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ROCKETING THROUGH MACH 2

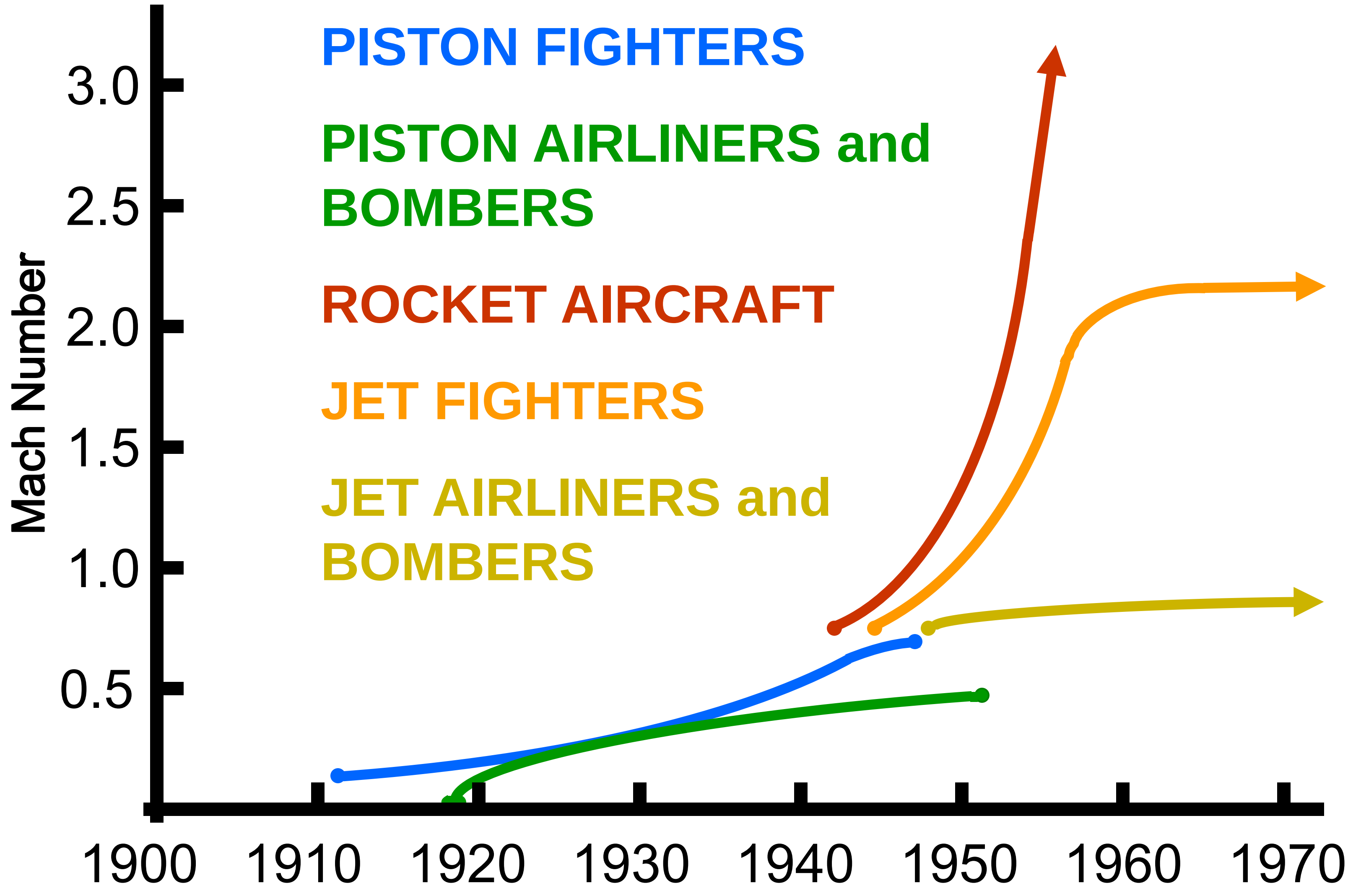
Scott Crossfield and the D-558-2: A Tribute

Dr. Richard P. Hallion

National Air and Space Museum
Smithsonian Institution
Washington, D.C.

20 November 2013

…Speed by Function…



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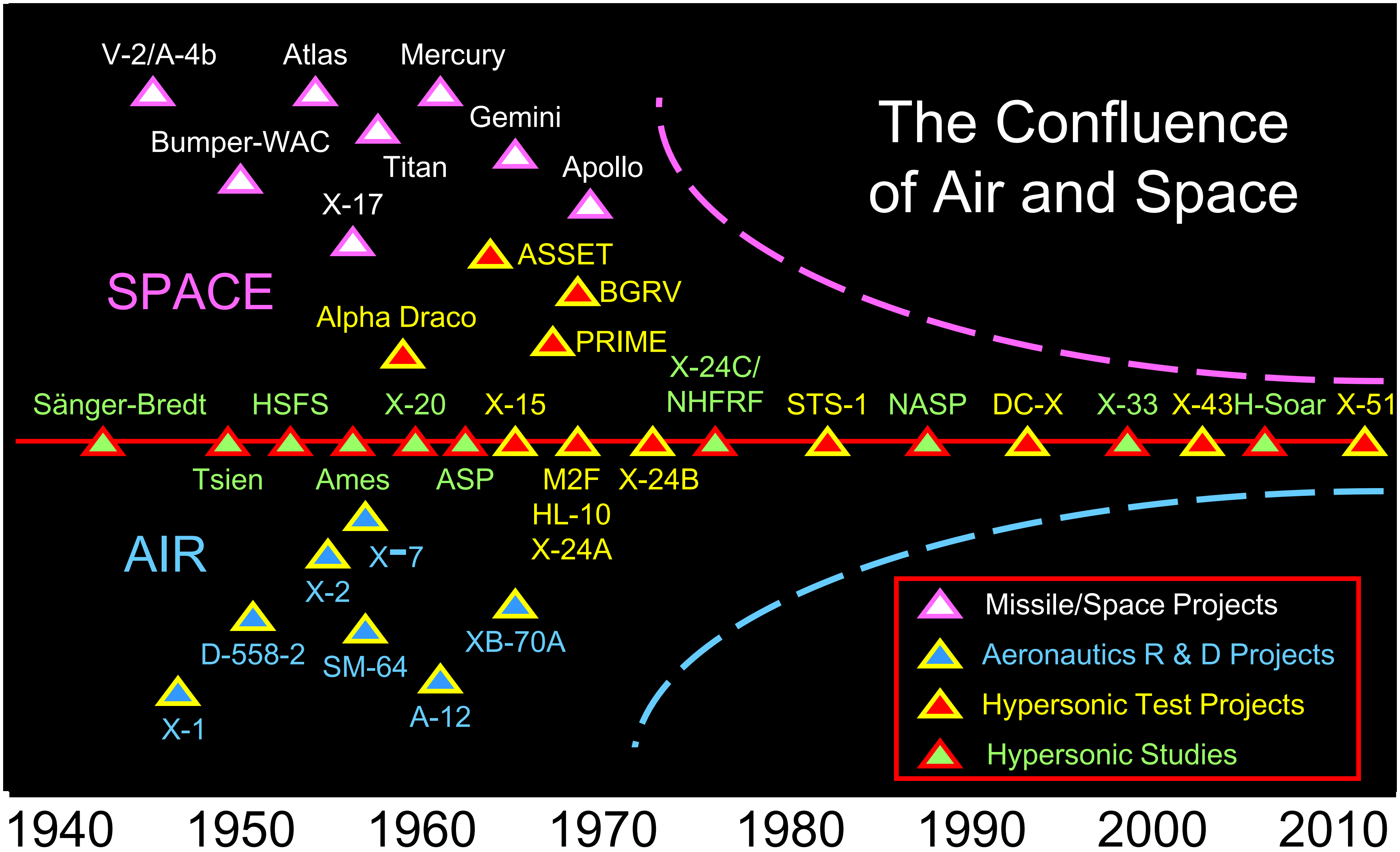
Over Six Decades of High-Speed Flight



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…A Review of Flight Research Efforts…

Designation	Research Purpose	Performance	Propulsion
Bell XS-1 (X-1)	Exceed Mach 1 for first time	Mach 1.45	air-launch; rocket
Bell X-1A/B/D/E	Mach 2+ aerodynamic research	Mach 2.44	air launch; rocket
Bell X-2	Sweptwing & airfoil research	Mach 3.2	air launch; rocket
Douglas X-3	Mach 2+ turbojet & configuration	Mach 1.21	ground takeoff; jet
Northrop X-4	Semi-tailless behavior	Mach 0.88	ground takeoff; jet
Bell X-5	Variable-sweep wing behavior	Mach 0.95	ground takeoff; jet
Convair XF-92A	Delta wing behavior	Mach 1.0	ground takeoff; jet
Douglas D-558-1	Transonic configuration studies	Mach 1.0	ground takeoff; jet
Douglas D-558-2	Supersonic sweptwing studies	Mach 2.005	ground/air; jet/rocket
Lockheed X-7	M = 4+ aerodynamic & ramjet	Mach 4.31	air-launch; ramjet
NAA X-15	Hypersonic & high alt. research	Mach 6.72	air-launch; rocket
Lockheed X-17	Hypersonic reentry testing	Mach 14.4	4-stage rocket
NAA XB-70A	Sustained Mach 2.5+ cruise	Mach 3.1	ground takeoff; jet
ASSET	Hypersonic Aerothermodynamics	Mach 18.4	Thor-Delta booster
PRIME	Maneuvering; ablative studies	Mach 25.4	Atlas booster
BGRV	Maneuvering w. flaps, thrusters	Mach 18.0	Atlas-booster
Shuttle *Columbia*	Piloted Lifting Entry, 4/12-14/81	Orbital	Solid/Liquid rocket
X-43A *Hyper-X*	Scramjet Ignition and operation	Mach 9.7	Solid/scramjet
X-51A	Hydrocarbon, Therm. Bal. Scram	Mach 5.10	Solid/scramjet
X-37B	Routine Reusable Space Access	Orbital	Atlas-V booster

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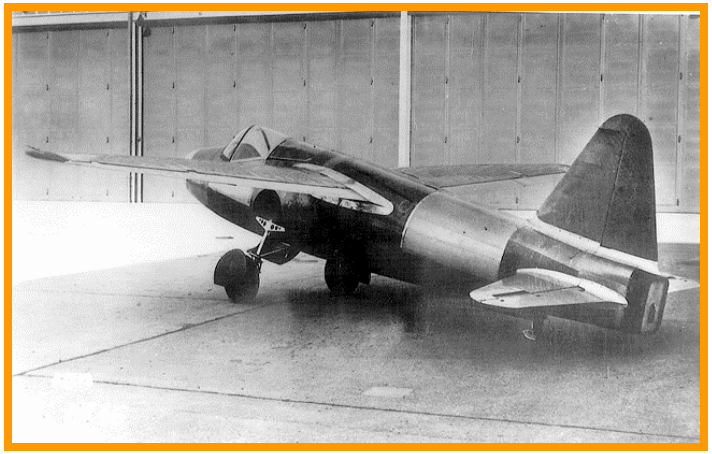
The Arrival of the Jet Age…



Heinkel He 178 (1939)

Gloster E.28/39 (1941)

Bell XP-59A (1942)

Messerschmitt Me 262 (1944)

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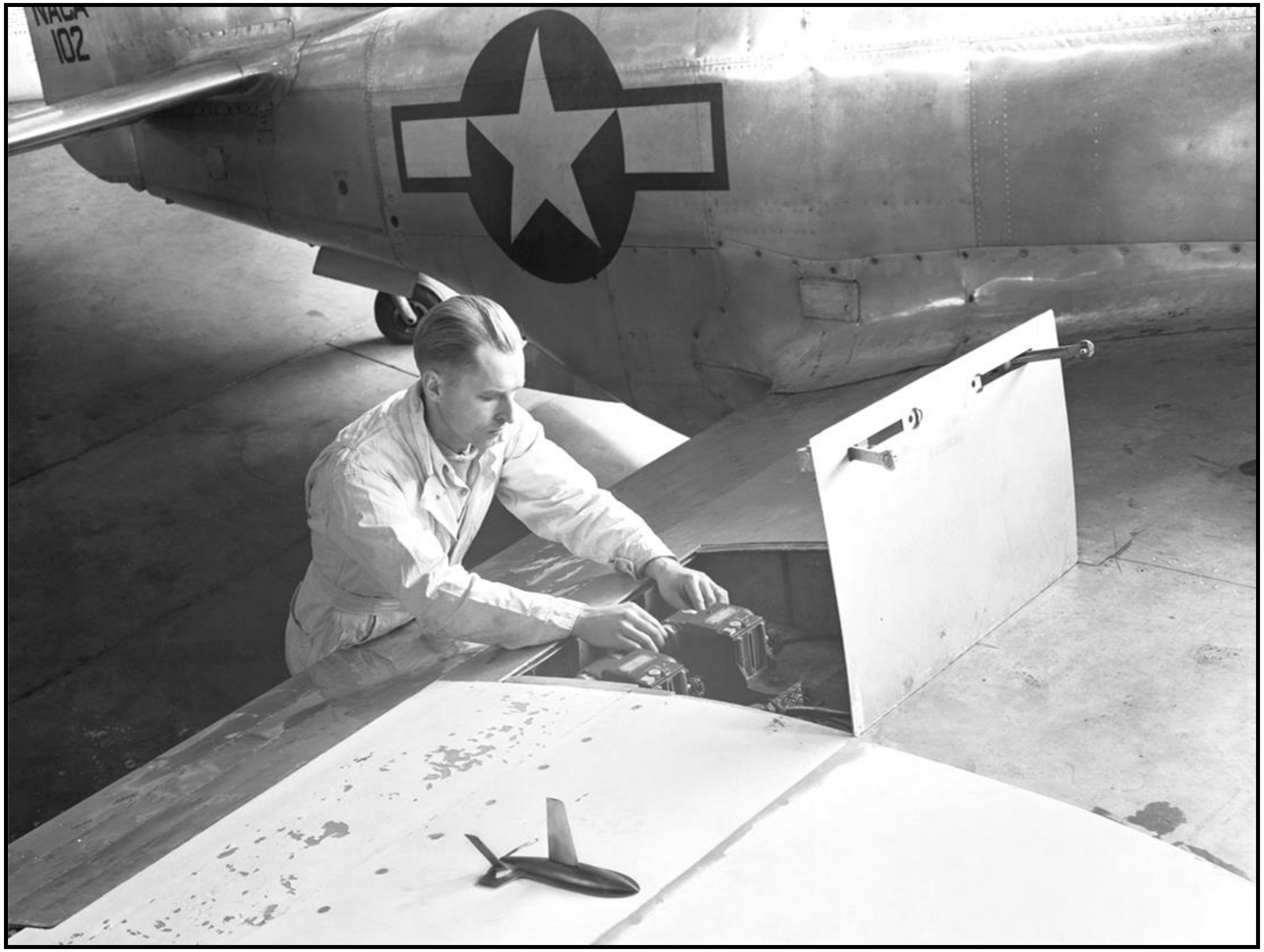
Stopgap Research Methodologies



Accelerated Wing Flow Research Model on a P-51

NASA Photo

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The High-Speed Sweptwing: Origins

Das zylindrische Strömungsfeld um den schräg angeblasenen Tragflügel (Abb. 4) kann man nach diesen Überlegungen soweit in eine ebene Strömung verwandeln, als es sich um die Berechnung der Druckkräfte auf den Tragflügel handelt. Die achsiale Geschwindigkeitskomponente fällt für die Erzeugung von Drücken völlig fort. Sie ändert jedoch die Bezugsgrößen der Strömung. Man muß bei einer Schräganblasung um den Winkel φ unterscheiden den wirklichen Staudruck q_0 der Strömung und den wirksamen Staudruck q, der die achsiale Komponente der Anblasegeschwindigkeit nicht einhält. Zwischen beiden besteht die Beziehung:

$$q = q_0 \cdot \cos^2 \varphi \; . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

Genau in gleicher Weise gibt es eine wirkliche Machsche Zahl $M_0 = \frac{w_0}{c}$ und daneben eine wirksame Machsche Zahl $M = \frac{w}{c}$ mit der Beziehung:

$$M = M_0 \cos \varphi \; . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

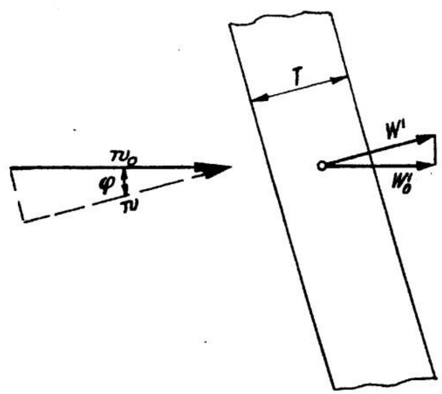


Abb. 4. Schräg angeblasener Tragflügel.

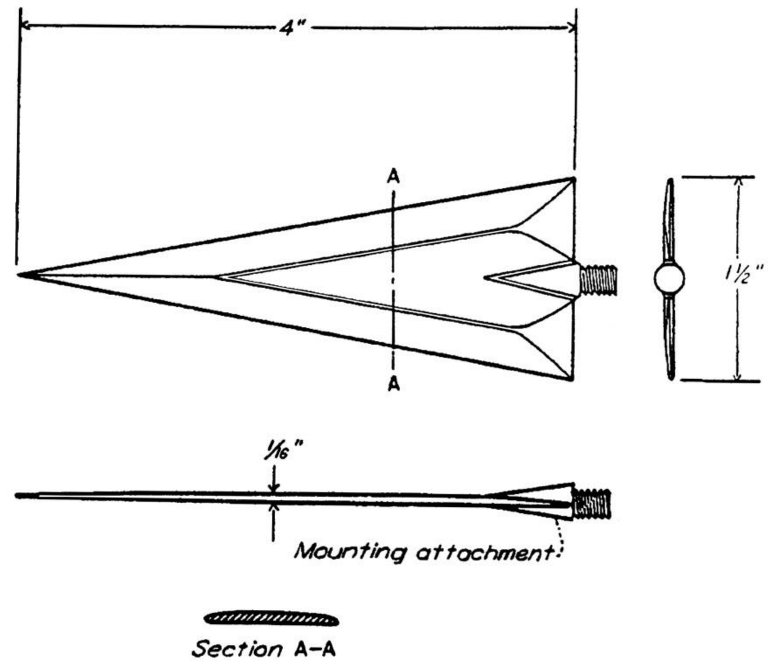
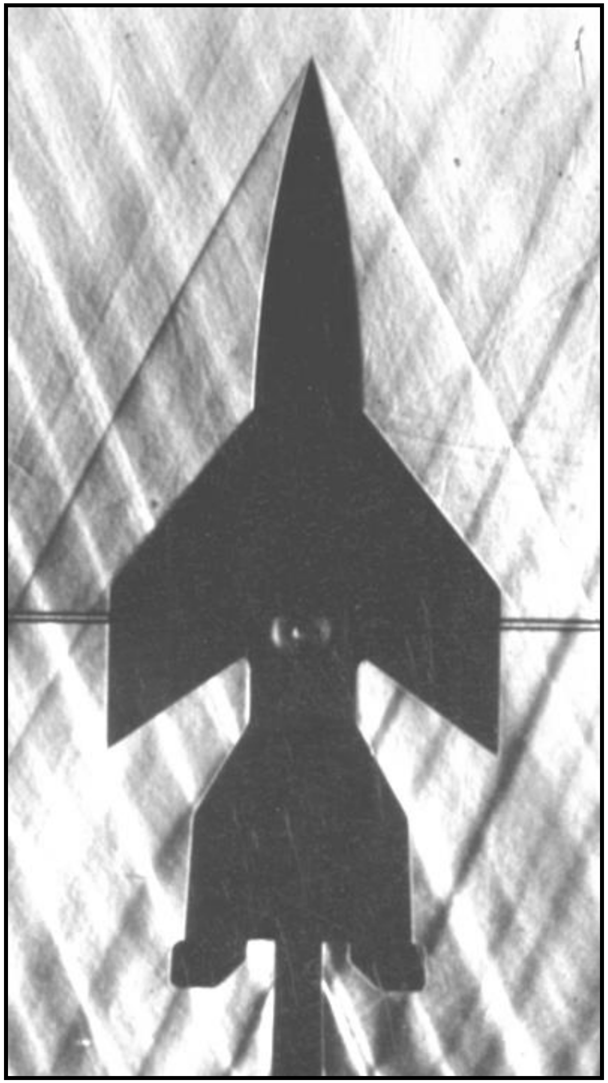


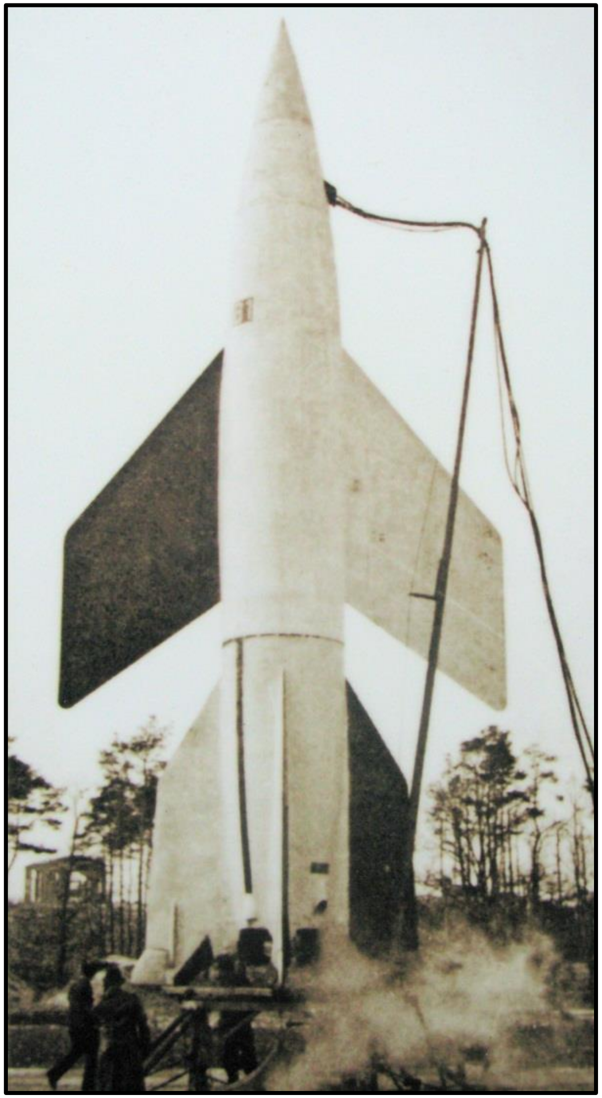
FIGURE 9.—Airfoil tested in Langley model supersonic tunnel.

Adolf Busemann's 1935 Volta Paper **Robert T. Jones, Langley, 1945**

Exploitation of the Sweptwing



1940 Tunnel Test of Winged A-4



M = 4+, Jan. 24,1945

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Initial American Efforts

North American XP-86 Sabre

Boeing XB-47 Stratojet

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Birth of the X-Series

Capt. Charles E. "Chuck" Yeager, 1st M = 1+ Flight, 14 Oct 1947

Transonic Through M = 2

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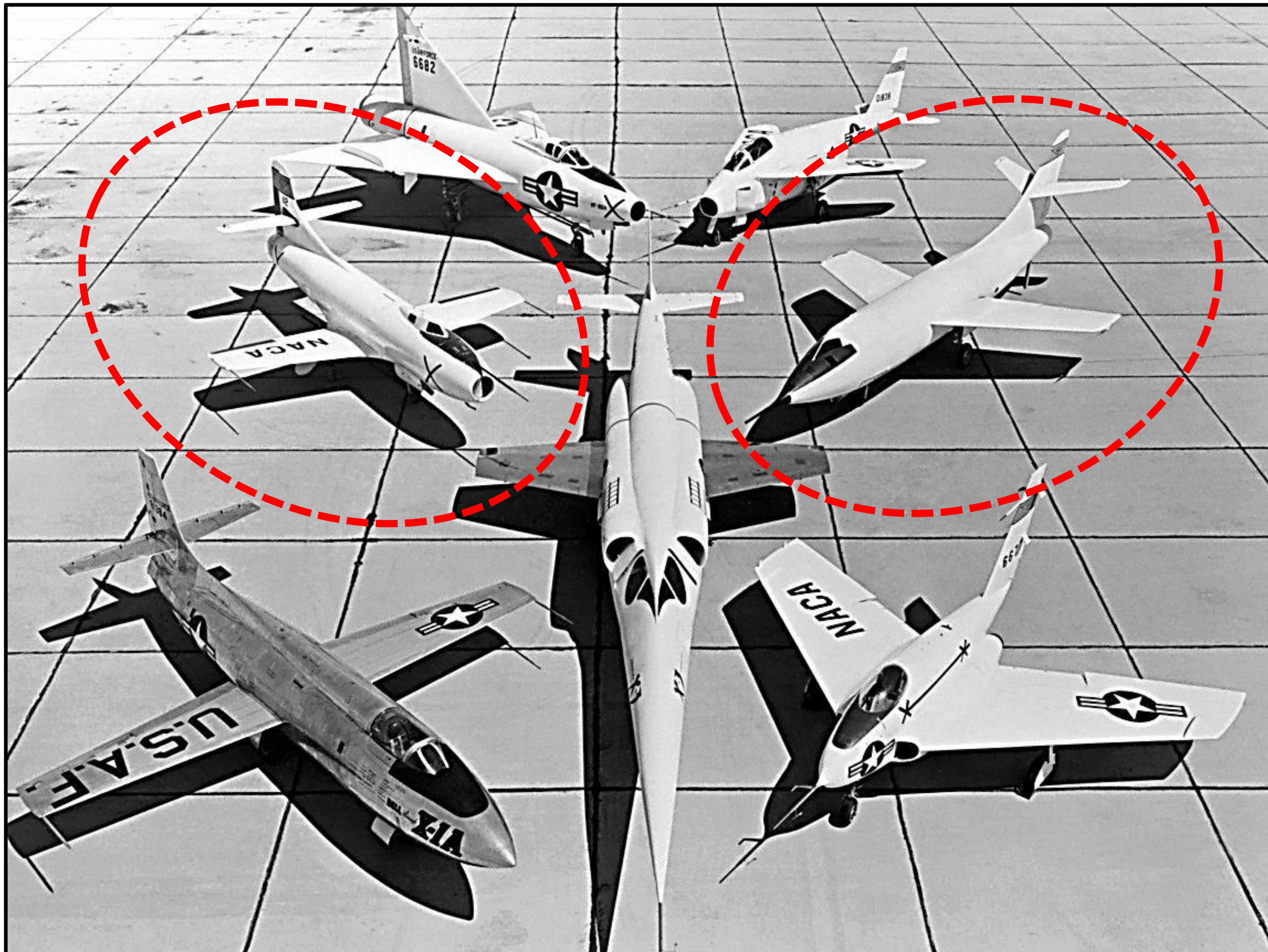
Clockwise: X-1A, D-558-1, XF-92A, X-5, D-558-2, X-4, center X-3 (1953)

NASA Photo

Transonic Through M = 2

Mach 2 is 60!



Clockwise: X-1A, D-558-1, XF-92A, X-5, D-558-2, X-4, center X-3 (1953)

NASA Photo

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D-558-1: The First Step…

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Towards the D-558-2…

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D-558-2 NACA 144, 1949

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D-558-2 NACA 144 on Lakebed

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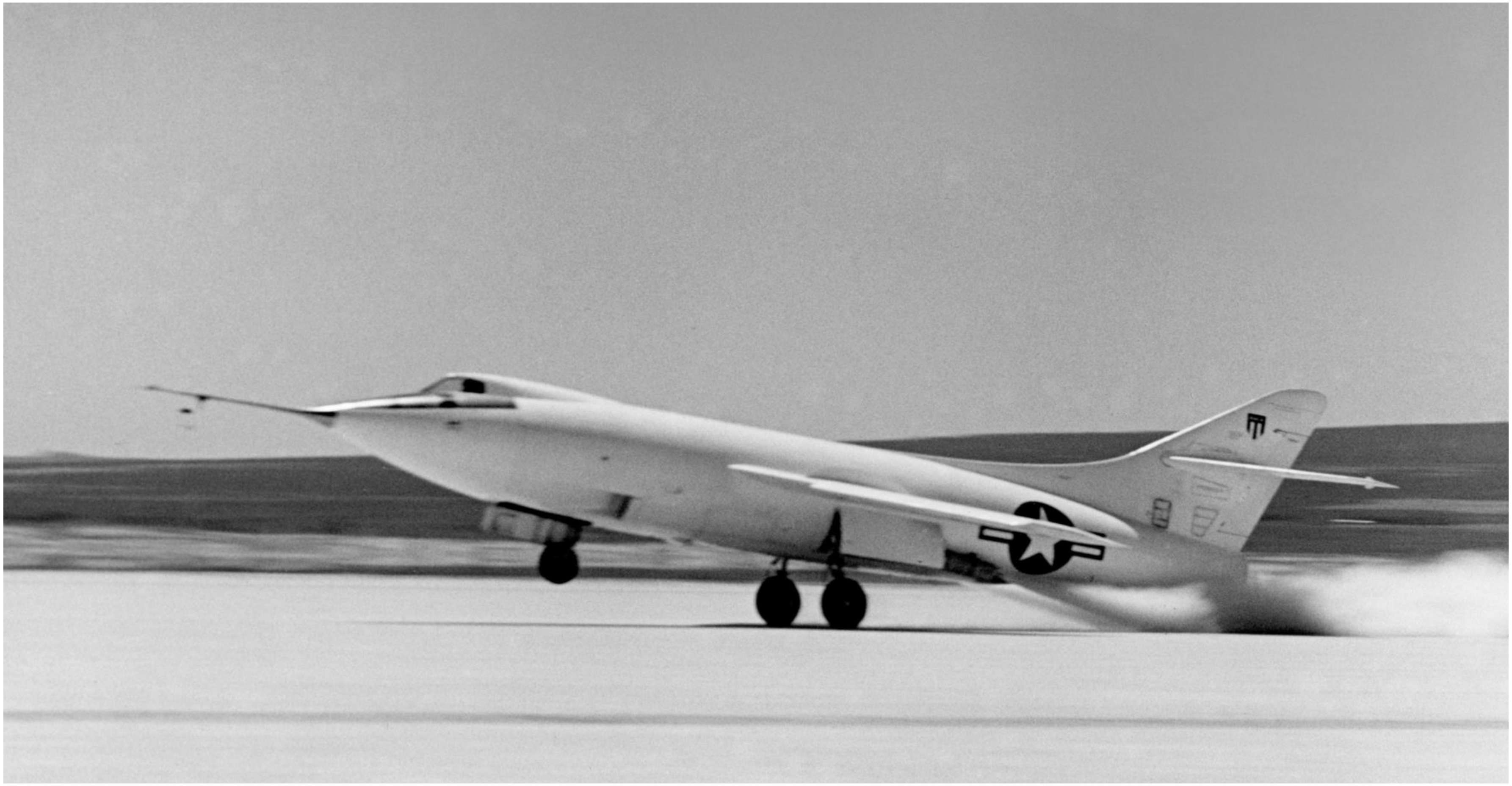
D-558-2 NACA 144 JATO Takeoff



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D-558-2 Air-launch from P2B-1S, 1951

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Chuck Yeager and Bill Bridgeman…

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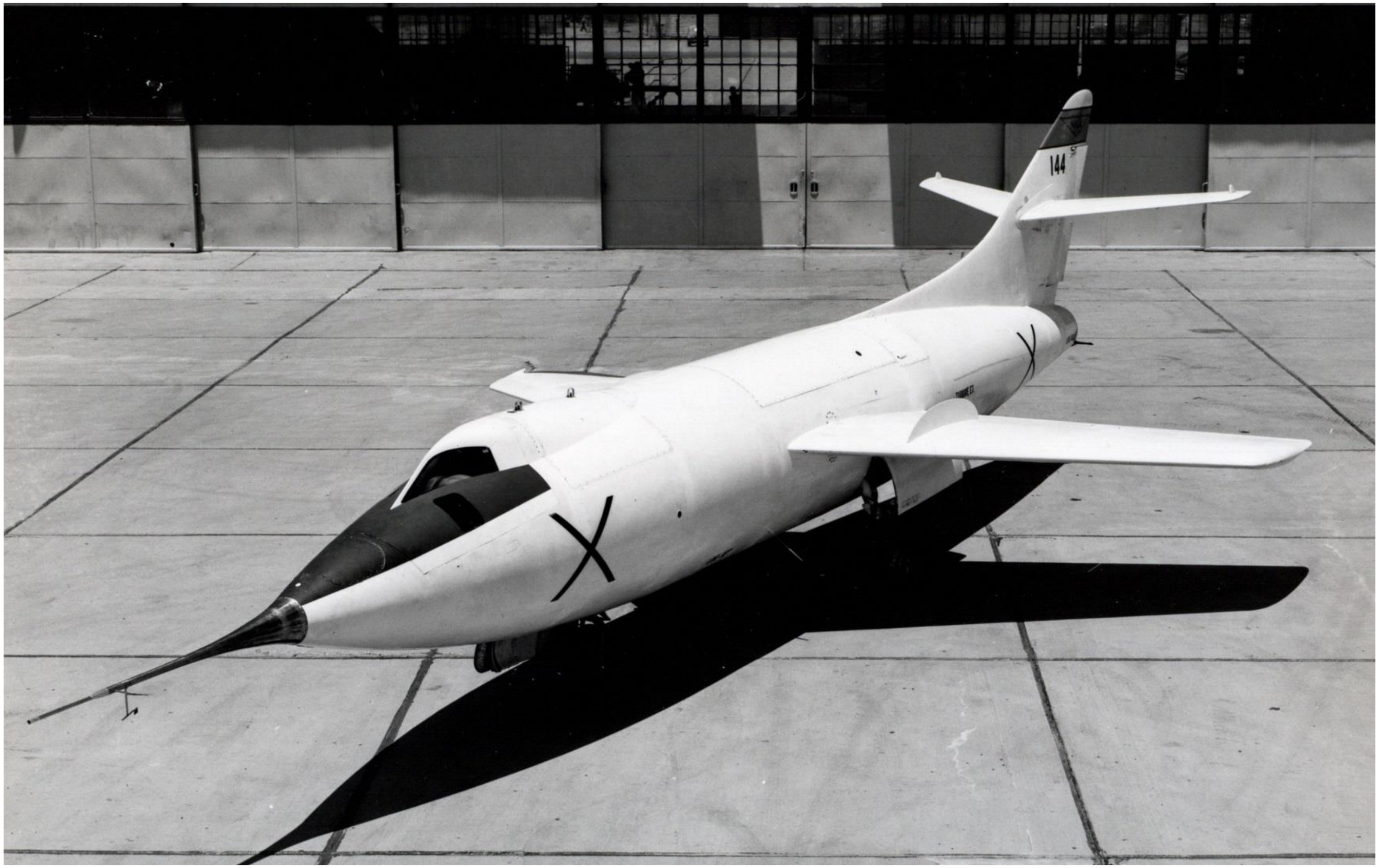
D-558-2 NACA 144 in All-Rocket Configuration



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The NACA-USAF D-558-2 Test Team

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Mating the D-558-2 to its Mothership

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Scott Crossfield (1921-2006)

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…Pure Streamline…

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Success: 20 Nov. 1953, M = 2.005

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Walt Williams, Scott Crossfield, & Joe Vensel

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NACA Tells the World…

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…Just Another Workhorse…

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Two Pioneers…Some Perspective

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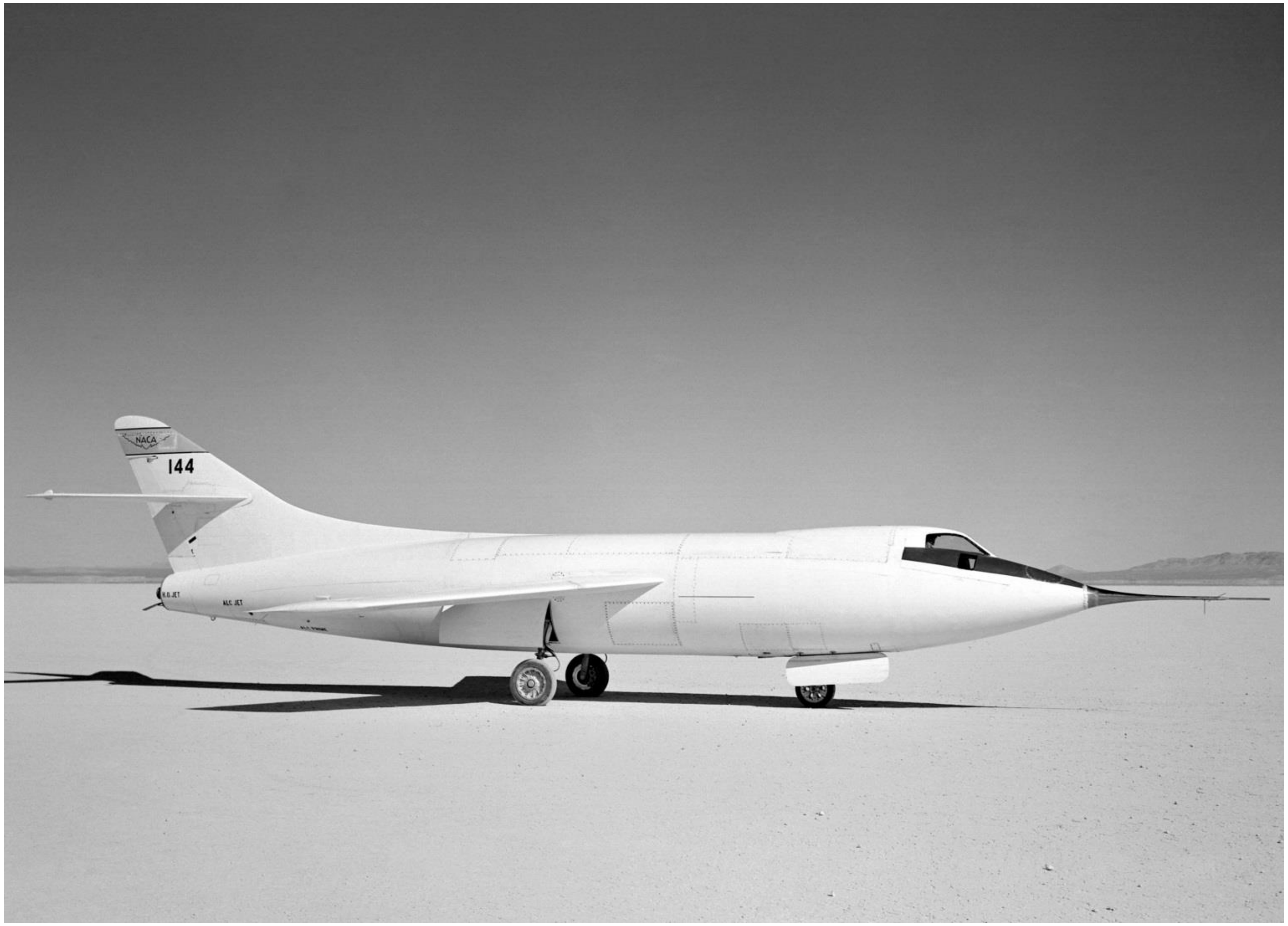
…Another Perspective…



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Skyrocket Pitch-up Fixes…

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Skyrocket External Stores Tests

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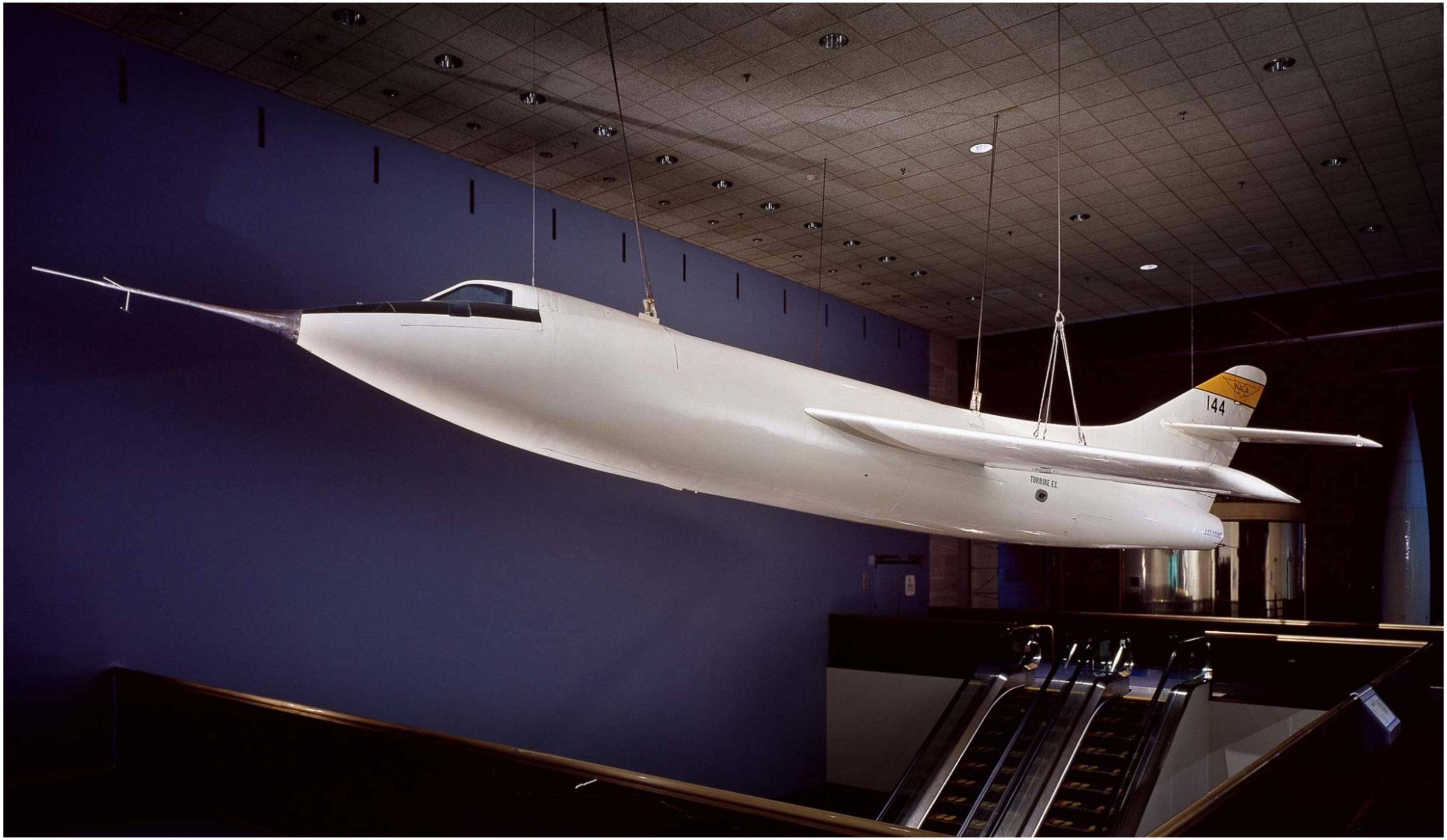
Honored at the Smithsonian…



NASM-SI Photo

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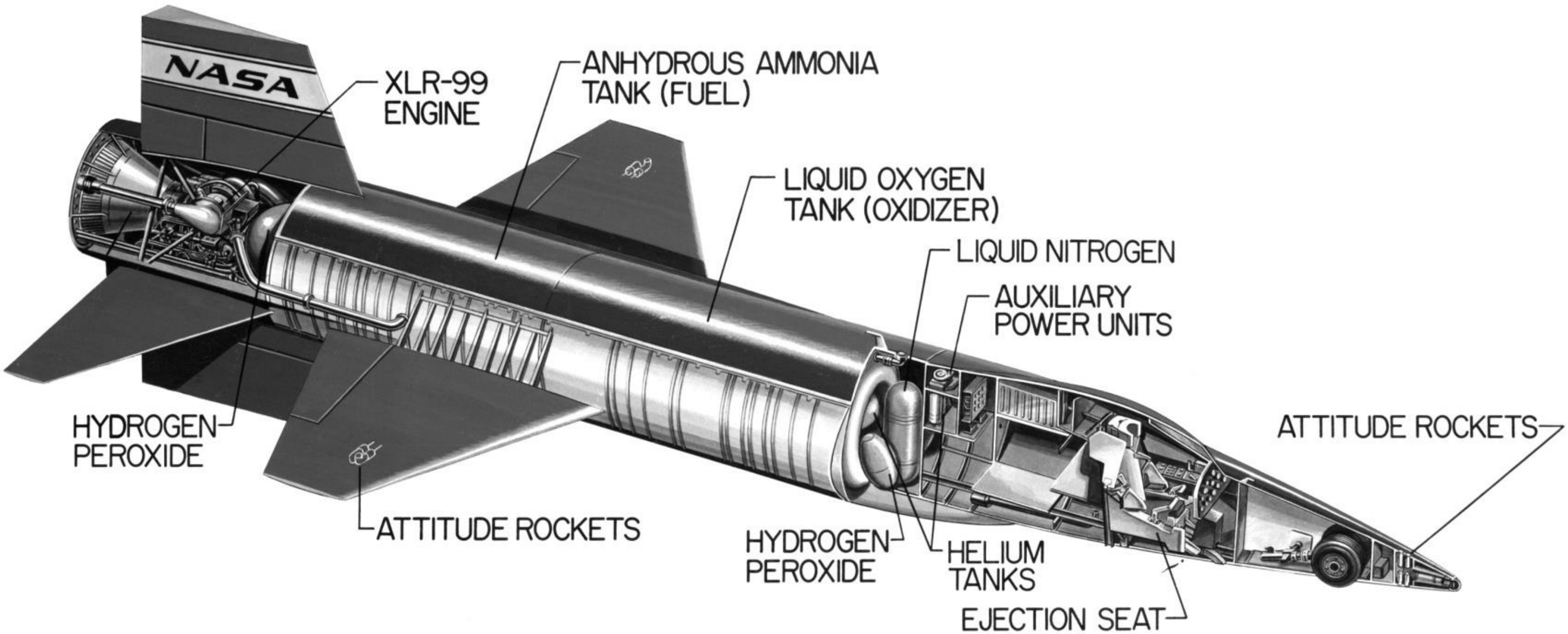
The Next Step: the X-15



NACA

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The X-15: 1959-1968

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Two of a Remarkable Kind…

Chad Slattery Photo

Mach 2 is 60!

Two of a Remarkable Kind…

Thanks, Scotty—
for <u>ALL</u> you did!!

RIP…

with respect and admiration from all you helped

Chad Slattery Photo