# XB-70 Valkyrie

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# Overview

- Mission
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- Specifications
- Design Features
- Compression Lift
- Aerodynamic Analysis
- Final Remarks


# Mission Profile

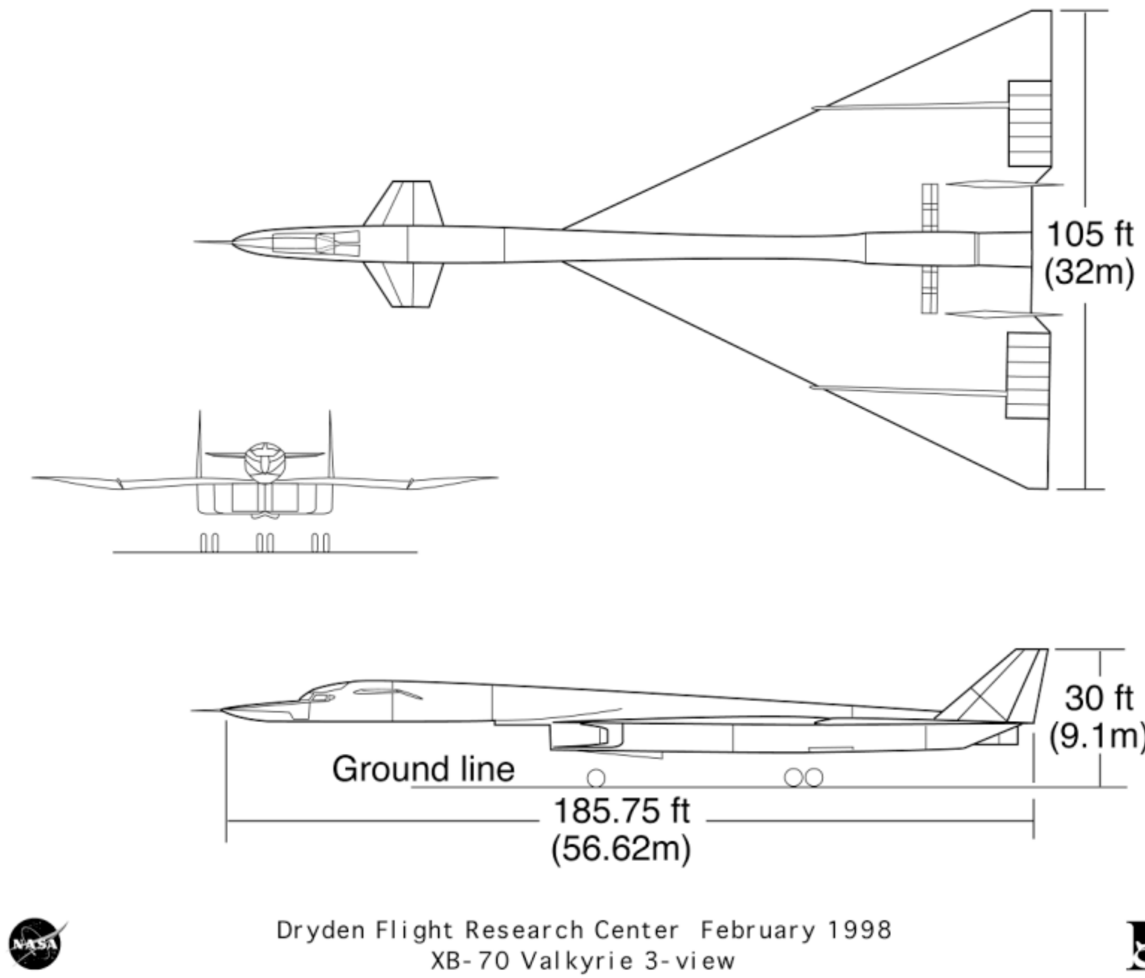
- Proposals Submitted by Boeing and North American
  - Boeing utilized a conventional swept-wing configuration;
  - North American, a canard-type, resembling a scaled-up Navaho missile (vertically launched, air-breathing, intercontinental surface-to-surface, delta-wing missile).

- It was originally designed for the Strategic Air Command in the late 1950's as a replacement for the B-52 bomber,
  - These characteristics called for a speed of Mach 3 to Mach 3.2, a target altitude of 70,000 to 75,000 feet, a range of 6,100 to 10,500 miles, and a gross weight between 475,000 and 490,000 pounds.

# History

- The first XB-70 made its maiden flight on September 21, 1964.
- October 14, 1965-the first flight exceeding a speed of Mach 3
- On May 19, 1966 aircraft number two flew 2,400 miles (3,840 km) in 91 minutes, attaining Mach 3 for 33 minutes
- Mid-air collision with F-104 June 8, 1966 (aircraft number two)
- The remaining Valkyrie continued service until February 4, 1969 when it was flown to the Wright-Patterson AFB in Dayton, Ohio.
- Total development cost: $1.5 billion

# Configuration



# Specifications

- **Span:** 105 ft
- **Length:** 185 ft 10 in
- **Wing Area**: 6297.8 $ft^2$
- **Height:**30 ft 9 in
- **Empty Weight**: 231,215 lbs
- **Weight:** 534,700 lbs loaded
- **Leading Edge Sweep**: 65 deg
- **Trailing Edge Sweep**: 0 deg
- **Dihedral**: XB-70-1: 0 deg
  XB-70-2: 5 deg (roll and yaw stability)
- **AR**= 1.751
- **MAC** = 17.82 ft

# Aerodynamic Specifications

- **Engines:** Six General Electric YJ-93s of 30,000 lbs. thrust each with afterburner
- **Maximum speed:**2,056 mph. (Mach 3.1) at 73,000 ft
- **Cruising speed:**2,000 mph (Mach 3.0) at 72,000 ft
- **Range:**4,288 miles
- **Service Ceiling:**77,350 ft
- **Endurance:** 1.87 hours
- **Take-Off Distance:** 7400 ft
- **Rate of Climb**: 7170 ft/min

- **Zero Lift Drag**:
  - 0.007 for 0 tip deflection at M= 0.75
  - 0.026 for 25 deg tip deflection at M = 1.1
  - 0.014 for 65 deg tip deflection at M = 1.6
  - 0.0095 for 25 deg tip deflection at M = 2.1
- **Lift Coefficients**
  - Cruise: 0.1 to 0.13
  - Takeoff: 1.3 to 0.73
  - Landing: 0.626
- **Mach**
  - Takeoff: 0.21
  - Landing: 0.23

# Performance

- Subsonic (M = 0.76-0.93)
  - Base drag coefficient approximately 0.0010 at M = 0.76. There was a change of 0.0008 at M = 0.93 and a $C_L$ of 0.23 due to engine power changes.
- Transonic (M = 1.06-1.18)
  - Drag coefficient for $C_L$ near 0.16 rises from about 0.016 (M = 0.93) to 0.028 at M = 1.06. Base drag is at a maximum for M = 1.18 (approximately 12% of total aircraft drag)
  - Wave drag and after body drag are dominant at transonic Mach numbers and drag coefficient does not change much with $C_L$ at M = 1.06

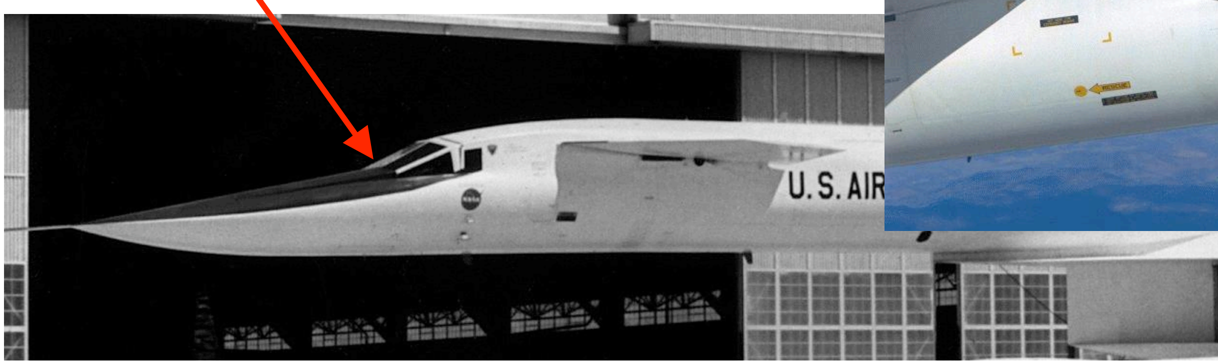
# Design Features

- Movable Canard
  - The canard design enabled the foreplane to be used to assist with trimming the aircraft across a wide speed range from a minimum of 150 knots (278 km/h) landing speed, up to Mach 3; they could also serve as flaps.
- Crew Accommodations
  - In-flight accessibility to electronics equipment, a shirt-sleeve environment for the crew, and encapsulated seats for crew ejection at speeds up to Mach 3 and at altitudes above 70,000 feet.

# Design Features-Movable Canopy

- Movable Canopy
  - A variable-geometry system was fitted to the nose, allowing a ramp forward of the cockpit to be raised for supersonic flight or lowered for a direct forward view. This visor was merely aerodynamic.

Subsonic-
better pilot visibility




Supersonic-
Canopy
Streamlined

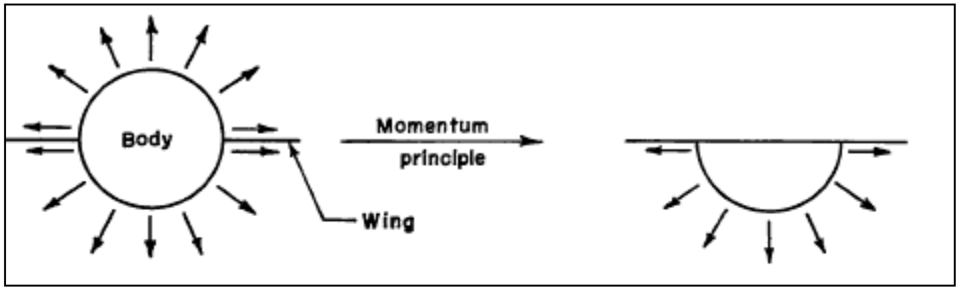
# Design Features-Folding Wing Tips

- *Front view of the XB-70 with all three wingtip angles*



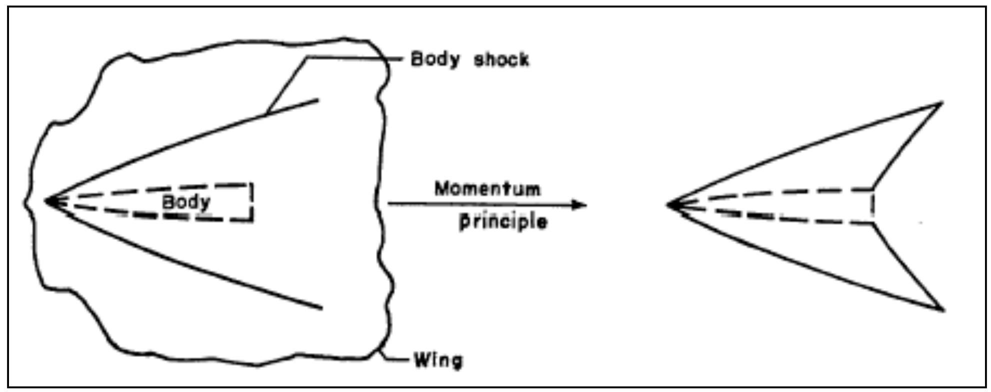
- In flight, the XB-70 could lower the outer wing sections 25 degrees for flying from 300 knots to Mach 1.4, or a severe 65 degrees for speeds from Mach 1.4 to Mach 3+. Measuring just a bit over 20 feet at the trailing edge, these wingtips represent the largest movable aerodynamic device ever used.
- Lowering the wingtips had three distinct effects on the XB-70.
  - Total vertical area was increased, allowing shorter vertical stabilizers than would otherwise be needed.
  - The reduction in rearward wing area countered the delta wing's inherent rearward shift of the center of lift as speed increased, keeping drag-inducing trim corrections to a minimum.
  - Compression lift was 30 percent more effective because the pressure under the wing was better managed.

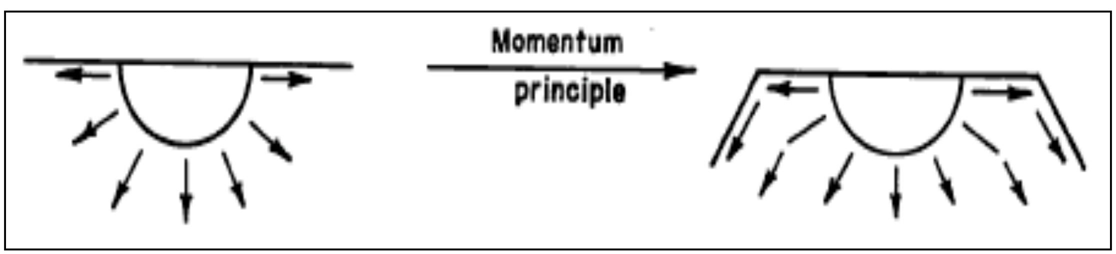
# Compression Lift




Consider a body of revolution mounted symmetrically on a thin wing at zero angle of attack. A front view of this arrangement, along with the disturbance velocities created by the body, is shown in the figure to the left.

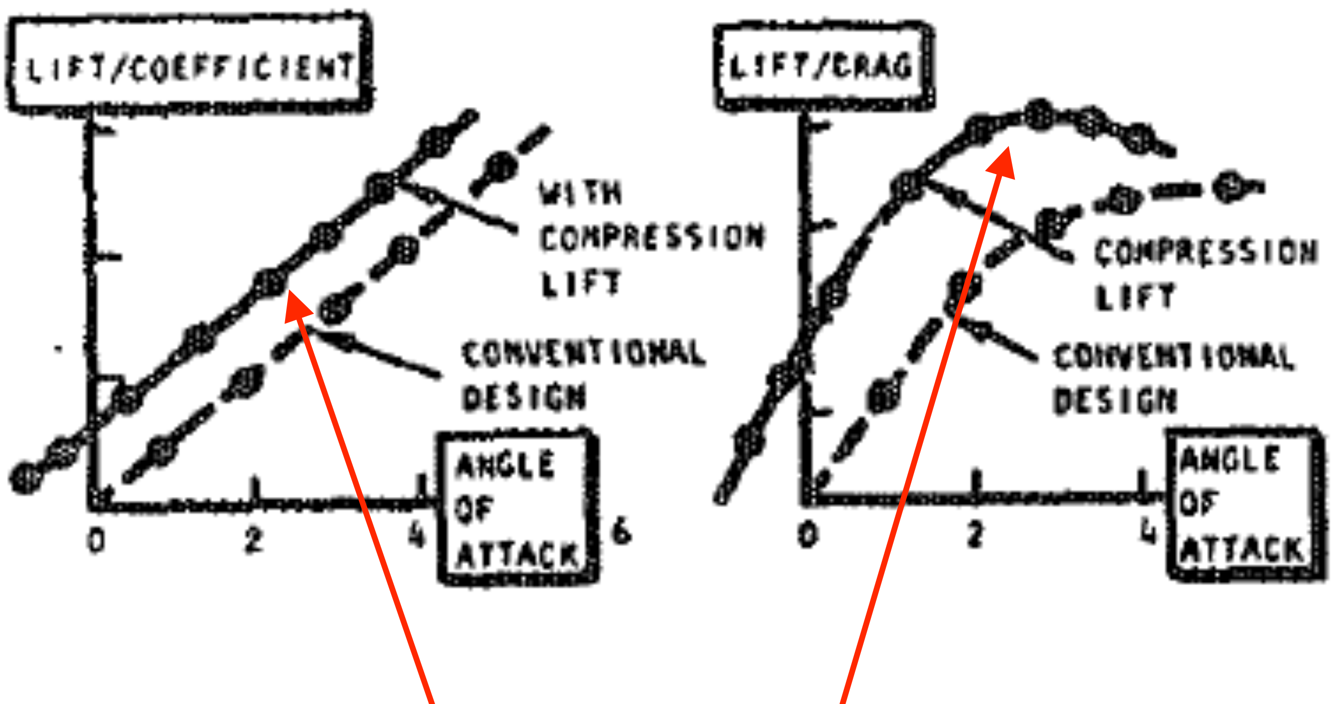
Consider a plan view. The wing extends arbitrarily far beyond the body shock in this view. Now the body can impart downward momentum to the air in the region between it's surface and it's shock wave. The wing, therefore, should extend out at least as far as the shock wave in order to preserve this momentum.




Finally, lateral momentum should be converted into downward momentum. This could be accomplished, without significantly increasing forward momentum, by deflecting the wing tips downward about hinge lines as shown on the left.

# Effects of Compression Lift on the Lift Coefficient and L/D Ratio




Shift in the lift curve up and to the left. This has the effect of moving $(L/D)_{max}$ to a lower angle of attack and increasing the maximum value.

# Aerodynamic Analysis-CG Movement

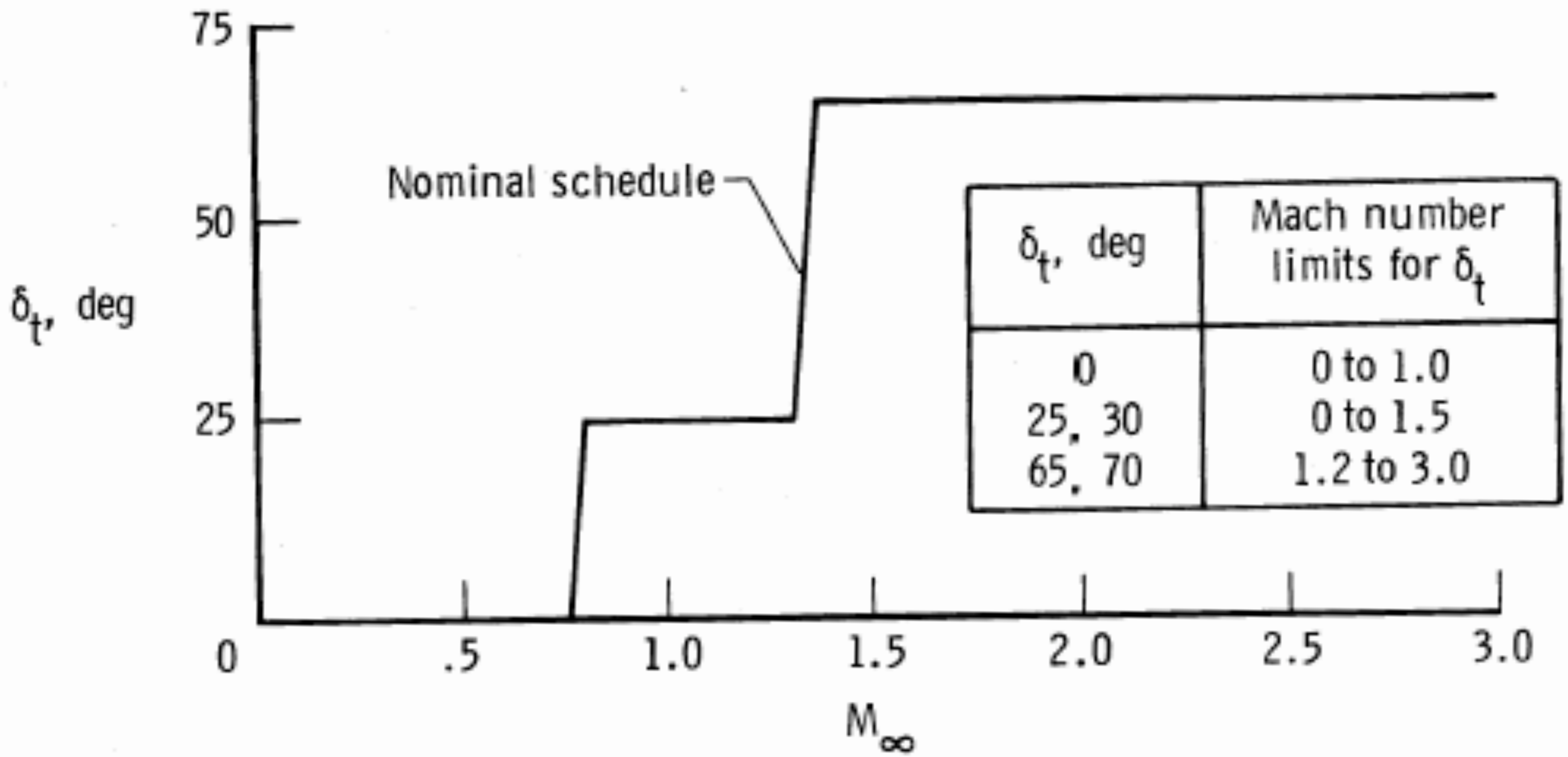



Figure 3.- Nominal folding schedule and operating limits for wingtip positions.

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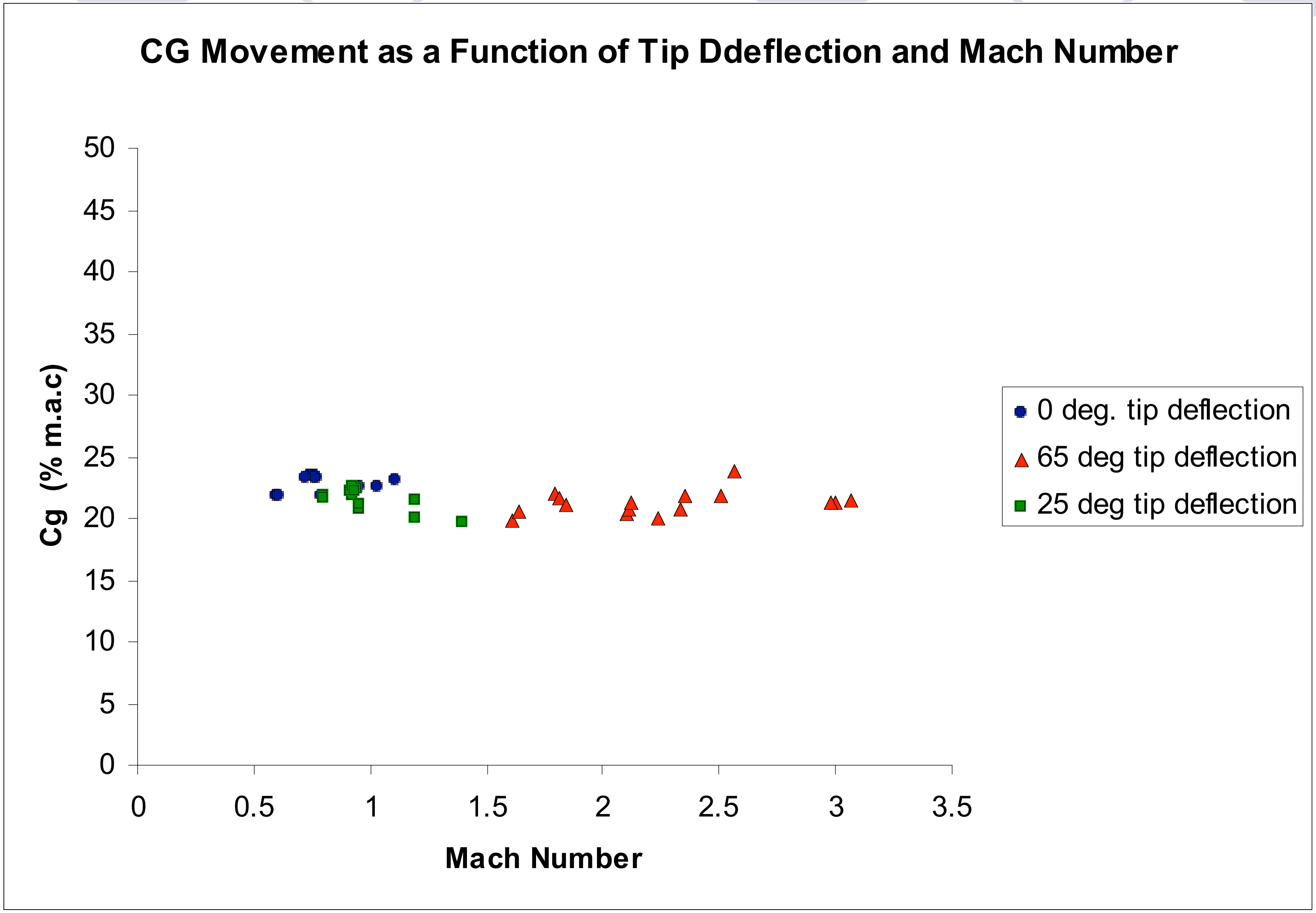

# Final Remarks

- Largest experimental aircraft in history
- Was able to complete the mission of sustained M>3 flight at an altitude greater than 70,000 ft
- Project cancelled due to budgetary constraints. 1.5 billion for two aircraft = 750 million each
- Use of new materials and technologies previously unseen

# Citations


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- Aircraft configurations developing high lift-drag ratios at high supersonic speeds **Eggers**, A J , **Jr**; Syverton, Clarence A
- ROSS, J. W.ROGERSON, D. B. (Rockwell International Corp., El Segundo, CA) AIAA-1983-1048
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Bill Mason (summer before coming to Tech)
Circa June 7, 1966
Questions?
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U.S. AIR FORCE