



Quieting the Boom

Eight Decades of NASA's Supersonic Flight Research

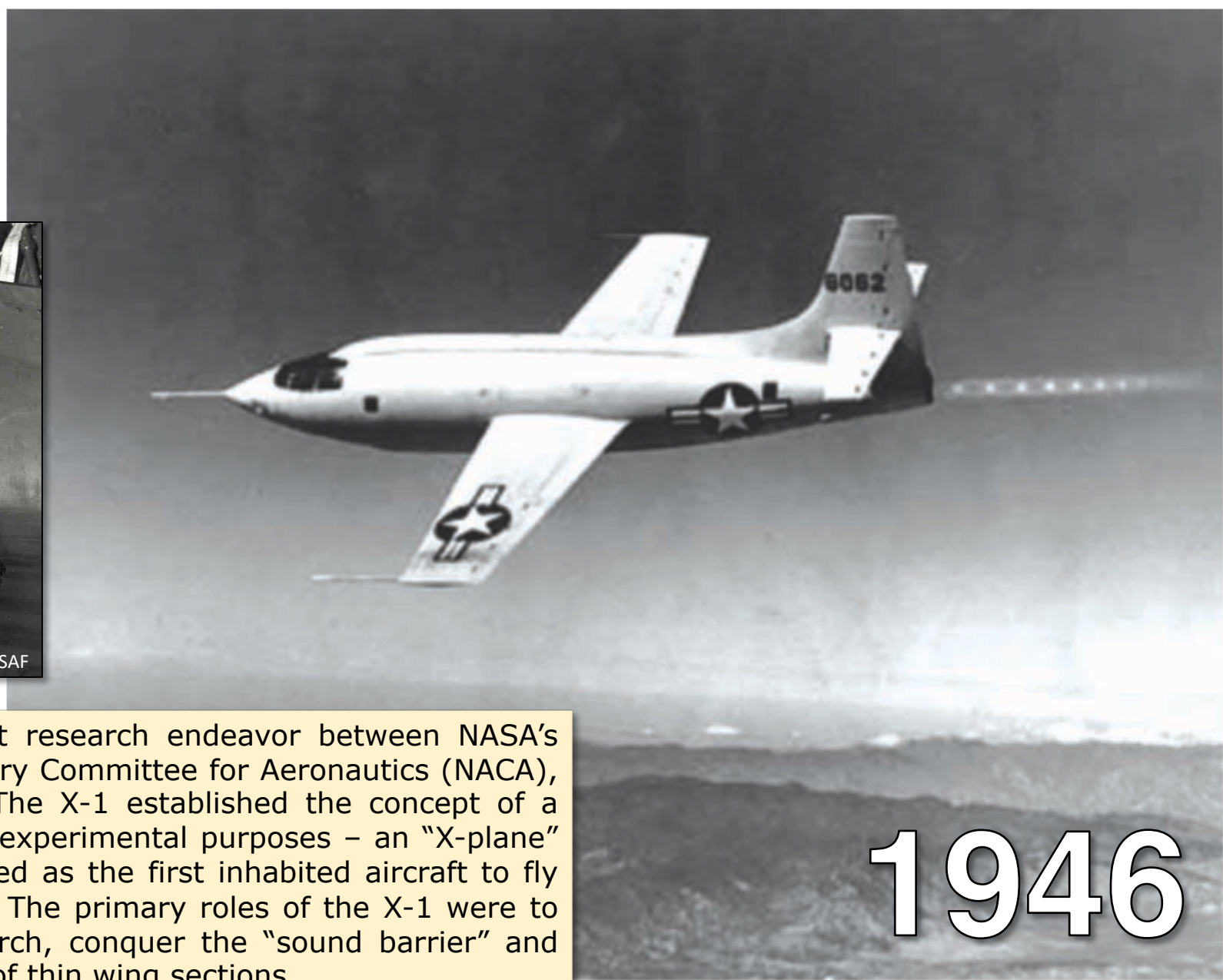
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Special thanks to the many contributors to this historical overview



X-1

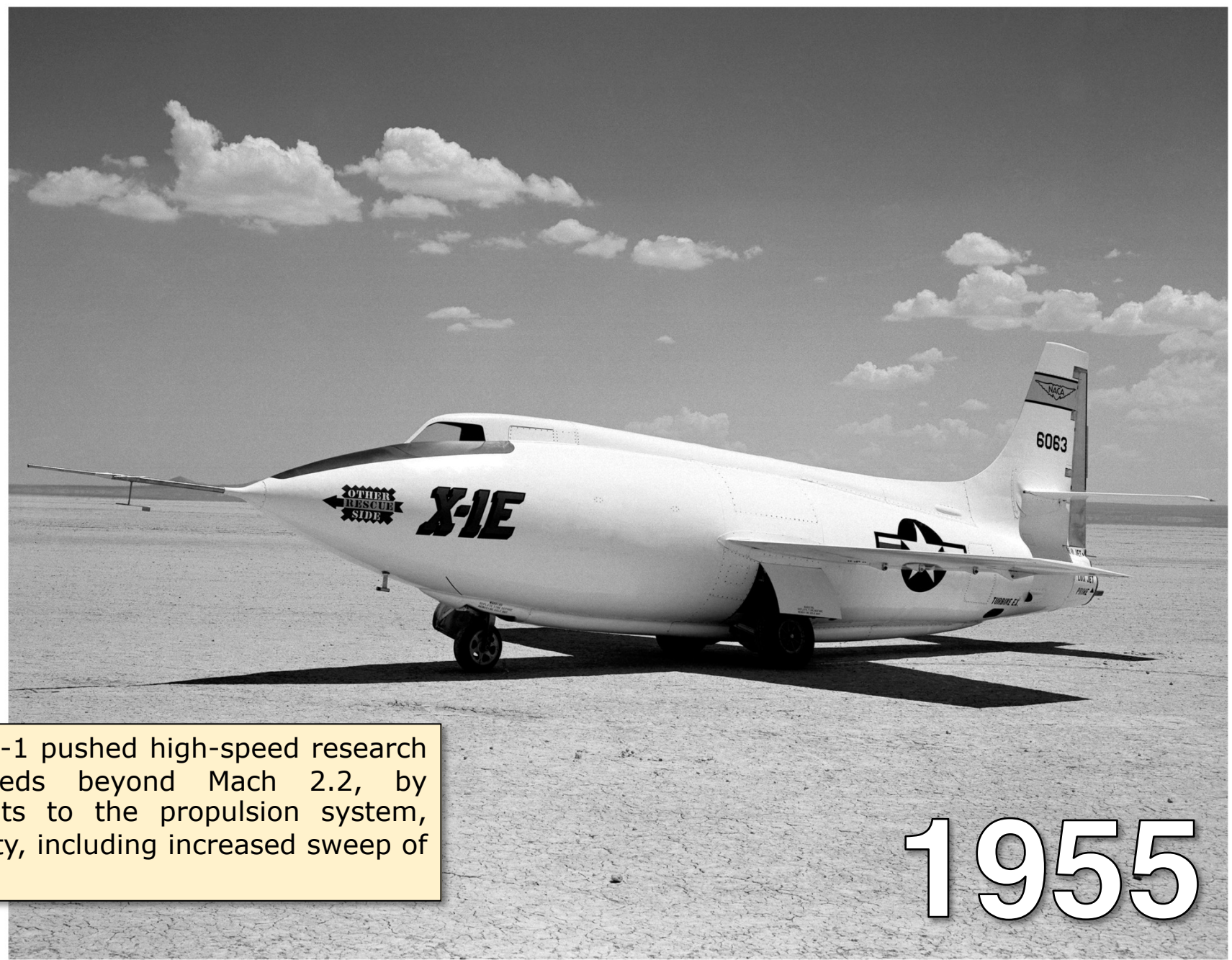


The X-1 aircraft flew as a joint research endeavor between NASA's predecessor, the National Advisory Committee for Aeronautics (NACA), and the U.S. Army Air Force. The X-1 established the concept of a research aircraft built solely for experimental purposes – an “X-plane” – and will always be remembered as the first inhabited aircraft to fly faster than the speed of sound. The primary roles of the X-1 were to conduct high-speed flight research, conquer the “sound barrier” and prove the aerodynamic viability of thin wing sections.

1946



X-1E



The larger variant of the X-1 pushed high-speed research to new limits, at speeds beyond Mach 2.2, by incorporating improvements to the propulsion system, fuel, and directional stability, including increased sweep of the ultra-thin wings.

1955

X-1E



The X-1E aircraft is prominently displayed in front of NASA Armstrong's building 4800.

F-104



NASA's F-104s were in operation from 1956 to 1994 and considered the most versatile workhorses in its stable of research and support aircraft. NASA's fleet of 11 F-104s accumulated 18,000 flight hours over a 38-year period. F-104 research aircraft supported a wide variety of research missions including some early investigations into the sonic boom phenomenon. An F-104 was the first aircraft to probe and measure the near-field flow of another aircraft during supersonic flight.

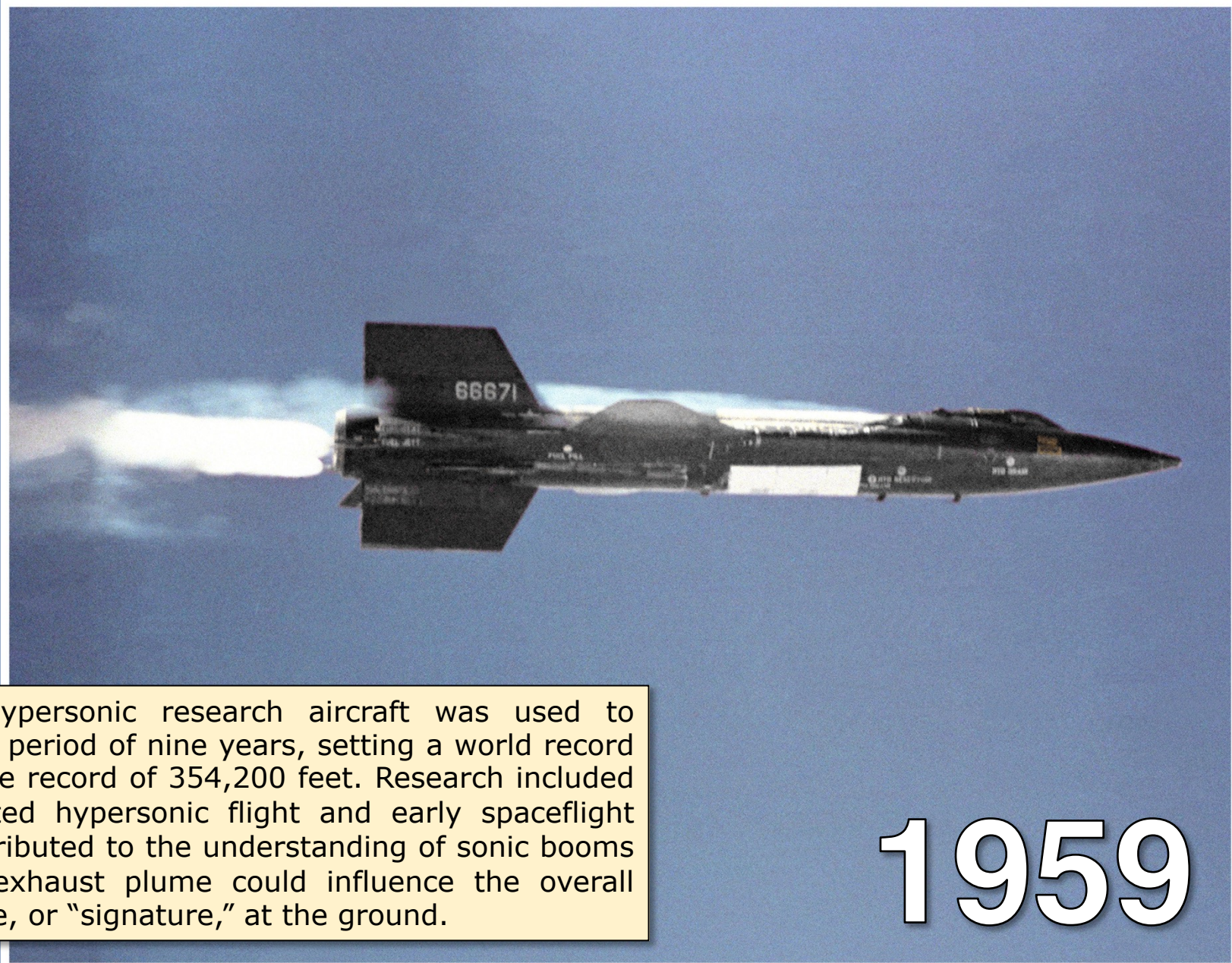
1956

F-104



One critical research mission included rain erosion studies of space shuttle tiles.

X-15



The rocket-powered X-15 hypersonic research aircraft was used to conduct flight research over a period of nine years, setting a world record speed of Mach 6.7 and altitude record of 354,200 feet. Research included investigating aspects of piloted hypersonic flight and early spaceflight programs. The X-15 also contributed to the understanding of sonic booms including how the engine's exhaust plume could influence the overall character of the pressure wave, or "signature," at the ground.

1959

X-15



Neil Armstrong



Dryden Flight Research Center EC66-1017 Photographed 1966
X-15 pilots: Joseph Engle, Robert Rushworth, Jack McKay,
Pete Knight, Milt Thompson, Bill Dana NASA photo



F-100



The F-100 Super Sabre was the first of a new series of Air Force fighter aircraft that were capable of sustained supersonic flight. The development of these "Century Series" fighters revealed many unique challenges related to the supersonic speed regime. The NACA initially flew the F-100 to investigate supersonic stability and control and later used a modified F-100 for a number of sonic boom research activities in support of the X-15 and the U.S. SuperSonic Transport (SST) program.

F-100 in formation with F-101 (top), YF-102A (fwd), F-104 (aft)

1960

B-58

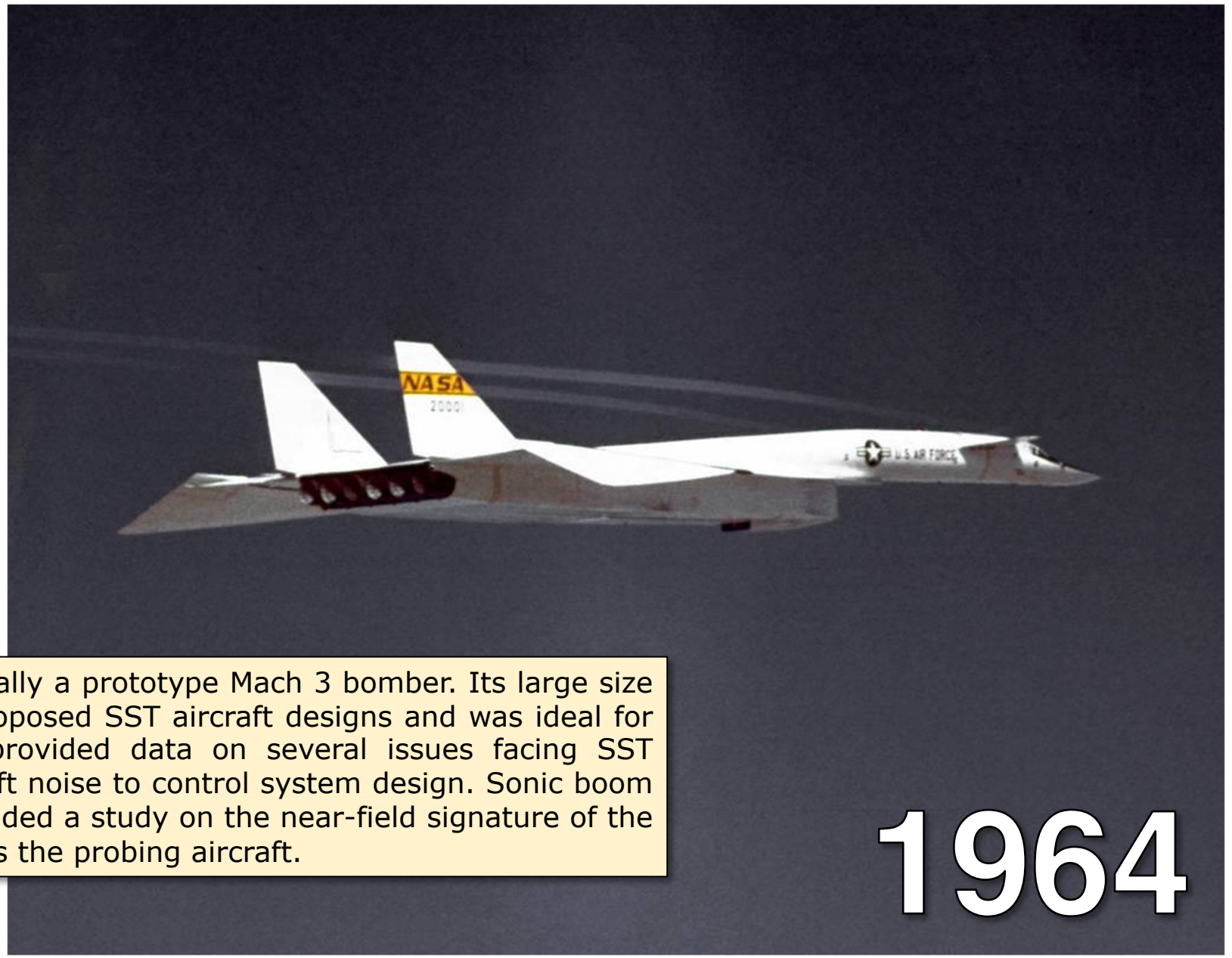


The B-58 Hustler was initially developed by the Air Force as a supersonic bomber. The delta-wing B-58 was remarkable due to its long range and load-carrying capability that far exceeded any prior supersonic airplane. This 96-foot-long aircraft was ideally suited to expand sonic boom research as it was the most similar in size and speed to proposed SST aircraft designs. NASA used the B-58 to demonstrate the contribution of aircraft lift on the near-field shock wave and resulting sonic boom signature on the ground.

1960

Credit: USAF

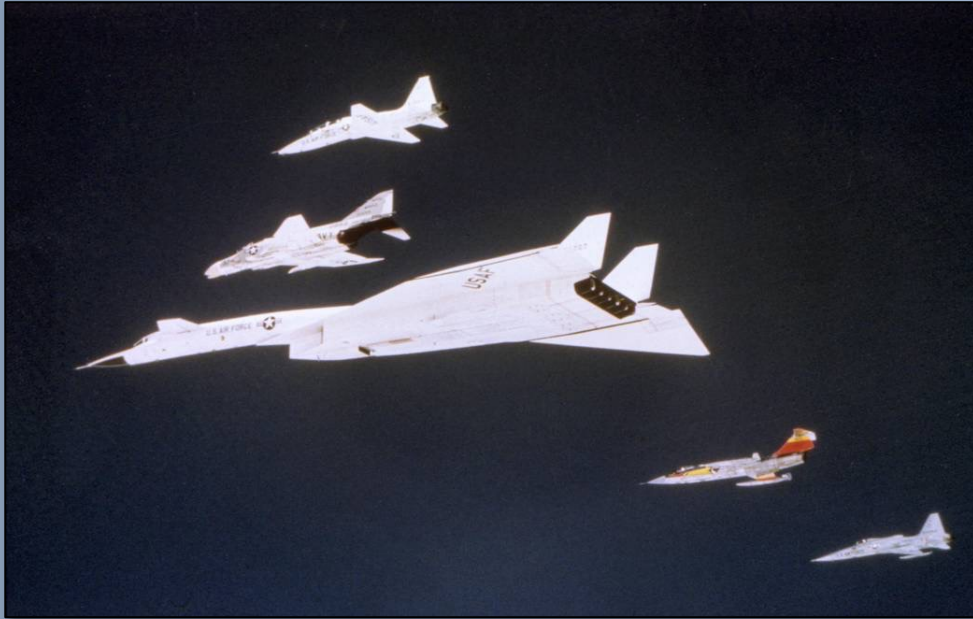
XB-70



The XB-70 Valkyrie was originally a prototype Mach 3 bomber. Its large size closely represented that of proposed SST aircraft designs and was ideal for SST research. Early flights provided data on several issues facing SST designers, ranging from aircraft noise to control system design. Sonic boom research using the XB-70 included a study on the near-field signature of the XB-70 aircraft using a F-104 as the probing aircraft.

1964

XB-70



The XB-70 #2 flight formation with a T-38, F-4, YF-5 and F-104N (orange tail) moments before mid-collision that occurred June 8, 1966.



The XB-70 was 185 feet long with a wingspan of 105 feet.

The final XB-70 research flight was piloted by Fitz Fulton (NASA) and Ted Sturmthall (AF) on Feb. 4, 1969 and flew to Wright-Patterson Air Force Base, OH, where the aircraft is on display at the National Museum of the U.S. Air Force.

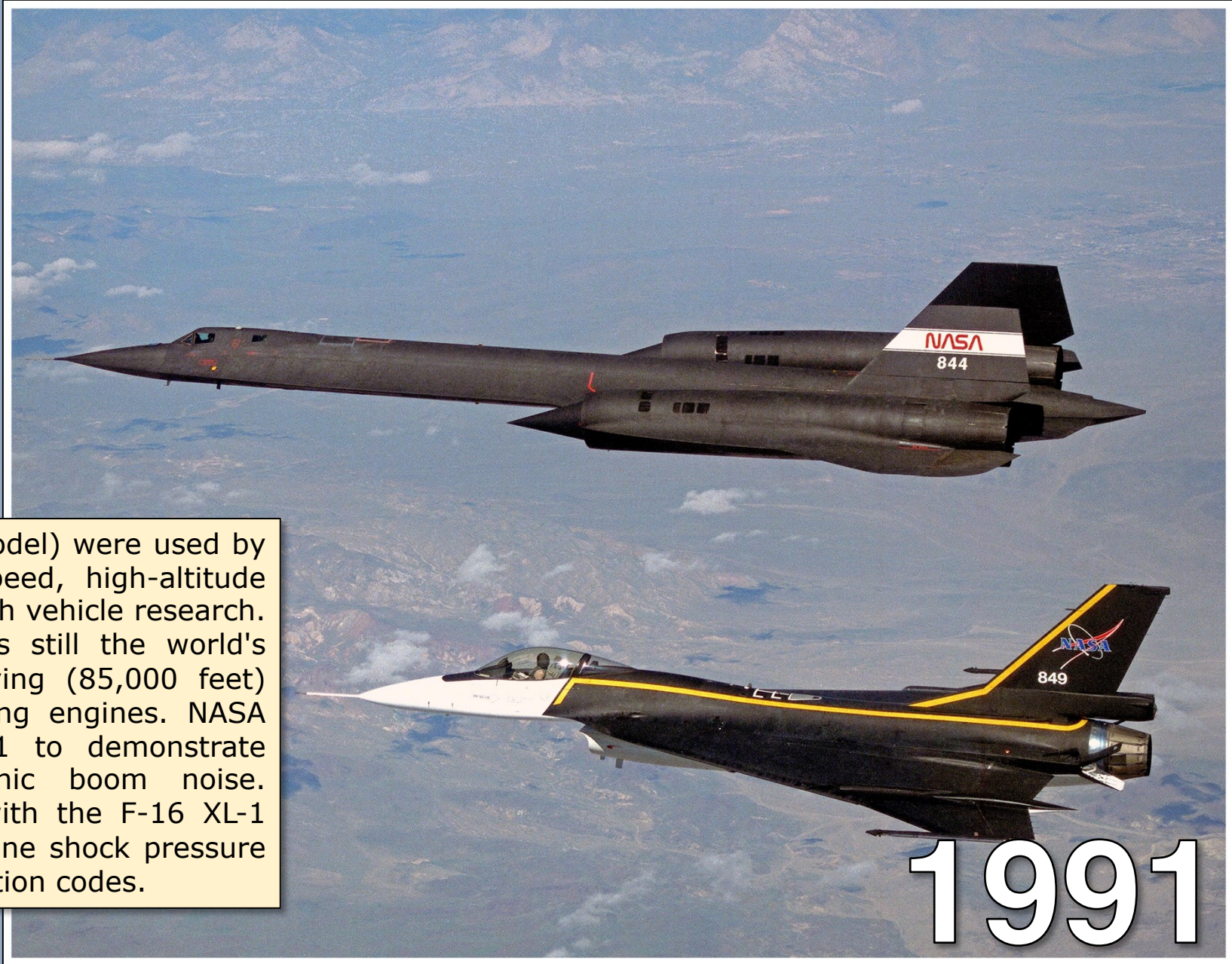
F-16 XL

NASA's two F-16 XL aircraft were prototypes of an improved version of the F-16 that did not go into production. The F-16 XL had a unique delta wing design that was representative of a wing shape with potential for use in future supersonic cruise aircraft. The F-16 XL-1 provided aerodynamic data for NASA's High-Speed Research (HSR) program and eventually shifted to the role of the probing aircraft for the SR-71. The F-16 XL-2 was modified for flight research in active laminar flow control to reduce aircraft drag and fuel consumption at supersonic speeds.



1988

SR-71



Two SR-71 aircraft (A and B model) were used by NASA as testbeds for high-speed, high-altitude aeronautical and reusable launch vehicle research. Retired in 1999, the SR-71 is still the world's fastest (Mach 3+), highest-flying (85,000 feet) piloted aircraft with airbreathing engines. NASA proposed modifying an SR-71 to demonstrate technology for reducing sonic boom noise. Extensive near-field probing with the F-16 XL-1 was conducted to gather baseline shock pressure data for the validation of prediction codes.



SR-71



NASA flight crew from left to right: Rogers Smith, Robert Meyer, Marta Bohn-Meyer, and Steve Ishmael. Edward Schneider not shown.

F-15B



For more than 25 years, NASA's F-15B Research Testbed has been a highly effective testbed aircraft that continues to fly a wide variety of research experiments and missions as supersonic chase and probing aircraft. Some of these experiments have utilized test fixtures mounted under the aircraft to investigate supersonic laminar flow and other aerodynamic and propulsion phenomena. The F-15B was used as the probing aircraft for the Shaped Sonic Boom Demonstration (SSBD). An improved shock measurement probe is being added to the F-15B to support X-59 acoustic validation flight testing.

1993

Tu-144LL



The end of the Cold War gave rise to an opportunity for international collaboration on an element of the HSR program. NASA engineers worked with their counterparts at Tupelov to restore a Tu-144 to flight status. Twenty-seven research flights of the Tu-144LL were conducted over a two-year period, greatly enhancing supersonic flight databases in propulsion, aerodynamics, structural heating, structural acoustics, ground effects, and handling qualities. In 1998, three evaluation flights were accomplished by NASA test pilots.

1996

Tu-144LL



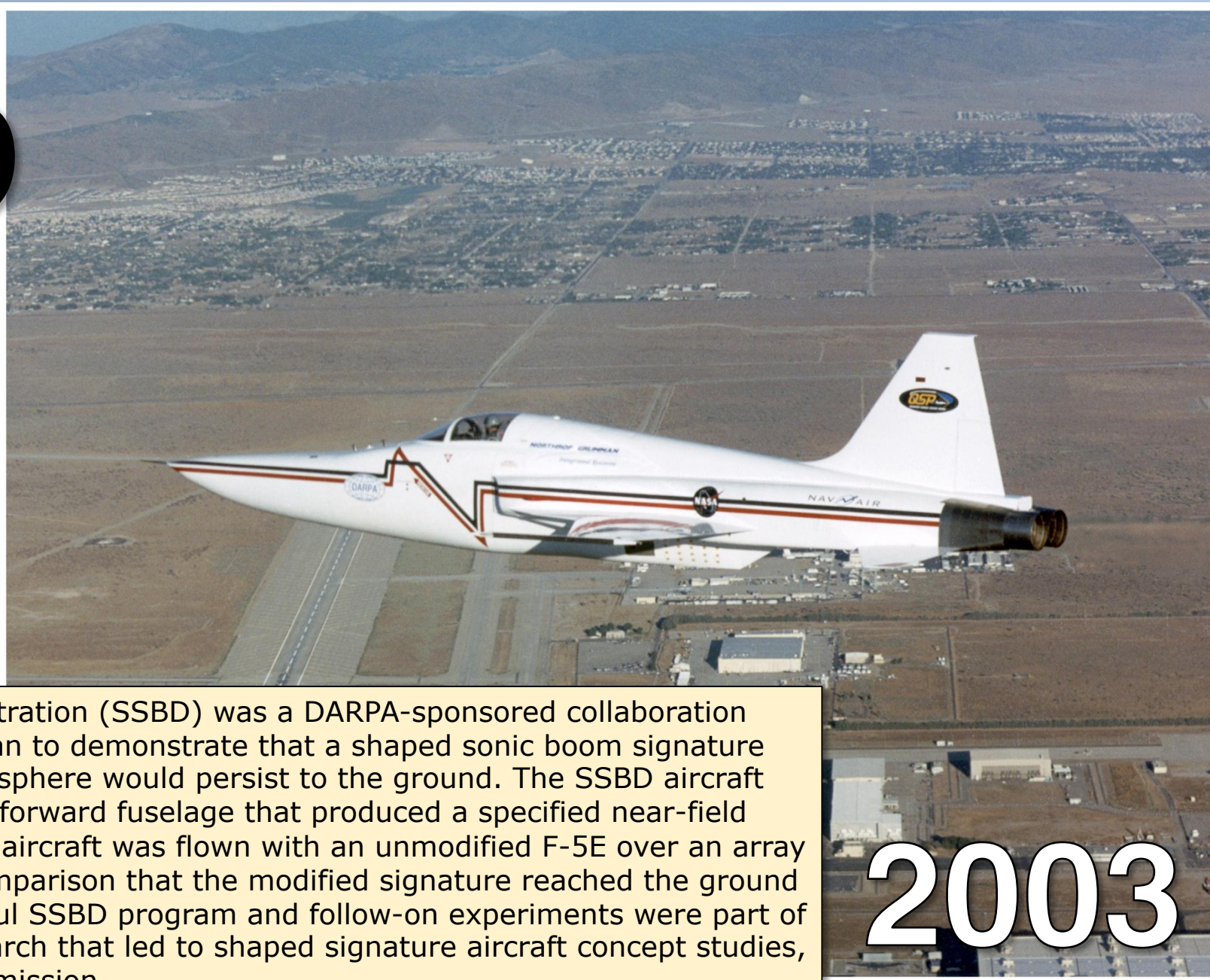
NASA pilots Gordon Fullerton and Rob Rivers.



NASA Dryden Flight Research Center Photo Collection
<http://www.dfrc.nasa.gov/gallery/photo/index.html>
NASA Photo: EC97-44203-3 Date: July 1997 Photo by: NASA/IBP

Russian Tu-144LL SST Flying Laboratory Takeoff at Zhukovsky Air Development Center

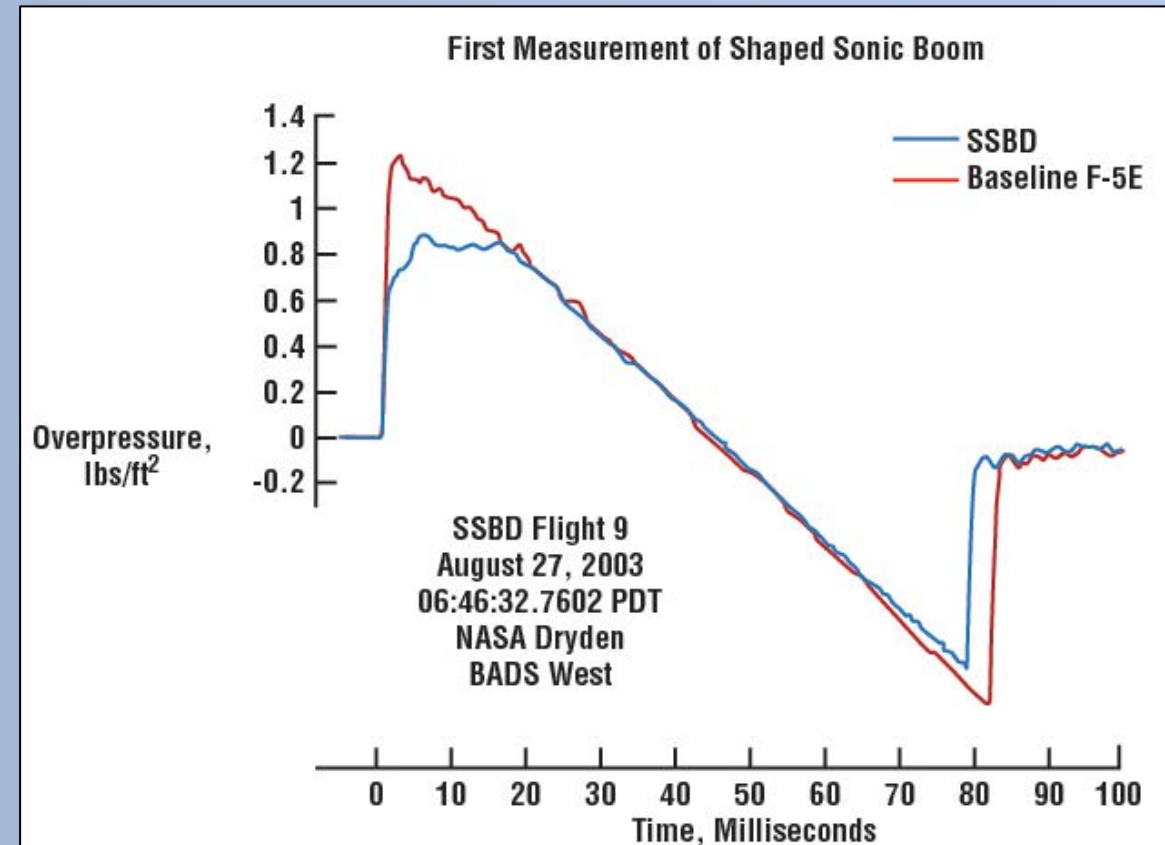
SSBD



The Shaped Sonic Boom Demonstration (SSBD) was a DARPA-sponsored collaboration with NASA and Northrop Grumman to demonstrate that a shaped sonic boom signature from aircraft flying in a real atmosphere would persist to the ground. The SSBD aircraft was a Navy F-5E with a modified forward fuselage that produced a specified near-field shock wave signature. The SSBD aircraft was flown with an unmodified F-5E over an array of ground sensors to show by comparison that the modified signature reached the ground as predicted. The highly successful SSBD program and follow-on experiments were part of a resurgence of sonic boom research that led to shaped signature aircraft concept studies, and ultimately to NASA's Quesst mission.

2003

SSBD



Northrup Grumman pilot Roy Martin / Joe Pawlowski quote (2003):
“In 1947, Chuck Yeager broke the sound barrier, we just fixed it.”

Might have been a bit overstated, but it was a critical step to “fixing” or reduction of sonic boom noise.

Quiet Spike



In 2006, NASA and Gulfstream Aerospace Corporation collaborated on a flight test of the company's Quiet Spike concept. The idea behind Quiet Spike was to use a large telescoping nose section to control the strength and position of the forward shock waves and thereby reduce the sonic boom noise. A prototype, extending from 14 feet in subsonic flight to 24 feet in supersonic flight, was designed and installed on NASA's F-15B. Although the flight test focused on understanding the structural and operational characteristics of the concept, data from probing flights did show that the sonic boom signature modification technique was feasible.

2006

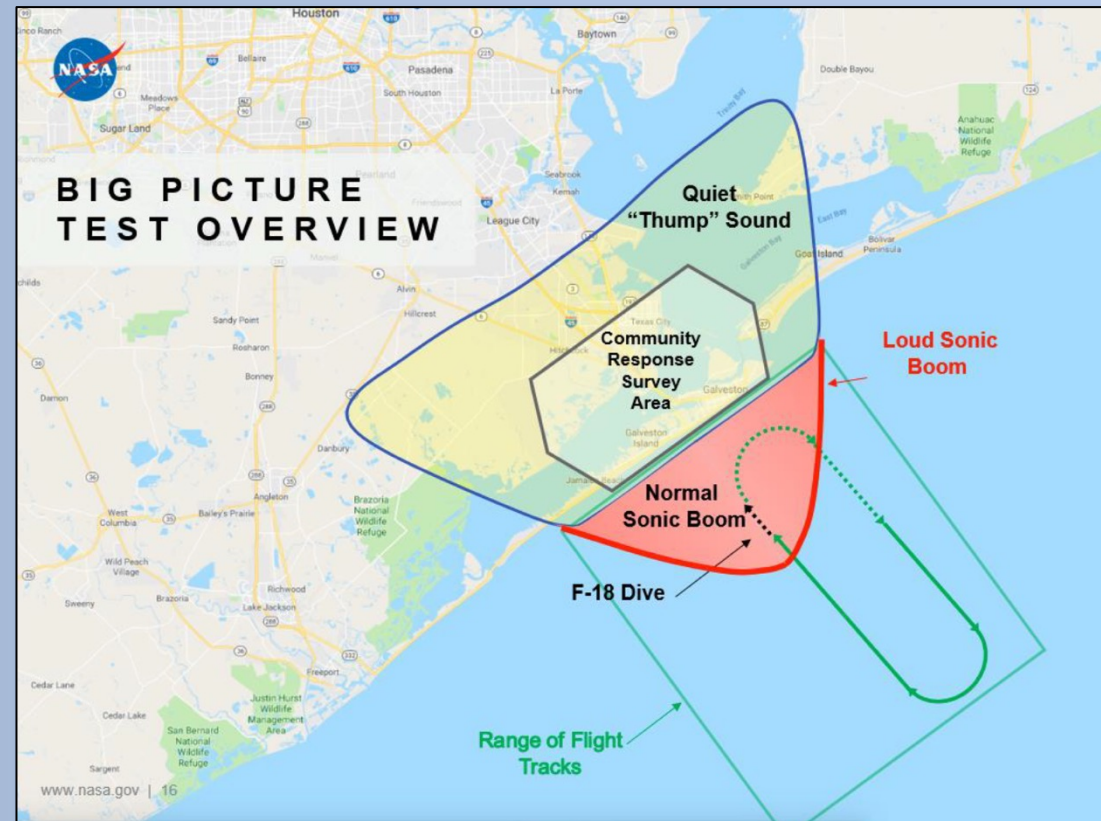
F-18 Supersonic Research



NASA's F-18 aircraft have supported flight research for more than three decades, participating in a multitude of supersonic research studies. Over the past decade, the F-18s supported development of a specially designed supersonic dive maneuver that generates localized, low-amplitude sonic booms. This technique enabled moving research on people's response to quieted sonic boom sounds from the laboratory environment to flights over small communities.

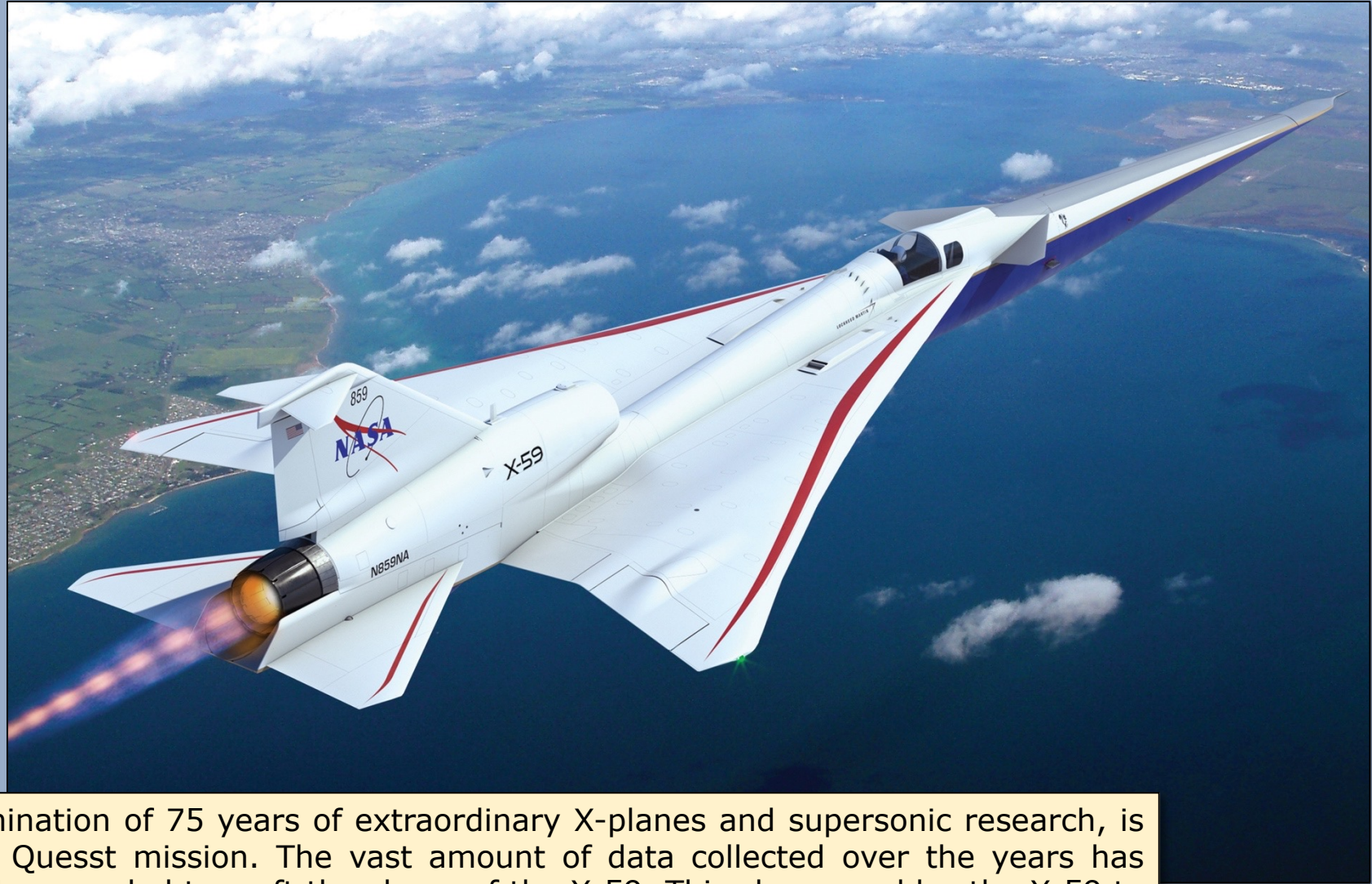
2018

F-18 Supersonic Research



During the Quiet Supersonic Flight 2018 (QSF18) campaign, the dive maneuver was used to expose the community of Galveston, Texas, to low-amplitude sonic booms enabling researchers to develop techniques that will be used during the Quesst mission's community overflight studies.

X-59



The X-59 aircraft, the culmination of 75 years of extraordinary X-planes and supersonic research, is the centerpiece of NASA's Quesst mission. The vast amount of data collected over the years has given designers the tools they needed to craft the shape of the X-59. This shape enables the X-59 to fly at supersonic speeds and reduce the loud sonic boom to a quiet "sonic thump" sound. The Quesst mission will use data from X-59 community overflight studies to provide regulators the data needed to support new standards for quiet supersonic flight that will open the future to commercial supersonic air transportation over land.

Credit: Lockheed Martin

X-59 Features



Long nose to shape forward shock

External and forward visions systems for forward visibility

T-38 aft canopy and ejection seat to minimize qualification cost and schedule

Fixed canard for nose-up trim at low-boom design point

T-tail to minimize aft shock

Large, unitized skins reduce parts count and manufacturing cost

F-16 landing gear and other systems from high performance aircraft to minimize qualification cost and schedule

Wing shielding to minimize impact of inlet spillage on sonic boom

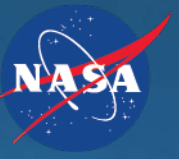
Conventional tail arrangement to simplify stability and control considerations

Single GE-F414 engine with standard nozzle to minimize cost and schedule

Design Parameters

- **Length: 99 ft**
- **Span: 29.5 ft**
- **Speed: Mach 1.4 (925 mph)**
- **Altitude: 55,000 ft**

Quesst Vision & Mission



Exciting new market potential seen for supersonic civil aircraft

Evidenced by the appearance of several commercial programs even with existing restrictions on overland flight and other challenges

Overland flight restrictions based on unacceptable sonic boom noise are viewed as the main barrier to this vision



The vision of the supersonics community is a future where fast air travel is available for a broad spectrum of the traveling public

Future supersonic aircraft should have an environmental impact that is compatible with a sustainable global aviation transportation system



Quesst Overview



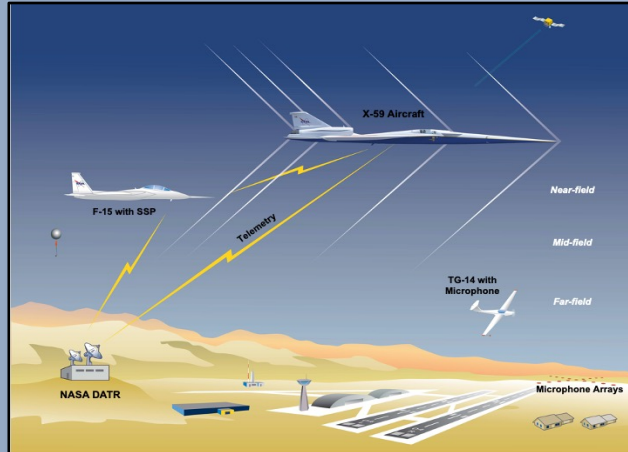
Phase 1 – X-59 Aircraft Development

Aircraft design, fabrication, and ground test
Checkout and envelope expansion

**Systematic Approach Leading
to Community Testing**

**First Flight
Late 2023**

Credit: Lockheed Martin



2024

Phase 2 – Acoustic Validation

Detailed ground and flight measurements



2025

Credit: Lockheed Martin

Phase 3 – Community Response

Community response overflights,
ground measurements, and
surveys
over representative communities
across the U.S.

Weight On Wheels



Credit: Lockheed Martin

Transition to Ramp



Credit: Lockheed Martin

Quieting the Boom



Credit: Lockheed Martin

QUESST

Quesst – Upcoming Forum Talks



Preparing to Fly the X-59 - David “Nils” Larson, Lead X-59 Test Pilot
Forum Stage 8 GAMA Wed @ 11:30 am

NASA’s Supersonic Quesst - Peter Coen, Mission Integration Manager
Forum Stage 11 Deltahawk Engines Sat @ 10:00 am

Visit the NASA pavilion!