Air Force Base, perhaps 300 miles distant, decelerating without power through hypersonic Mach 6 and 5, supersonic Mach 4, 3, and 2, and then the sonic speed of 1 before guiding the aircraft to land at 200 miles per hour. The entire time of fight from drop to touchdown on the desert floor usually lasts about 10 minutes.

The X-15 was a research aircraft, part of a program designed to study the problems of hypersonic flight. For that purpose, the plane's Mach number range had to be above 5, and its practical altitude range likewise had to be between 100,000 feet to about 350,000 feet, above which not enough of the sensible atmosphere exists to exert a useful aerodynamic effect. There is no sudden change in airflow characteristics in progressing faster from supersonic flow to hypersonic flow as there is from transonic to supersonic flow, where shock waves form and a so-called sonic boom occurs (and where the myth of a "sound barrier" was created in the 1930s, suggesting that airplanes could never fly faster than sound). The X-15 was

MACH NUMBERS

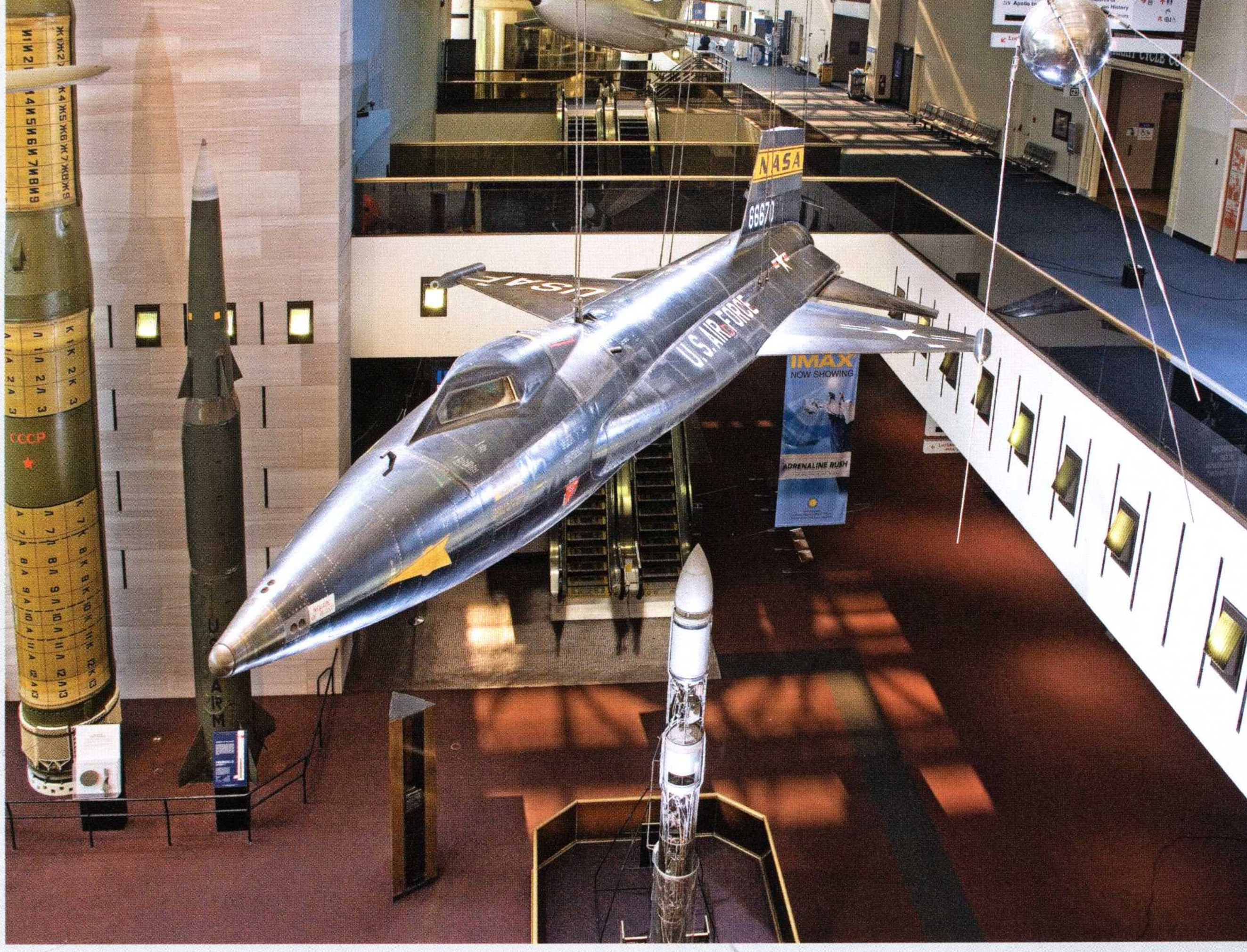
Sound moves at a finite speed through air. Its speed depends on the temperature of the air; as the air gets hotter, sound travels faster. At standard sea level conditions, the speed of sound is 340 meters per second, or 761 miles per hour. At 70,000 feet of altitude, where the air is cooler, the speed of sound is 660 miles per hour. Mach number is defined as the ratio of the speed of a vehicle to the speed of sound in the surrounding atmosphere. For example, an airplane flying at a velocity of 4,620 miles per hour at 70,000 feet is flying at seven times the speed of sound, or Mach 7. This leads to the definition of different flight regimes. The subsonic regime is where flight is less than Mach 1. Transonic flight is just below, to just above, Mach 1. Supersonic flight occurs at Mach numbers above 1, and hypersonic flight is considered to be flight at Mach 5 or higher.

Bill Dana and the X-15. *NASA*

designed to explore Mach numbers and altitudes at speeds and heights never previously achieved by manned flight in order to learn about aerodynamic heating, stability, and control. Another purpose was to generate the engineering data that would be gathered for use on future hypersonic aircraft designs, such as the Space Shuttle.

On October 24, 1968, pilot Bill Dana landed the X-15 airplane following what would turn out to be its 199th and last flight. He had reached a Mach number of 5.38 and an altitude of 255,000 feet. The rocket engine had been at 100 percent thrust of 57,000 pounds for 84 seconds, and the whole flight from launch to touchdown had taken a mere 11 minutes and 28 seconds. This achievement followed nine years of testing that had begun with Scott Crossfield's first unpowered X-15 flight on June 8, 1959, in which the B-52 mother airplane dropped Crossfield and the X-15 at Mach 0.8 and an altitude of 37,550 feet. That flight, strictly a glide flight, lasted only 4 minutes and 57 seconds. From 1959 to 1968, twelve undaunted pilots explored the rocket-powered airplane's performance at hypersonic speeds up to 6.7 times the speed of sound and at altitudes of up to 67 miles (354,200 feet). Their courage and commitment to aviation research and engineering contributed directly to the success of the Space Shuttle program run by the National Aeronautics and Space Administration (NASA).

The X-15—a research aircraft that was never intended to wage war on America's enemies, that was never designed to travel to space, and that was never meant to become an active part of the Air Force fleet—now hangs with distinction in the Milestones of Flight Gallery of the Smithsonian's National Air and Space Museum (NASM). The airplane was donated to the NASM in a ceremony on July 7, 1971, in the Smithsonian Arts and Industries Building. The other remaining aircraft is displayed at the National Museum of the U.S. Air Force at Wright-Patterson Air Force Base in Dayton, Ohio. The third X-15 was destroyed in a fatal wreck, taking with it the life of the pilot, Michael J. Adams.



X-15 at the National Air and Space Museum's Milestones of Flight Gallery. *Photo by Eric Long, NASM*

Several excellent books have been written about the X-15, which the authors wish to acknowledge as valuable reference sources for this book. They are: *At the Edge of Space: The X-15 Flight Program* by Milton O. Thompson (Smithsonian Institution Press, 1992); *Hypersonic: The Story of the North American X-15* by Dennis R. Jenkins and Tony R. Landis (Specialty Press, 2003); *X-15: Extending the Frontiers of Flight* by Dennis R. Jenkins (NASA SP-2007-562, U.S. Government Printing Office, 2007); and *The X-Planes: X-1 to X-45* by Jay Miller (Midland Publishing, 2001). This book is written from a different perspective than these previous titles. It is intended to be a concise biography of the X-15, its mission, and its undaunted pilots and engineers, and will be a companion to the airplane that hangs at the National Air and Space Museum. We hope that this book can help visitors to the NASM better appreciate why the airplane hangs in the Milestones of Flight Gallery along with such aircraft as the path-breaking Bell X-1 and Lindbergh's *Spirit of St. Louis*.

Finally, the lion's share of the research for, and writing of, this book was carried out by one of the coauthors, Richard Passman, who deserves special acknowledgment for his long hours of work and dedicated effort serving as a volunteer at the NASM, for whom the only reward is the satisfaction and pure joy of living the X-15 experience. Mr. Passman was the chief aerodynamicist for the Bell X-2, the first airplane to fly faster than Mach 3. He shared and contributed to the heady research airplane environment that pervaded the 1950s and '60s, and much of this book reflects his experience in that environment.

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WHY THE X-15?

On October 14, 1947, the Bell X-1 and its Air Force test pilot, Capt. Chuck Yeager, made aviation history by becoming the first to fly faster than the speed of sound. When the sonic boom from this flight reverberated across the desert at Muroc Dry Lake in California, it opened a powerful new chapter in the history of the airplane—the age of supersonic flight. By the early 1950s, supersonic airplanes had become the central focus of airplane design. The Lockheed F-104 Starfighter, for example, was the first airplane designed for sustained cruise at Mach 2. Designed by the famous Lockheed Skunk Works under the direction of iconic designer Kelly Johnson, this airplane exhibits excellent supersonic aerodynamic design. Its fuselage is slender and streamlined, with a pointed nose. Its straight wings are thin, short, and stubby, with a leading edge so sharp that, when on the ground, a protective glove is placed over it to protect the ground personnel from injury—as

Lockheed F-104 Starfighter. *NASA*

Chuck Yeager in the Bell X-1. *USAF*

F-104 on display at the National Air and Space Museum. *NASM*

well as to protect the leading edge from damage from the ground personnel. These design features were driven by the need to minimize wave drag produced by the shock waves that are present on any supersonic flight vehicle. The thinner the wing and the sharper the nose and leading edges, the weaker are the shock waves, and hence the wave drag is smaller.

The "need for speed" drove the evolution of airplane design. Inspired by the mantra of "flying faster and higher," designers started working in the late 1950s on an airplane capable of flight at Mach 7 and at altitudes higher than 300,000 feet. The result was the first hypersonic airplane, the X-15. One of the three X-15s ultimately produced hangs now in the Milestones of Flight Gallery at the Smithsonian's National Air and Space Museum.

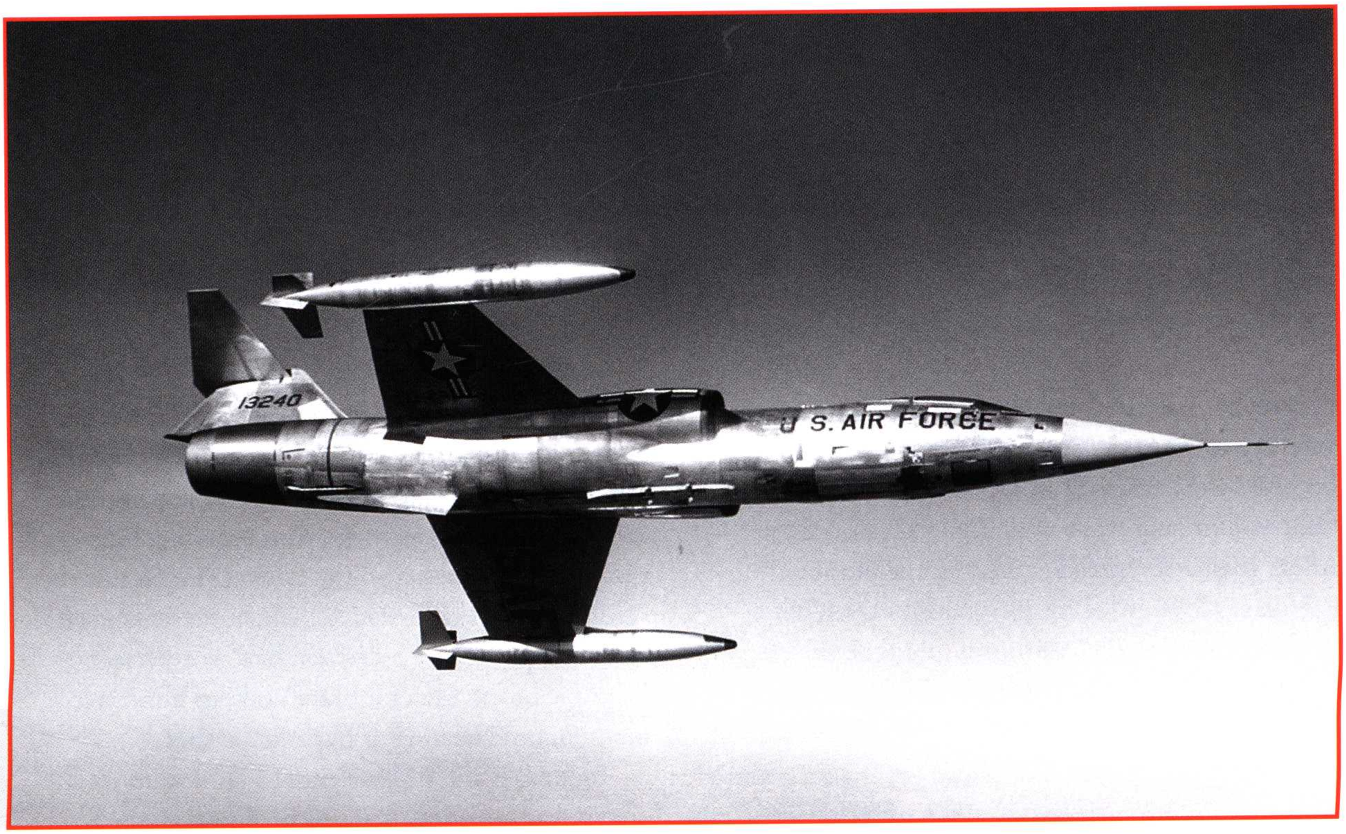
One might think that an airplane designed for Mach 7 would follow the supersonic aerodynamics exhibited by the F-104, but with an even more slender fuselage, a more pointed nose, a thinner wing with a sharper leading edge, etc. However, what we see in the X-15 is a wider fuselage with a blunted nose as well as a thicker wing with blunt leading edges. This is a dramatic departure from good supersonic airplane design because the aerodynamic heating to the aircraft increases with the square of the Mach number, and at

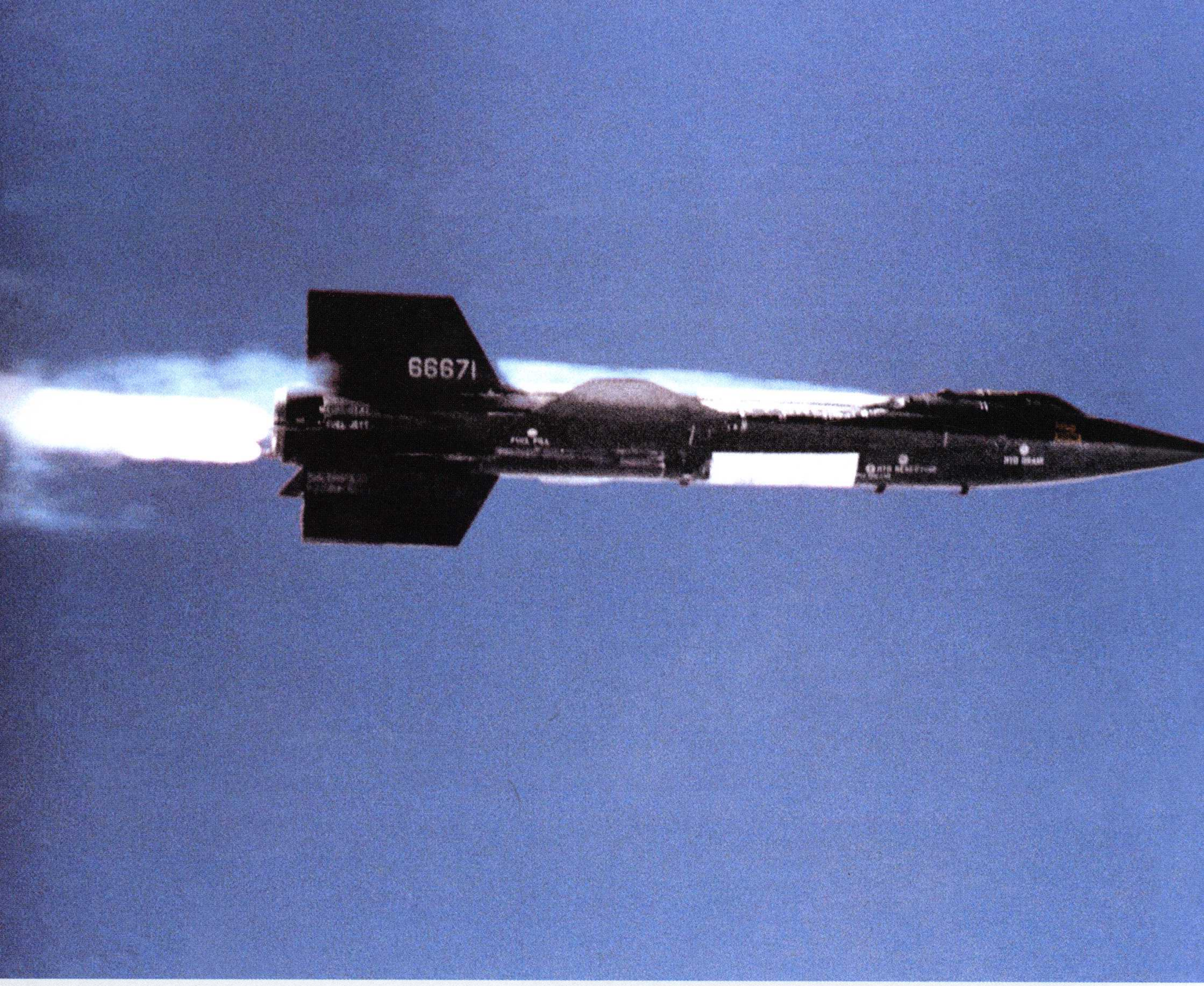
F-104 in flight. *USAF, National Museum of the U.S. Air Force*

SKUNK WORKS

The Skunk Works is a self-contained special projects group within the Lockheed-Martin Company. Its origin within the Lockheed Aircraft Company was in 1944, when Kelly Johnson was given permission to create a small, elite group to design, build, and test the P-80, America's first mass-produced jet fighter. Subsequently, the Skunk Works has become famous for its innovative airplane designs, such as the U-2 spy plane, the SR-71 Blackbird, and the F-117, America's first stealth fighter.

Building the SR-71 at Lockheed's Skunk Works. *Lockheed-Martin*





X-15-2 just after launch, early 1960s. *USAF, Air Force Flight Test Center History Office, Edwards Air Force Base*

hypersonic speeds aerodynamic heating becomes severe. Minimizing the aerodynamic heating becomes the dominant design feature rather than minimizing wave drag. In 1952, H. Julian Allen, then a research engineer at the National Advisory Committee for Aeronautics (NACA) Ames Laboratory in California, proposed the novel idea that aerodynamic heating can be reduced by blunting the nose and leading edges of hypersonic vehicles. The bluntness creates stronger shock waves in front of the vehicle, with higher air temperatures behind the stronger shock waves. The higher air temperatures cause much of the vehicle's potential and kinetic energy to go into the air, leaving less energy to go into the body, thus reducing the aerodynamic heating to the body. (The face of the Apollo lunar return vehicle, which presents itself to the air much like a cannon ball, is a perfect example of the use of a blunt body to minimize aerodynamic heating at hypersonic speeds.)

Indeed, if the super-slender F-104 with its sharp leading edges were to be flown at

Apollo return module. *NASA*

Mach 7, the extreme heat would melt the nose and leading edges, turning them naturally into blunt configurations. This is an example of nature always taking the path of least resistance, blunting the nose and leading edges in a natural attempt to reduce the aerodynamic heating. Designing to minimize aerodynamic heating is the primary reason why the X-15 looks different than the F-104. There are many other aspects of hypersonic flight (arbitrarily defined as flight above Mach 5) that make the X-15 different from a supersonic airplane. The X-15 is a unique airplane in the history of flight and is still today the fastest and highest-flying piloted airplane in existence. The fact that the X-15 is now a museum piece is food for thought.

THE GENESIS OF THE X-15

The first hypersonic vehicles in flight were missiles, not airplanes. On February 24, 1949, a WAC Corporal rocket mounted on top of a captured German V-2 boost vehicle was fired from the White Sands Proving Ground in New Mexico, reaching an altitude of 244 miles and a velocity of 5,150 miles per hour. After nosing over, the WAC Corporal careened back into the atmosphere at over 5,000 miles per hour, becoming the first object of human origin to achieve hypersonic flight. In this same period, a hypersonic wind tunnel capable of Mach 7, with an 11- by 11-inch cross-section test section, went into operation on November 26, 1947, the brainchild of NACA Langley researcher John Becker. For three years following its first run, this wind tunnel was the only hypersonic wind tunnel in the United States. It later provided key data for the design of the X-15.

The real genesis of the X-15, however, was human thinking, not test facilities. On January 8, 1952, Robert Woods of Bell Aircraft sent a letter to the NACA Committee on Aerodynamics in which he proposed that the committee undertake the study of basic problems in hypersonic and space flight. At that time, several X-airplanes were already probing the mysteries of supersonic flight: the X-1, X-1A, and X-2. Accompanying Woods's letter was a document from his colleague at Bell, Dr. Walter Dornberger, outlining the development of a hypersonic research airplane capable of Mach 6 and reaching an altitude of 75 miles. By June 1952, the NACA Committee on Aerodynamics recommended that the NACA expand its efforts to study the problems of hypersonic manned and unmanned flight, covering the Mach number range from 4 to 10.

After two more years of deliberation, the committee passed a resolution during its October 1954 meeting recommending the construction of a hypersonic research airplane. Among the members of this committee were Walter Williams and Scott Crossfield, who would later play strong roles in the X-15 program. Kelly Johnson, who not only was the Lockheed representative to the committee but was considered to be the country's most famous airplane designer, opposed any extension of the manned research program, arguing that to date