Experimental Aerodynamics

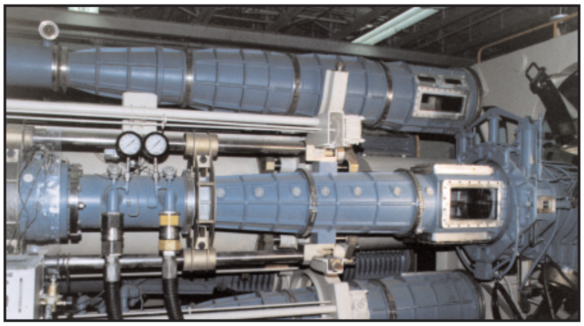
Experimental aerodynamics capabilities at Sandia National Laboratories are unique among the Department of Energy (DOE) national laboratories and critical to DOE's nuclear weapons program. Since the 1950s, Sandia's aerospace and aeronautical engineers have provided critical data for the design and analysis of flight vehicles such as the B61, the B83, and exploratory reentry systems.

Force and pressure data at Mach numbers from 0.5 to 14 are obtained in blow-down, medium-scale wind tunnels. The aerodynamics facilities include a High-Altitude Chamber (HAC) for low-pressure experiments for exo-atmospheric systems such as satellites and reentry vehicles.

Sandia aerodynamics specialists integrate the results from experiments, analysis, and simulation to solve complex aerodynamics problems of national interest. Sandia's aerodynamic facilities support the enduring stockpile and advanced flight system designs, as well as Department of Defense projects such as PRISM (U.S. Air Force) and STARS (U.S. Army). These state-of-the-art facilities and capabilities include:

- **Trisonic Wind Tunnel (TWT) Facility**
  - Mach 0.5 - 1.3, 1.5, 2, 2.5, and 3 flow-fields
  - Porous and solid wall test sections, 12-inch-square
  - Model scales from 6 to 10 percent (gravity bombs and missiles)
  - Reynolds numbers from 4 to 17 million per foot

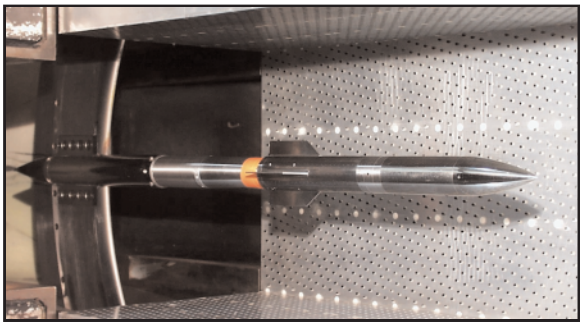
- **Hypersonic Wind Tunnel (HWT) Facility**
  - Mach 5 (air), 8 (N_2), and 14 (N_2)
  - Reynolds numbers from 0.4 to 8 million per foot
  - Model scales from 6 to 20 percent (missiles and reentry vehicle geometries)



HWT with discrete nozzle assemblies for Mach 5, 8, and 14 flows.

- **High-Altitude Chamber (HAC)**
  - Pressure altitudes to 220,000 feet (65 microns)
  - 27-foot-diameter sphere with five-foot access door
  - Centrifuge capability for spinning test articles
  - Explosive and pyrotechnic component testing
  - Ejection, inflation, and free-fall component testing

The Engineering Sciences Experimental Facility houses Sandia's experimental aerodynamics wind tunnels. The HAC is the third sphere (furthest to the right) of the vacuum system used for HWT operations.

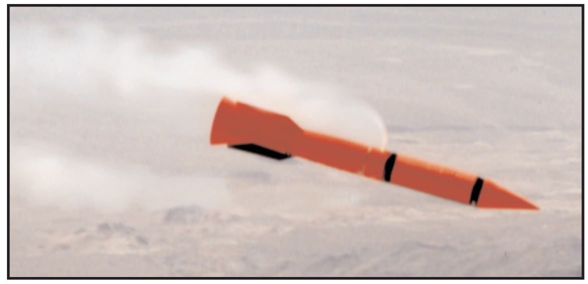


A model in the test section of the TWT.

- **Advanced Diagnostics for Flow Measurements**
  - Six-component strain-gage balances for force data
  - Surface pressure data in low-pressure flows
  - Oil, lampblack, and Xyglow surface flow imaging
  - Schlieren and shadowgraph imaging
  - Laser-based flow measurement diagnostics:
    - Laser Doppler velocimetry (LDV)
    - Particle imaging velocimetry (PIV)
    - Filtered Rayleigh scattering
    - Laser-induced fluorescence (LIF)

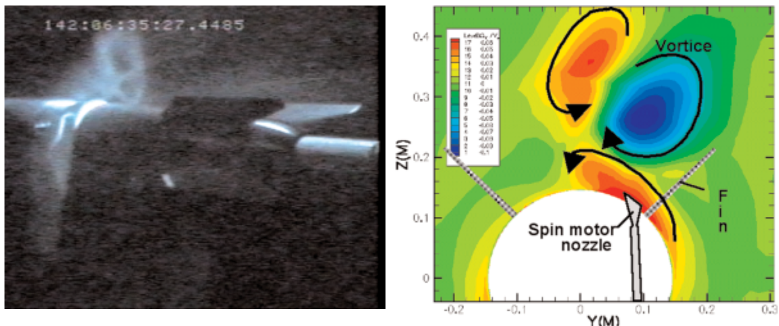
Successful Projects Include:

- **Plume Impingement Effects on Flight Vehicles**
  Model experiments in Sandia's TWT facility in conjunction with full-scale experiments provided detailed data for the B61 gravity bomb. The experiments investigated the effects of impingement of spin rocket plumes on fins and roll rate performance. These data were used with computer simulations of the flow-field to facilitate decisions for hardware and geometry changes to the B61 stockpile weapon.



The B61-11 in flight with spin rockets firing.

- **Validation of Computer Simulations of Aerodynamic Flow-Fields**
  Sandia is engaged in an extensive program to develop sophisticated computational tools to support system certification. Model validation through experimentation is critical for establishing confidence in computed results. The Sandia wind-tunnel facilities provide detailed data for validating compressible fluid mechanics codes. This effort is enhanced by experimental and computational teams working side-by-side.



Side-by-side comparison of observed and predicted vortex structures downstream of a spin jet on a wind tunnel model of the B61.

- **Evaluating Advanced and Exploratory Flight Vehicle Design**
  Sandia's wind tunnel facilities provide critical data for geometry trade-off studies for new flight systems such as Technology Demonstration 2 (TD2). These experiments are done efficiently, at low cost, and directly impact flight control system design. The TD2 flight vehicle, designed using wind tunnel data, successfully demonstrated precision strike capability.

Airbag configurations mounted in the High-Altitude Chamber for impact testing as part of Sandia's work for NASA and JPL for the Pathfinder surface landing missions on Mars.

- **Ground Testing for High-Altitude Vehicles**
  Sandia's HAC played a vital role in defining the airbag system used to cushion the Mars Lander for the successful Pathfinder mission to the Red Planet's surface. Airbag performance and geometry trade-off studies directly contributed to the NASA/JPL success. The HAC is critical to Sandia's mission; it is frequently used for low-pressure deployment of exo-atmospheric experiments, contributing to successful flight tests of space-based systems.

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