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# Test Facility Guide



**Arnold Engineering Development Complex**

Arnold AFB, Tenn. 37389
An Air Force Test Center Test Complex




**Arnold Engineering Development Complex**

# OVERVIEW

The Arnold Engineering Development Complex is part of the Air Force Test Center (AFTC). Headquartered at Arnold Air Force Base in Tennessee, the Complex also consists of geographically separated units - the Hypervelocity Wind Tunnel, Maryland; the National Full-Scale Aerodynamics Complex, California; 704th Test Group, Holloman AFB, Kirtland AFB and White Sands, New Mexico, Wright-Patterson AFB, Ohio; McKinley Climatic Laboratory, Eglin AFB, Florida; Hypersonic CTF, Edwards AFB, California.

## AEDC MISSION

Conduct developmental test and evaluation for the Nation through modeling, simulation, ground and flight test

## AEDC VISION

Be the nation's best value ground test and analysis source for aerospace and defense systems

**America's Aerospace Advantage**

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# DOING BUSINESS WITH AEDC

AEDC offers extensive test and evaluation capabilities, and our team is focused on providing the best possible data and a positive test experience for our customers. The AEDC test facilities can be used by government, private industry and academia.

The following steps summarize how typical test programs are planned and conducted at AEDC facilities:

1. The customer contacts one of the AEDC representatives listed below to inquire about our testing and evaluation services. Lead time to using AEDC facilities is primarily based on test complexity and can range from two weeks for less complex tests to 24 months for very complex ones.
2. AEDC provides an initial rough order of magnitude (ROM) cost estimate and schedule availability for customer inquiries.
3. If the estimated cost and schedule are acceptable to the customer, AEDC requires that a test request be submitted.
4. AEDC contacts the customer to determine schedule dates and set up the initial pretest meeting. The customer is required to provide AEDC advanced funding for initial project planning and estimating.
5. After the initial pretest meeting, the customer provides a detailed test plan containing the test objectives, scope, schedule, desired test program matrix, test article descriptions, instrumentation, data reduction and analysis requirements. AEDC prepares a statement of capability (SOC) or contract using this information, which will be the formal agreement between AEDC and the customer for test requirements scope, schedule, risks and costs.
6. Once the SOC or contract has been signed, the balance of test funding is required by AEDC to proceed.
7. AEDC Combined Test Force representatives will work closely with the test customer throughout the test planning phase to review and finalize the test plan, test matrix, and data reduction and analysis requirements and prepare the necessary documents to schedule test periods and configure all systems to support testing.
8. The AEDC Customer Service Representative (CSR) assists the customer with getting on-base using the visit authorization letter (VAL) process, accessing AEDC's computers, long distance access when at AEDC, and general AEDC/local area information. Customers are free to contact the CSR at any time with questions.
9. During the testing process, the customer is billed for actual charges and costs for facility operations.
10. Once the test has been completed, AEDC provides analyses and data products as detailed in the SOC or contract.

**For assistance or additional information about AEDC, visit our website: www.arnold.af.mil or contact the AEDC Public Affairs Office at *Arnold.AEDC.PA@us.af.mil* or call (931) 454-4204.**

# TEST OPERATIONS DIVISION

## Flight Systems Combined Test Force

The Flight Systems Combined Test Force at AEDC offers aerodynamic ground-test capabilities from very low subsonic speeds through Mach number 10 in various wind tunnels. These wind tunnels provide essential test and analysis services in support of DoD, national, U.S. industry and international aerospace programs. AEDC operates six active wind tunnels in two primary facilities, the Propulsion Wind Tunnel Facility (PWT) and the von Kármán Gas Dynamics Facility (VKF).

AEDC wind tunnels are used for testing and evaluation in areas including vehicle aerodynamic performance evaluation and validation, weapons integration, inlet/airframe integration, exhaust jet effects and reaction control systems, code validation, proof-of-concept, large- and full-scale component research and development, system integration, acoustics, thermal protection system evaluation, hypersonic flow physics, space launch vehicles, operational propulsion systems and captive flight.

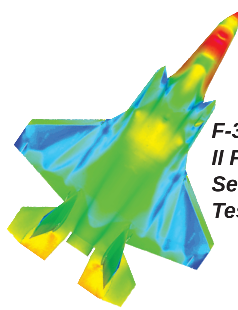
An extensive inventory of instrumentation is available for testing use, including force and moment balances, heat-transfer gauges and electronically scanned pressure modules. AEDC can provide design, fabrication, and calibration services for force and moment balances. AEDC is experienced with other wind tunnel test instrumentation such as model attitude measurement devices, heat-transfer gauges, dynamic pressure transducers, and several flow visualization techniques including pressure-sensitive paint (PSP). In addition, customers can choose to have AEDC design and fabricate their wind tunnel test models to best meet program requirements.

### Propulsion Wind Tunnel Facility

The Propulsion Wind Tunnel 16T and 16S provides flight vehicle developers with the aerodynamic, propulsion integration, and weapons integration test capabilities needed for accurate prediction of system performance. Large-scale models can be accommodated in the 16-ft square by 40-ft long test section and can be tested at Mach numbers from 0.05 to 1.60 for 16T and 1.60 to 4.75 for 16S. Air-breathing engine and rocket testing can also be performed in Tunnel16T using a scavenging system to remove exhaust from the flow stream.

AEDC's 4-ft transonic wind tunnel (4T) is a versatile, continuous-flow, mid-size test facility that can be used for a variety of aerodynamic test needs. Used primarily in conducting

*Blended-Wing-Body Concept Model*



*F-35 Lightning II Pressure-Sensitive Paint Test Results*

*F-35 Lightning II Store Separation*

**Wind Tunnel Test Facility Capabilities**

| Tunnel | Test Section Size: Cross Section (ft) | Test Section Size: Length* (ft) | Speed Range (Mach No.) | Reynolds No. Range (million per ft) | Dynamic Pressure (psf) | Total Pressure | Total Temperature (º F) | Pressure Altitude (nominal, K ft) |
|---|---|---|---|---|---|---|---|---|
| Propulsion Wind Tunnel 16T | 16 x 16 | 40 | 0.05 - 1.6 | 0.03 - 7.2 | 0.35 - 1161 | 200 - 3950 (psf) | 80 - 140 | Sea Level - 86 |
| Propulsion Wind Tunnel 16S | 16 x 16 | 40 | 1.5 - 4.75 | 0.1 - 2.4 | 25 - 564 | 200 - 1900 (psf) | 120 - 580 | 43 - 154 |
| Aerodynamic Wind Tunnel 4T | 4 x 4 | 12.5 | 0.05 - 2.46 | 0.02 - 7.1 | 0.17 - 1465 | 100 - 3400 (psf) | 80 - 140 | Sea Level - 115 |
| Supersonic Wind Tunnel A | 3.3 x 3.3 | 9 | 1.5 - 5.5 | 0.3 - 8.5 | 50 - 1750 | 3 - 195 (psi) | 90 - 280 | 17 - 152 |
| Hypersonic Wind Tunnel B | 4.17 diam | 9 | 6 or 8 | 0.40 - 5.2 | 66 - 620 | 40 - 900 (psi) | 290 - 890 | 100 - 162 |
| Hypersonic Wind Tunnel C | 4.17 diam | 9 | 10 | 0.3 - 3.0 | 48 - 475 | 200 - 2000 (psi) | 1220 - 1700 | 130 - 180 |
| High Re. No. Wind Tunnel C | 2.08 diam free jet | 3 | 8 | 0.5 - 7.9 | 132 - 1256 | 200 - 1900 (psi) | 760 - 1440 | 97 - 147 |
| Aerothermal Wind Tunnel C | 2.08 diam free jet | 3 | 4 | 0.3 - 7.1 | 212 - 2018 | 20 - 190 (psi) | 290 - 1440 | 56 - 106 |

* Nominal test section length dimensions are shown. The actual model lengths that can be tested depend on Mach number and should be coordinated with the AEDC test engineering staff.

***Fully-Resuable Access to Space Technology Proof-of-Concept Launch Vehicle in Tunnel A***

small-scale aerodynamic and store separation testing, the tunnel has a 4- by 4- by 12.5-ft test section. The transonic designation indicates its primary use for testing at near-sonic airspeeds; however, its Mach number capability extends from 0.05 to 2.46. Tunnel 4T can simulate altitudes from sea level to 115,000 ft and provide Reynolds numbers up to approximately 7.1 million/ft.

### von Kármán Gas Dyanamics Facility

The von Kármán Gas Dynamics Facility (VKF) is comprised of a supersonic wind tunnel (Tunnel A) and two hypersonic wind tunnels (Tunnels B and C). These tunnels provide high-quality flow in the Mach number 1.5 to 10 flight regime and operate as variable-density, continuous-flow units. Tunnels A, B, and C offer large test sections (40 to 50 in.) for aerodynamic testing and have unique operating capabilities.

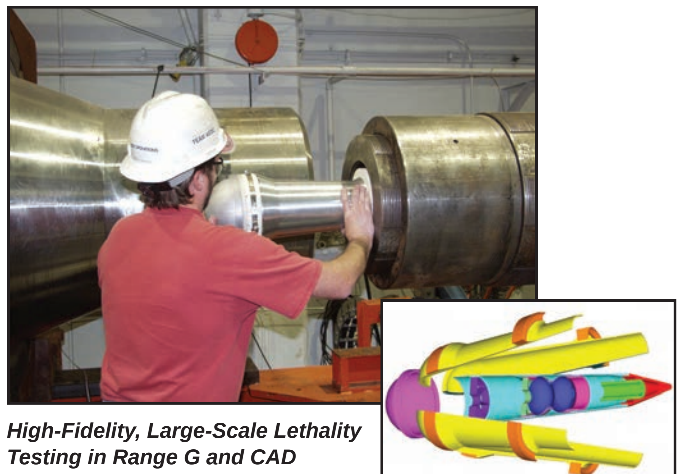
# Space and Missiles Combined Test Force

The Space and Missiles Combined Test Force at AEDC is responsible for ground testing space and missile weapon systems. The CTF provides lethality, rocket propulsion, aerothermal, supersonic, hypersonic, and space test and evaluation services. The Complex coordinates testing and evaluation in 19 facilities that support the development of tactical missile interceptors, ballistic missiles, launch vehicles, reentry materials, hypersonic air vehicles, space sensors, and satellite systems. Additionally, the Space and Missiles CTF is chartered with collecting and maintaining the nation's largest archive of missile and rocket hard-body and plume signature data in the Advanced Missile Signature Center (AMSC).

Space testing capabilities include evaluating infrared and visible sensor performance, mission simulation and other hardware-in-the-loop activities. AEDC performs testing for space systems in a thermal/vacuum environment from component level to full-scale, flight-qualified systems. For component scale hardware, testing to simulate full spectrum space environments is available and includes contamination, solar, atomic oxygen, outgassing, radiation and other effects. For combined effects of natural conditions, self-induced hazards, and hostile threats on full-scale systems or subsystems; the Space Threat Assessment Testbed (STAT) can provide analysis leading to the development of operational Tactics, Techniques, and Procedures (TTPs) for satellite systems.

### Ballistic Ranges G, I, S1 and S3

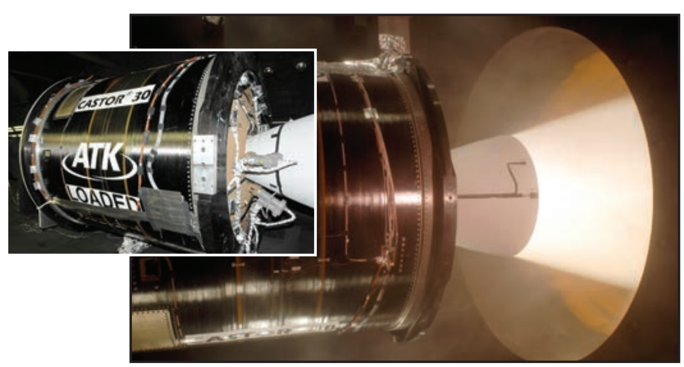
Hypervelocity Ballistic Range G is used to conduct kinetic energy lethality and impact phenomenology tests. The Range G launcher is the largest two-stage, light-gas gun system in the United States that provides unequalled "soft launch" (minimized acceleration loading) capability to launch extremely high-fidelity missile simulations at hypervelocity speeds. Quarter-scale testing is available at velocities from 4,900 to 23,000 ft/sec (1.5- to 7-km/sec). Recent improvements have extended the range of capabilities to projectiles near half scale of actual interceptors.



***High-Fidelity, Large-Scale Lethality Testing in Range G and CAD Drawing of the Model***

### Rocket Development Test Cell J-6

The J-6 Facility provides ground-test simulations for solid-propellant rocket motors. J-6 has been used mainly for aging and surveillance and in testing of stages II and III for both Minuteman and Peacekeeper ICBMs. Additionally, J-6 has supported ORBUS and CASTOR® 30 as well as




***ATK's CASTOR® 30 was Ground Tested in J-6.***

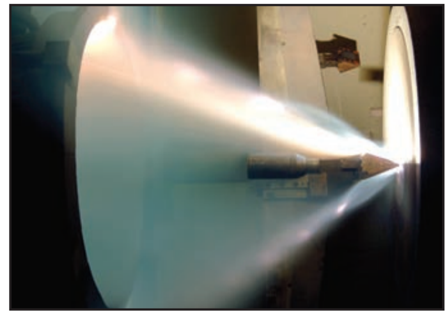
STAR37 motor qualification testing for the Air Force's Global Positioning Satellite (GPS) constellation. AEDC has unique test capabilities for testing rocket propulsion systems with high-performance/high-area-ratio nozzles and those requiring altitude start and restart, stage separation and spin testing.

The J-6 digital data acquisition system is designed to acquire up to 500,000 samples/sec. Testing can also include an extensive array of sophisticated rocket diagnostic instruments obtainable only in a ground-test configuration. State-of-the-art techniques such as wide-band infrared and ultraviolet radiometric coverage, emission/absorption detection, laser-induced fluorescence, plume surveys and real-time radiography are applications available for use in J-6 testing.

## Arc Heaters H1, H2 and H3

The AEDC arc heater facility is used to provide high-enthalpy test environments to test materials and other means of thermal protection. The AEDC arc-heated test facilities include two high-pressure, segmented arc heaters (H1 and H3) and one Huels arc heater (H2). Both types utilize an arc discharge to heat air to temperatures up to 13,000ºR. The combination of high-enthalpy test gas and high plenum pressure makes possible heat flux simulations representative of flight at speeds in excess of Mach 20 at high dynamic pressures.

*Materials Test for the NASA Orion Crew Exploration Vehicle*



**Space and Missiles Test Facility Capabilities**

| Lethality | Facility | Projectile Size (in. diam) | Launch Velocity (ft/sec) | Projectile Mass (lbs) | Pressure Altitude (ft) | Run Time (shot/day) |
|---|---|---|---|---|---|---|
| Ballistic Ranges - | Range G | 3.3 | 4900 - 22,700 | 1.0 - 13.2 | Sea Level - 225,000 | 1 |
| Hypervelocity and | Range G | 4.0 | 4900 - 19,700 | 1.0 - 13.2 | Sea Level - 225,000 | 1 |
| Impact/Lethality | Range G | 8.0 | 5600 - 17,100 | 13.2 - 44.1 | Sea Level - 225,000 | 1 |
| Erosion | Range I | 2.5 | 4900 - 22,100 | 0.7 - 8.8 | Sea Level - 225,000 | 1 |
| | Range S1 | 0.3 - 0.75 | 4900 - 26,200 | 0.018 - 0.820 (oz) | Sea Level - 300,000 | 2 |
| | Range S3 | 7.0 | 131 - 2300 | 3.3 - 55.1 | Sea Level | 2 |

| Rocket Propulsion | Facility | Test Section Size | Thrust Stand (lb) | Pressure Altitude (ft) | Cell Temp Control (ºF) | Run Time (min) |
|---|---|---|---|---|---|---|
| Solid Propellant | Cell J-6 | 26 ft diam x 62 ft long | 5000 - 500,000 | up to 100,000 | 15 - 110 | 1 - 6 min |
| Liquid Propellant | Cell J-4† | 48 ft diam x 82 ft high | 5000 - 500,000 | up to 100,000 | | 5 min |

| **Aerothermal** | **Facility** | **Nozzle Exit (in.)** | **Mach No.** | **Stagnation Enthalpy (Btu/lbm)** | **Pressure Atmos** | **Mass flow (lbm/sec)** | **Run Time (min)** |
|---|---|---|---|---|---|---|---|
| High Enthalpy | H1 | 0.75 - 3.0 | 1.8 - 3.5 | 600 - 8500 | <120 | 0.5 - 8 | 1 - 2 |
| Ablations | H2 | 5.0 - 42.0 | 3.4 - 8.3 | 1200 - 5500 | <120 | 2 - 10 | 3 - 30 |
| Erosion | H3 | 1.2 - 4.5 | 1.8 - 3.5 | 600 - 8500 | <150 | 3 - 25 | 1 - 2 |
| | Tunnel 9* | 11.3 | 6.7 | 900 - 925 | 52 - 67 | 18 - 37 | 3 - 6 |
| | Tunnel C* | 25 | 4, 8 | 170 - 480 | 1 - 130 | 0.6 - 55 | Continuous |

| Space Sensor | Facility | Environmental Conditions | Run Time | Image Sources |
|---|---|---|---|---|
| Sensor Calibration | 7V | sensor: ambient - 15K, $10^{-7}$ torr | Continuous | 2 Independently Moving Precision Blackbody Targets - 500 K |
| Characterization | | background: 15K, $10^{-7}$ torr | | Dynamic Complex Scenes - IR Arrays, 512 x 512, 45 Hz, 1◦ x 1◦ FOV |
| 3-Color Sensor HWIL | 10V | 15K, $10^{-7}$ torr | Continuous | 2 Independently Moving Precision Blackbody Targets - 800 K<br>2 IR Arrays, 512 x 512, 45 Hz; 1 Visible Array, 1024 x 1024, 45 Hz<br>Closed-loop HWIL |

| Space Environments | Facility | Test Section Size | Wall T, Altitude P | Environmental Capabilities |
|---|---|---|---|---|
| Combined Space | STAT | fits 2.5 ft x 2.5 ft x 2.5 ft test article | 80 K, $10^{-6}$ torr P | Combined effects of natural/self-induced/ man-made threat sources:<br>Natural - Protons [30-150 KeV, $10^2$ to $10^8$ p+/cm$^2$/sec]**<br>Electrons [20-100 KeV, $5x10^2$ to $5x10^8$ e-/cm$^2$/sec]**<br>Solar [120-2500 nm photons at 1 sun (±20%)]<br>Atomic oxygen [5 eV, $1x10^{10}$ to $2x10^{12}$ 0/cm$^2$/sec]**<br>Self-induced - thruster ions, material outgassing, spacecraft charging |
| Combined Space | CCOSE | fits 2" diam x 1/2" thick test article | ambient T, $10^{-6}$ torr P | electrons, protons, ions, atomic oxygen, 120-2500 nm solar |
| X-ray Environment | MBS | 2.5 ft diam target area | ambient T, $10^{-6}$ torr P | Cold (5 KeV) or Hot (1-2 MeV) X-Ray |
| Electric Propulsion (<50kW) | 12V | 12 ft diam x 35 ft tall | 15K, $10^{-7}$ torr P | $10^6$ torr L/sec Xenon pumping capacity |

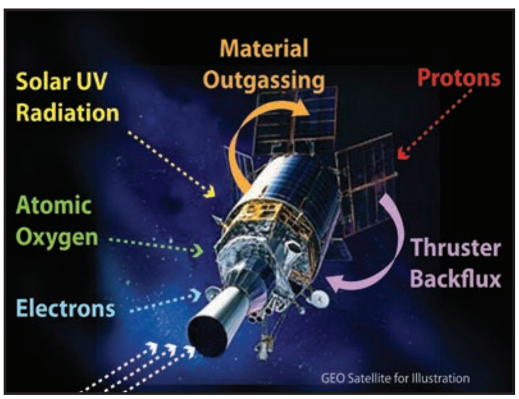
| Signature Measurement | Facility | Spectral Bands (µm) | Equipment | Calibration |
|---|---|---|---|---|
| AMSC | Rapid Deployment Team | 0.250-12 | 10 Radiometers, ~20 Imagers, 4 spectrometers, 4 Tracking Mounts | NIST Traceable Engineering Units |

† Inactive
* See Flight Systems section for additional information.
** Higher fluxes available with smaller test volumes

## Space Environmental Chambers

The AEDC 7V (7-ft diam by 21-ft long) and 10V (10-ft diam by 30-ft long) sensor chambers are part of a state-of-the-art space environment simulation test facility designed to test interceptors and surveillance sensors. These chambers are configured to provide complete characterization and radiometric calibration of visible and infrared (IR) sensors. This includes all categories of sensor characterization (flood, point, polarized source, spectral calibration and mission simulation).

*10V Sensor Test Chamber*



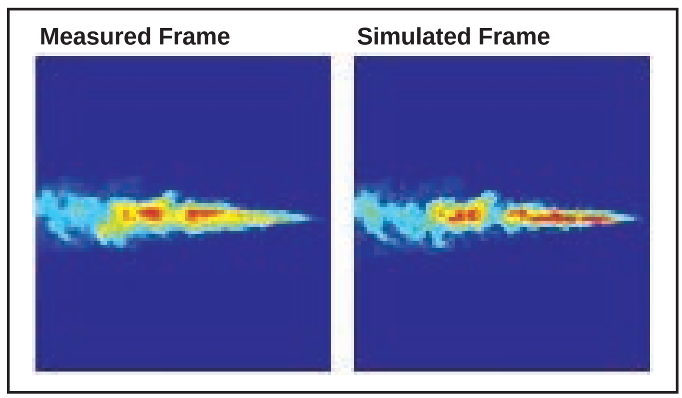

*Spacecraft Environment for STAT*

The 12V Chamber is a 12-ft-diam by 35-ft-high hermal vacuum test facility. The facility has its own nitrogen thermal shroud and an optional gaseous helium liner that can be cooled to 10° K.

The Space Threat Assessment Testbed (STAT) can evaluate space systems and subsystems in natural environments subjected to hazards and threats while simulating various orbits. The STAT chamber is contained in a class 10,000 clean room. STAT delivers a combined research and development test environment approach for simulating a mission environment with natural space sources (solar, proton, electron, atomic oxygen), self-induced hazard sources (ions to simulate electric thrusters, outgassing, spacecraft charging) and man-made threat sources.

## Advanced Missile Signature Center

The Advanced Missile Signature Center (AMSC) is a national facility supporting the Missile Defense Agency (MDA), Defense Intelligence Agencies (DIA) and other DoD programs with analysis, modeling, measurement, archival and distribution services. The AMSC archives include target, threat and battlespace environment signatures for missiles and other vehicles.




*Measured and Simulated Tactical Missile Plumes*

# Propulsion Combined Test Force

The Propulsion Combined Test Force at AEDC is responsible for propulsion testing in the Engine Test Facility (ETF) test cells, which are used for development and evaluation testing of turbine-based propulsion systems for advanced aircraft. These test cells provide essential test and evaluation services in support of DoD, U.S. industry, and international programs. AEDC operates 11 active test cells for atmospheric inlet and altitude testing.

These AEDC test cells are used for testing and evaluation in areas including performance, operability, aeromechanical, icing, corrosion, inlet pressure distortion, inlet temperature distortion, accelerated mission testing (AMT), engine-inlet dynamics, mission simulations, and engine component testing. Test cells are available in a range of sizes to meet customer needs.

The ETF contains instrumentation and controls infrastructure to acquire measurements from an extensive variety of instrumentation used in turbine engine testing. The various sensors available can support the requirements of both production and development engines. Measurement capabilities include force, fuel flows, airflows, high-frequency-response pressures, displacement, acceleration, digitally-scanned temperatures, digitally-scanned pressures and high-speed digital video. Measurement capabilities in the various test cells range from 600 channels to over 3,000, with parameter recording options from 1 sample per second up to 156,250 samples per second. AEDC can provide exacting calibration services for force, fuel flow, and pressure measurements. Spectral structural analysis equipment provides real-time engine component health monitoring in conjunction with steady-state and transient data. Our systems can be modified to accommodate the customer's digital or analog systems.

## Test Cells C-1 and C-2

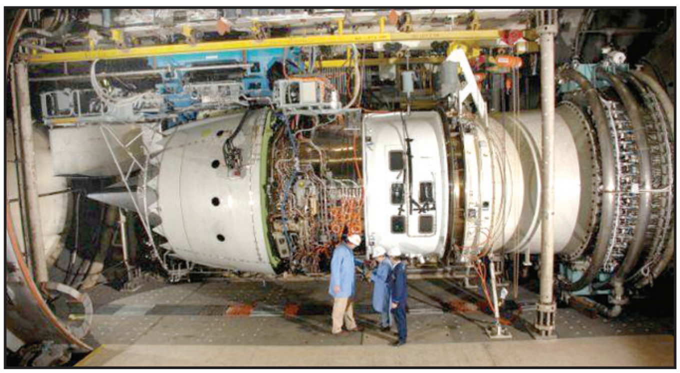
Altitude Test Cells C-1 and C-2 comprise the Aeropropulsion Systems Test Facility (ASTF). This is a unique national asset designed to test large military and commercial engines in true mission environments. ASTF is part of the Engine Test Facility and has helped establish AEDC as the USAF center of expertise in turbine engine testing. Each cell is capable of testing up to Mach 2.3 and simulating altitudes of up to 75,000 ft. Either cell can provide engine inlet temperatures of up to 350º F.

C-1 is normally used to conduct performance testing of large augmented turbine engines. C-2 can also be used to test large augmented turbine engines, but it has recently been used for performance testing of large turbofan engines. Aeromechanical testing, vectored-thrust testing, icing testing and inlet pressure distortion testing may also be accomplished in ASTF.

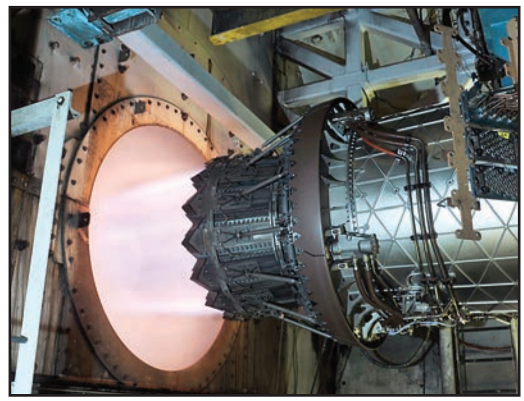
In recent years, C-1 has principally tested F119 engines for the F-22A aircraft and F135 engines for the F-35 aircraft. C-2 has tested various large turbofan engines such as the Trent 900 and GP7200 for the Airbus A380, the PW6000 for the Airbus A318, the Trent 1000 for the Boeing 787, the XF7-10 for the Japanese P-1 and the BR725 for the Gulfstream G650.

## Test Cells J-1 and J-2

Test Cells J-1 and J-2 are altitude test cells sized for medium and large turbine engine testing. The cells are similar in capability to cells C-1 and C-2, but smaller in size. The cells are each approximately 44 ft in length, but J-1 is 16 ft in diameter while J-2 has a diameter of 20 ft. Both J-1 and J-2 are capable of simulating altitudes up to 75,000 ft and testing up to Mach 3.2 and Mach 2.6, respectively. J-1 and J-2 can provide engine inlet temperatures of up to 450ºF; however, J-1 can attain 720ºF with facility modifications.



***The Rolls-Royce Trent 1000 Engine for the Boeing 787 Installed in C-2***



***The F135 Engine for the F-35 being Tested in Test Cell J-2***

**Engine Test Facility Capabilities**

| Propulsion Development Test Cell | Test Section Size: Cross Section | Test Section Size: Length (ft) | Nominal Capability Range: Speed Range | Total Temperature (ºF) | Pressure Altitude (Nominal, ft) | Axial Thrust Capacity (lb) |
|---|---|---|---|---|---|---|
| Test Cell C-1 | 28 diam (ft) | 45 | Mach 0 - 2.3 | -60 - 350 | Sea Level - 75,000 | 100,000 |
| Test Cell C-2 | 28 diam (ft) | 47 | Mach 0 - 2.3 | -60 - 350 | Sea Level - 75,000 | 100,000 |
| Test Cell J-1 | 16 diam (ft) | 44 | Mach 0 - 3.2 | -60 - 720 | Sea Level - 75,000 | 70,000 |
| Test Cell J-2 | 20 diam (ft) | 46 | Mach 0 - 2.6 | -60 -450 | Sea Level - 75,000 | 50,000 |
| Test Cell SL-2 | 24 x 24 (ft) | 60 | Mach 0 - 1.4 | -15 - 260 | Sea Level | 70,000 |
| Test Cell SL-3 | 24 x 24 (ft) | 60 | Mach 0 - 1.4 | -15 - 260 | Sea Level | 70,000 |
| Test Cell T-3 | 12 diam (ft) | 15 | Mach 0 - 3.6 | -80 - 1,000 | Sea Level - 100,000 | 20,000 |
| Test Cell T-11 | 10 x 10 (ft) | 17 | Mach 0 - 2.0 | -80 - 250 | Sea Level - 65,000 | 10,000 |
| | | | | (ºR) | | On-Condition Run Time (sec) |
| APTU / Supersonic | 42 diam (in) | | Mach 3.1 | 1460 max | 21,000 - 54,000 | 120 max |
| | 42 diam (in) | | Mach 4.3 | 2300 max | 63,700 - 88,400 | 240 max |
| APTU / Hypersonic | 42 diam (in) | | Mach 5.2 | 2650 max | 54,500 - 96,400 | 120 max |
| | 42 diam (in) | | Mach 6.3 | 3233 max | 76,000 - 105,000 | 90 max |
| | 42 diam (in) | | Mach 7.2 | 4700 max | 88,000 - 110,000 | 60 max |

**NOTE 1: Expanded capability is available with custom upgrades to test cells.**
**NOTE 2: Maximum performance values (temperature, speed and altitude) do not occur simultaneously. Comparison of specific test points to cell capability will be required to ascertain feasibility.**

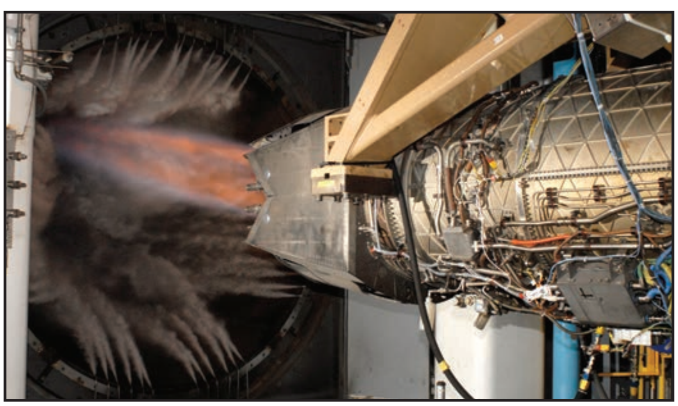
In recent years, J-1 has tested the F100 for the F-15 and F-16; the F110 for the F-16; the F118 for the B-2 and U-2; the F101 for the B-1B; and performed core testing on the Advanced Turbine Engine Gas Generator (ATEGG). J-2 has also tested the F110, F118 and F101 engines, as well as the F119 engine for the F-22A and the F135 and F136 engines for the F-35.

## Sea Level Test Cells SL-2 and SL-3

Sea-Level Test Cells, SL-2 and SL-3 provide the capability to economically conduct durability testing on large augmented turbine engines at near-sea-level conditions (1000 ft altitude) by eliminating the cost of running inlet and exhaust plant machinery. In addition to running ambient pressure inlet conditions, they also provide the capability of using the ETF plant to run ram conditions (inlet pressures above ambient), allowing testing at up to Mach 1.4 when necessary to achieve test objectives. Inlet temperature capability extends from ambient to 120ºF when running in the atmospheric inlet mode and from -15 to 260ºF in RAM mode. Both cells can accommodate engines that produce up to 70,000 lb of thrust.

These sea-level cells are normally used for Accelerated Mission Testing (AMT). These tests evaluate engine durability and performance retention by repeatedly simulating the types of missions the engine will fly in service. The RAM capability allows interspersed testing of atmospheric inlet and RAM AMT during a single test program and eliminates the expense of engine removal and installation into another facility. Additionally, SL-3 is equipped to perform specialized testing such as corrosion testing.

In recent years, SL-2 has tested the F100 engine for the F-15 and F-16 and the F119 engine for the F-22A. SL-3 has also tested the F100 engine, as well as the F135 engine for the F-35.



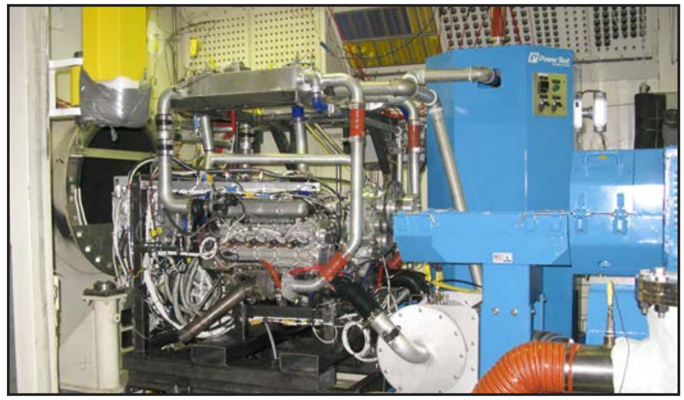
*The F119 Engine for the F-22A Raptor being Tested in SL-2*

## Test Cells T-3 and T11

Altitude Test Cells T-3 and T-11 are diverse test cells with multiple test applications for testing small and combustion, turbine, and cruise missile engines. Their sizes and capabilities are varied to accommodate a range of test articles.

These cells are used for a variety of types of testing. T-3 is used for high Mach number turbine engine and cruise missile engine testing; T-11 is typically used for small turbine and combustion engine testing. These cells are not in continuous use at AEDC. Some activation time may be required prior to use.

In recent years, T-3 has performed combustor rig testing for Westinghouse and supersonic flight conditions for advanced engine designs. T-11 has tested a variant of diesel combustion engines for military and commercial aviation applications.



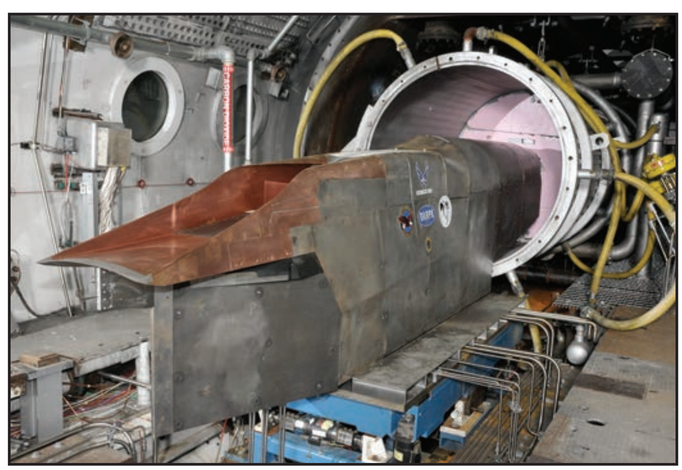
*The Engineered Propulsion Systems Inc. Vision 350 Heavy Fuel Engine Installation in T-11*

## Aerodynamic and Propulsion Test Unit

The Aerodynamic and Propulsion Test Unit (APTU) is a blow-down, true temperature and pressure test facility designed for testing the performance, operability, and durability of supersonic and hypersonic missile scale flight system hardware including propulsion systems and materials. APTU can test in either freejet or direct connect configurations.

The test environment at APTU is supplied by the Combustion Air Heater (CAH). The CAH, installed in 2004, burns isobutane fuel in a flow of high pressure air and oxygen to provide a test medium with an oxygen mole content equivalent to air.

The APTU data system can collect over 600 channels of pressure, temperature, and voltage data from user tests. High pressure water at flow rates greater than 300 lbm/sec (136 kg/sec) at pressures as high as 2000 psia (136 atm) is available.



*DARPA FaCET Test Article Installation*

# Hypervelocity Wind Tunnel 9 Combined Test Force

Hypervelocity Wind Tunnel 9 Combined Test Force an AEDC site located at White Oak, Maryland near Silver Spring, provides aerodynamic simulation critical to the development of hypersonic systems and hypersonic vehicle technologies.

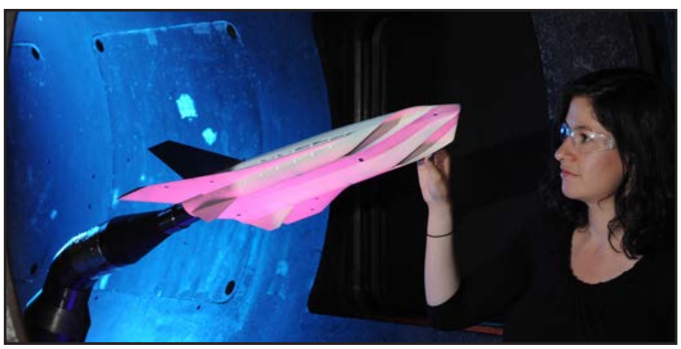
The facility supports testing for Air Force, Navy, Army, Missile Defense Agency and NASA programs, as well as advanced hypersonic technologies such as wave-rider-type vehicles, scramjets inlets and transatmospheric space planes.

Tunnel 9 is the primary high Mach number and high Reynolds number facility for hypersonic ground testing and the validation of computational simulations for the Air Force and DoD. Noteworthy advantages of Tunnel 9 over other facilities include a unique storage heater with pressures up to 1,900 atm and temperatures up to 3,650ºR. Axisymmetric contoured nozzles for Mach 6.7, 8, 10 and 14 operation are also available.

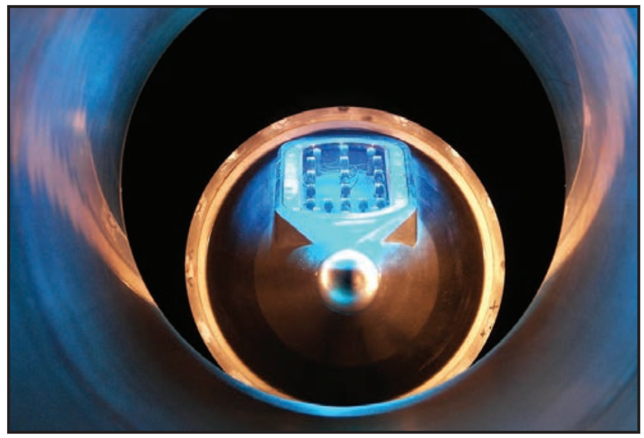
When compared to other hypervelocity facilities, which have run times of a few milliseconds, the long test times available in Tunnel 9, typically on the order of 1 sec (up to 15 sec), provide higher productivity by allowing for parametric variation such as an angle-of-attack sweep or flow survey during a single run. The 5-ft-diam (1.5 m) test cell accommodates large-scale heavily instrumented test articles.

The combination of operational range, long test times and a large test cell makes Tunnel 9 the highest Reynolds number, largest scale ground-test facility in the world, capable of simultaneously collecting continuous pitch-polar static force and moment, pressure and heat-transfer data during each run. Having the capability to test at flight-matched Reynolds numbers provides a significant risk reduction for the design and evaluation of hypersonic systems.

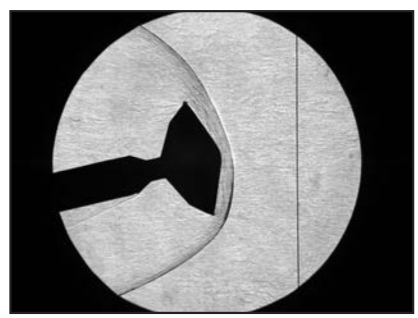
Tunnel 9 provides a useful and cost-effective environment for research and development test and evaluation (RDT&E) as well as for investigating the complex physics associated with hypersonic science and technology (S&T). Past testing includes aerodynamic, aerothermal, seeker window thermal-structural and aero-optic, shroud removal, hypersonic inlet, fundamental flow physics and computational fluid dynamics (CFD) validation experiments.



*Air Force HiFEX testing*



*Terminal High Altitude Area Defense (THAAD) Seeker Aerothermal Test*



*Schlieren Photo of NASA Mars Science Laboratory test*

**Hypervelocity Wind Tunnel 9 Test Facility Capabilities**

| Tunnel | Test Section Size: Cross Section (ft) | Test Section Size: Length* (ft) | Speed Range (Mach No.) | Reynolds No. Range (million per ft) | Dynamic Pressure (psf) | Total Pressure | Total Temperature (º F) | Pressure Altitude (nominal, K ft) |
|---|---|---|---|---|---|---|---|---|
| Hypervelocity Wind Tunnel 9 (Hypersonic) | 2.9 diam free jet | 9 | 8 | 4 - 48 | 960 - 11,300 | 1000 - 12,500 (psi) | 1100 - 1200 | Sea Level - 65 |
| | 5 diam | 12 | 10 | 0.5 - 20 | 95 - 4000 | 300 - 14,000 (psi) | 1200 - 1350 | 39 - 111 |
| | 5 diam | 12 | 14 | 0.05 - 3.6 | 8 - 900 | 100 - 19,000 | 1750 - 2800 | 82 - 173 |
| Hypervelocity Wind Tunnel 9 (Aerothermal) | 11.3 (in) diam free jet | 6 | 6.7 | 4 - 7.6 | 3540 - 6850 | 2600 - 5500 | 2100 - 2900 | 52 - 67 |

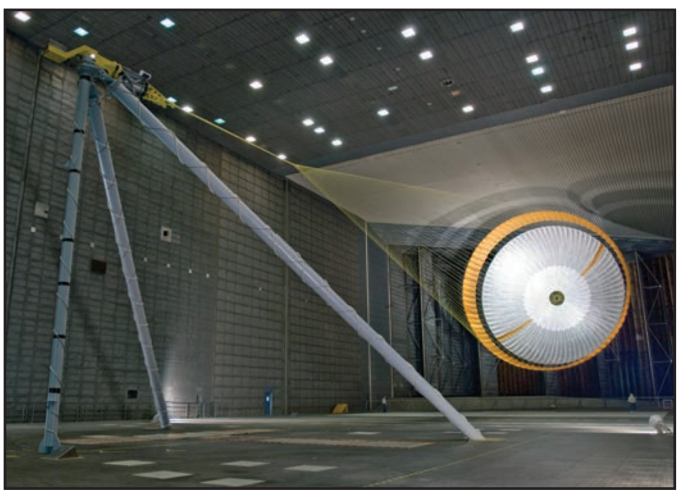
* Nominal test section length dimensions are shown. The actual model lengths that can be tested depend on Mach number and should be coordinated with the AEDC test engineering staff.

# National Full-Scale Aerodynamics Complex Combined Test Force

The National Full-Scale Aerodynamics Complex (NFAC) wind tunnel facility, located at Moffett Field, in Mountain View, California, is managed and operated by AEDC. This facility is composed of two large test sections and a common, six-fan drive system. A wide range of available support systems combine with this unique facility to allow the successful completion of aerodynamic experiments that cannot be achieved anywhere else. Additionally, each of the test sections is acoustically lined for acoustic testing.

The 40- by 80-ft wind tunnel circuit, originally constructed in the 1940s, is now capable of providing test velocities up to 300 knots and Reynolds numbers up to 3 million/ft. The 80- by 120-ft open-circuit leg was added and a new fan drive system was installed in the 1980s. The 80- by 120-ft test section is the world's largest wind tunnel and is capable of testing a full-size Boeing 737 at velocities up to 100 knots at nominal unit Reynolds numbers of 1.1 million/ft.

A system of moveable vanes can be positioned so that air is either drawn through the 80- by 120-ft test section and exhausted into the atmosphere, or driven around the closed circuit through the 40- by 80-ft test section. A passive air exchange system is utilized in the 40 by 80 circuit to keep air temperatures below 125ºF.



*JPL Mars Science Laboratory Parachute Testing*

The new fan drive system is composed of six variable-pitch fans, each 40 ft in diameter, arranged in two rows of three. Each fan has 15 laminated wood blades and is powered by a 22,500 hp electric motor. The six fans rotate together at 180 rpm drawing 106 MW of electricity at full power while moving more than 60 tons of air per second.

Unique test-specific requirements are explored with each customer to guide the experiment design, and new systems are integrated into the facility as needed. Utility support systems that have been used for testing powered vehicles and components include variable-frequency electrical power, hydraulic power units, cooling water, 150- and 400-Hz electrical power and jet fuel systems. Rotor test beds incorporating electric motors and rotor balance systems are available for testing complete rotor and hub systems independent of the flight vehicle.

*NASA/Army UH-60 Individual Blade Control Test on the Large Rotor Test Apparatus (LRTA)*

*Full-Scale F/A-18 Hornet at High Angle-of-Attack*

**National Full-Scale Aerodynamics Complex Capabilities**

| Tunnel | Test Section Size: Cross Section (ft) | Test Section Size: Length* (ft) | Speed Range (Mach No.) | Reynolds No. Range (million per ft) | Dynamic Pressure (psf) | Total Pressure | Total Temperature (º F) | Pressure Altitude (nominal, K ft) |
|---|---|---|---|---|---|---|---|---|
| National Full-Scale Aerodynamics Complex | 40 x 80<br>80 x 120 | 80<br>190 | 0 - 300 knots<br>0 - 100 knots | <3<br><1.1 | 0 - 262<br>0 - 34 | | | Sea Level<br>Sea Level |

* Nominal test section length dimensions are shown. The actual model lengths that can be tested depend on Mach number and should be coordinated with the AEDC test engineering staff.

# McKinley Climatic Laboratory

The McKinley Climatic Laboratory, an AEDC facility located at Eglin Air Force Base, Florida, has chambers where any climatic environment in the world can be simulated. The capabilities available at the Climatic Laboratory help engineers ensure maximum reliability and operational capability of complex systems as global operational theaters continue to impose harsh environments.

Tests at the facility for the Department of Defense, other government agencies and private industry have included items such as large aircraft, tanks, missile launchers, shelters, engines, automobiles and tire manufacturers.

The Climatic Laboratory has five testing chambers which include the Main Chamber; the Equipment Test Chamber; the Sun, Wind, Rain and Dust Chamber; the Salt Fog Chamber; and the Altitude Chamber.

The Main Chamber (MC) is the largest environmental chamber in the world. At approximately 252-ft wide, 260-ft deep and 70-ft high, tests have consisted of large items and systems for aircraft such as the B-2 Bomber and the C-5 Galaxy. The temperatures achieved in the chamber range between -65 ºF to 165 ºF with a simulation of all climatic conditions including heat, snow, rain, wind and sand.

The Equipment Test Chamber is 130-ft long, 30-ft wide and 25-ft high. Although it is smaller, it has the same capabilities of the MC. Tests usually consist of jet engines, small vehicles and turbine-driven ground power units.

The Sun, Wind, Rain and Dust Chamber produces ambient or hot test conditions. Wind-blown rain at rates up to 25 inches per hour and heavy sand and dust storms can also be created in this chamber.

Because of the corrosive properties of salt fog test conditions, the Salt Fog Chamber was designed to provide an ambient test chamber that is away from other test chambers. The chamber has two steam-fed heat exchangers that create the temperature to perform the salt fog test. The chamber is approximately 55-ft long, 16-ft wide and 16-ft high. The chamber doesn't have refrigeration capability.

The Altitude Chamber can create pressure altitudes as high as 80,000 ft. The chamber measures 13- by 9-ft and 6 -ft high.

***F-35 Lightning II endures freezing temperatures in the McKinley Climatic Laboratory***

***C-5M Super Galaxy extreme heat and ultraviolet exposure in the McKinley Climatic Laboratory***

**McKinley Climatic Laboratory Capabilities**

| Chamber | Test Section Size | | Total Temperature (º F) | Pressure Altitude (ft) |
|---|---|---|---|---|
| | Cross Section (ft) | Height (ft) | | |
| Main Chamber | 252 x 260 | 70 | -65 - 165 | |
| Equipment Test Chamber | 30 x 130 | 25 | -65 - 165 | |
| Sun, Wind, Rain and Dust Chamber | 50 x 50 | 30 | ambient - 170 | |
| Salt Fog Chamber | 16 x 55 | 16 | ambient - 170 | |
| Altitude Chamber | 9 x 13 | 6 | ambient | 80,000 |

# Hypersonic Combined Test Force

The Hypersonic Combined Test Force, located at Edwards Air Force Base, California, test cutting-edge, aircraft at hypersonic speeds. The Hypersonic CTF manages range coordination and scheduling with several testing facilities located within the 412th Test Wing at Edwards and with NASA resources for customers test needs.

Test capabilities at the Hypersonic CTF include range safety analysis and planning, technical consultation, trajectory analysis, trajectory optimization, simulation, test and safety planning, test excution and program management.

While working with partners such as NASA, the Air Force Research Laboratory (AFRL), Defense Advanced Research Projects Agency (DARPA) and other contractors, the Hypersonic CTF has provided testing coordination for the Hypersonic Technology Vehicle 2 (HTV-2), the Boeing X-51 Waverider, the Boeing X-37A/B Space Plane, the North American X-15 rocket plane, the NASA X-43 hypersonic aircraft and the Space Shuttle Landing.

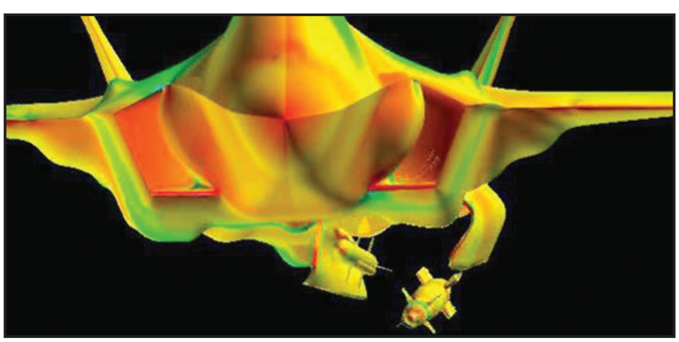
*Boeing Boeing X-37 Space Plane*

*Boeing X-51 Waverider*

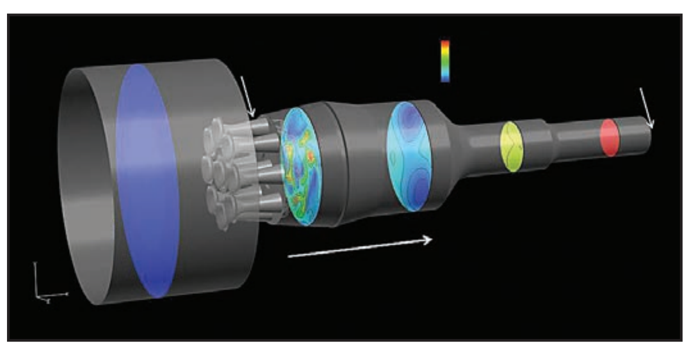
# Test Technology Branch

The Arnold Engineering Development Complex supports a robust and versatile Test Technology Branch focused on three primary disciplines in support of the CTFs and integrated test and evaluation processes: Modeling and Simulation (M&S), Instrumentation and Diagnostics (I&D) and Facility and Testing Technology (F&TT). A team of engineers, scientists, craft and support personnel provide expertise to develop, adapt and apply complex computational models, nonconventional diagnostic systems, advanced facility capabilities, test techniques and engineering-level facility models to address customer testing and AEDC facility infrastructure requirements.

The goal of the M&S focus area is to provide validated, computationally efficient tools that can be transitioned to support test engineers in their efforts to optimize test matrices and test facility configurations, including placement of critical diagnostic instrumentation. Posttest computational fluid dynamic (CFD) simulations provide insight for diagnosing and correcting data anomalies and extrapolating ground-test data to flight scenarios. To this end, we are key players in the High Performance Computing Modernization Office development and application of the Computational Research and Engineering Acquisition Tools and Environments - Air Vehicle (CREATE-AV) computational tools.



*F-35 Weapon's Bay Store Release*



*J-1 Turbine Engine Test Facility Venturi Flow Analysis*

Aerodynamic flow models predict environments surrounding complex aerodynamic vehicles. Interactions of the freestream flow with control surfaces and the separation of stores from aircraft bays and pylons are significant aerodynamic concerns addressed by CFD methodologies. Physics-based CFD models are also applied to predict internal flow streams passing through turbine engine rotating components and to simulate highly energetic combustion phenomena occurring inside propulsion systems. Specialized facility models predict the thermo/fluid dynamic behavior of ground-test facilities and provide insight for optimizing facility operations.

The goal of the I&D focus area is to provide AEDC test engineers and customers with state-of-the art diagnostic techniques which minimize measurement uncertainties, reduce diagnostic hardware interferences with interrogated flow environments and provide high-resolution, real-time measurements in complex and demanding test environments. The high-quality measurements are used to validate numerical models, guide model improvements and enhancements and provide test customers with unique insights into test article behavior.

Both intrusive and nonintrusive techniques are being developed and used to acquire quantitative, spatially resolved flow-field measurements and qualitative flow visualization across the full spectrum of test environments. Significant ongoing efforts are focused on innovative designs, fabrication techniques and stringent calibration requirements of specialized probe systems for applications in harsh environments. Currently, diagnostic probes have been used successfully to quantify Mach number, temperature, pressure and flow angularity in high-enthalpy flow streams, including Mach numbers approaching 7. Probe sampling systems have been developed which chemically quench flow samples entering the probe in order to quantify both gaseous and particulate species. Innovative probe designs and state-of-the-art fabrication techniques have been developed for embedding miniaturized cameras and Micro Electro Mechanical Systems sensors within the probe tips, allowing visualization of combustion phenomena occurring inside turbine engine combustion chambers and augmentor components. Improvements in probe design for survivability at higher temperatures, pressures and Mach number conditions continue to be addressed.

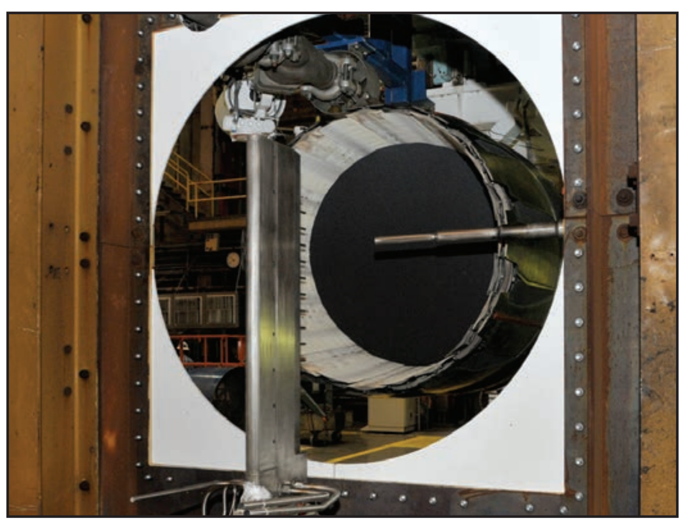
Nonintrusive optical diagnostic systems are being developed and applied to quantify and visualize flow environments inside AEDC test cells. Specialized active optical techniques which stimulate and measure exhaust emission features have been successfully demonstrated. These measurements are used to derive spatially resolved flow-field properties including temperature, multiple velocity components and chemical specie concentrations. In addition, characterizations of qualitative and quantitative flow structures are obtained through the development and implementation of techniques such as laser sheet visualization, Background Oriented Schlieren (BOS), Particle Image Velocimetry (PIV) and Planar Doppler Velocimetry (PDV). These techniques have been successfully demonstrated for monitoring test facility flow quality and for acquisition of flow-field properties on a noninterference basis. Capabilities are being developed to support measurement of global heat transfer, aero-optic effects on laser beam quality, and for other emerging diagnostic needs.

The goal of the F&TT focus area is to work enhancements closely with test engineers in developing and demonstrating specialized simulation hardware, facility systems and ground-test methodologies to address the challenges of providing realistic flight simulation conditions and efficient ground testing capabilities.

The scope of technology efforts supporting F&TT includes development and improvements of test facility systems and engineering-level facility models for the Propulsion, Aerodynamic and Space and Missile areas. Specifically, this focus area supports identification of required technology development to support future test facility requirements and address T&E deficiencies, analysis of facility performance and durability issues and the development of advanced test methodology concepts.

In summary, the Applied Technology and Analysis Program combines technical expertise in M&S, I&D and F&TT to support the Integrated Test and Evaluation (IT&E) process at AEDC. AEDC maintains dedicated technology investments to enhance these capabilities to support challenging requirements and address identified shortfalls in order to minimize technical risks and uncertainties associated with ground testing and data integration and analysis.

*Evaluation of Arc Heater Anode and Cathode Coatings on Wear*



*F-T Fuels Emissions Rake and High-Speed AB Camera from Inside Diffuser in J-1*

# Test Support Services

In addition to extensive test and evaluation capabilities, AEDC can provide a full range of other services for its customers.

AEDC understands that confidentiality of customer test and evaluation information is paramount, so AEDC has an active security program. AEDC can perform sensitive DoD testing and provide test preparation areas, test facilities, control rooms and data systems that are secure.

AEDC's precision machine shop has a full complement of skilled machinists and a complete range of modern machines, from conventional to six-axis computer-numerically controlled (CNC), as well as electrical discharge machine tools. Heat treatment, chemical cleaning and welding facilities are also available. The machine shop maintains coordinate measuring equipment for precise measurement of complex contours to allow 100% inspection and recording of all dimensions.

The Metallurgical/Nondestructive Evaluation Laboratory provides metallurgical test and evaluation services including stress and tensile strength testing, welder certifications, radiographic inspections, and other nondestructive test services. The Chemical Laboratory provides chemical analysis of various components including fuels, oils, soils, liquid-rocket propellants, exhaust gases, water and various other liquids and gases.

AEDC maintains the Precision Measurement Equipment Laboratory (PMEL), which is certified by the Air Force Metrology and Calibration (AFMETCAL). The PMEL provides calibration of test measurement instrumentation such as voltage measurement, pressure, temperature and dewpoint standards at the appropriate intervals to ensure measurements that are traceable to the National Institute of Standards and Technology (NIST).

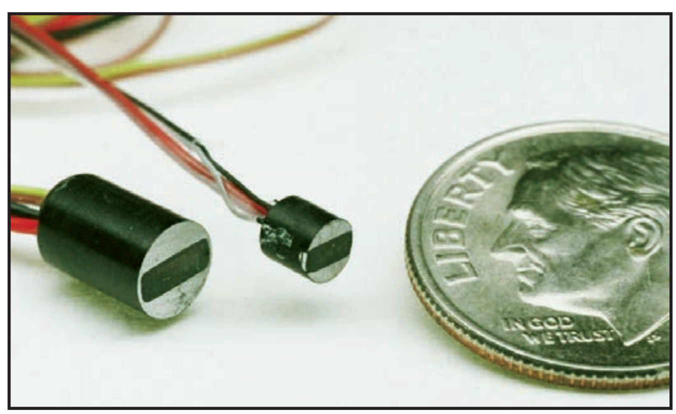
The Aerothermodynamic Measurement Laboratory (ATML) provides technical expertise, analytical tools and calibration/characterization facilities for applied research in aerothermal test measurement techniques. ATML services include specialization in heat transfer and transient temperature measurement for application to space and atmospheric high-speed flight models. Specialized instrumentation is designed, fabricated, calibrated and installed in supersonic and hypersonic test articles and facilities.

High-performance computing (HPC) computational resources are provided to support customers with time-critical mission support via rapid data analysis and the capability to computationally test high-fidelity physics models in a shorter time, thus saving resources. HPC computers are primarily used to provide computational fluid dynamics (CFD) solutions to customer requests and to develop numerical algorithm and physics modeling improvements.

***Chemical Lab***

***Metallurgical/Nondestructive Evaluation Lab***

***Fabrication of Precision Instrumentation***




***Sensor Fabrication and Assembly Capabilities of the ATML***

# 704th TEST GROUP

## Detachment 1, National Radar Cross Section Test Facility (NRTF)

The National Radar Cross Section (RCS) Test Facility (NRTF), the premier Department of Defense facility for RCS testing located near Holloman AFB on White Sands Missile Range, New Mexico, is comprised of two complementary sites, Mainsite and RATSCAT Advanced Measurement System (RAMS).

NRTF specializes in narrowband and wideband RCS signature characterization of scaled, full-scale and flyable articles. Additionally, it provides characterization data for antenna radiation patterns and antenna backscatter. Due to its remoteness and secure environment, the NRTF can accommodate customers requiring specialized testing of developmental systems. In addition, it provides unmatched full-service range support, rapid-response test preparation, design, conduct, data collection and processing.

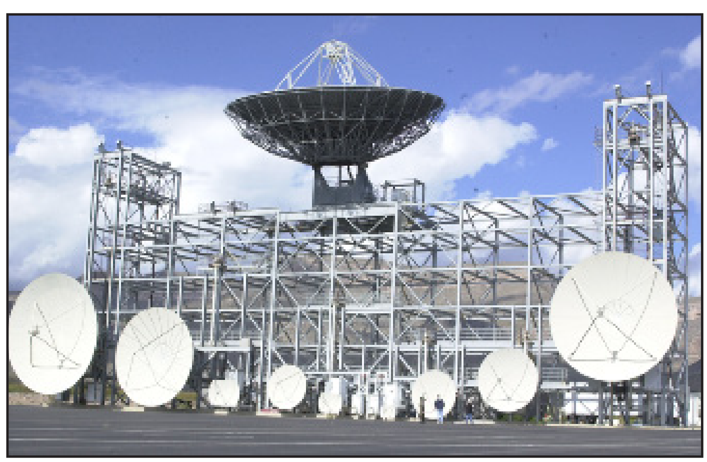
NRTF has successfully provided valid RCS data for hundreds of test programs. These test programs have resulted in major contributions to weapon airframe technology programs, such as the B-2, AMRAAM, F-16, F-22, F-117 as well as numerous rotorcraft and various other advanced technology programs.

NRTF is comprised of two complementary sites, Mainsite and RATSCAT Advanced Measurement System (RAMS). Mainsite has a ground plane RCS range with monostatic and bistatic capabilities to support a variety of targets. Both fixed and portable equipment can be set up in a wide variety of configurations for special tests. Mainsite is divided into two main ranges: The North Range, comprised of Pits 3, 5, and 6, and Pit 2 in the West Range. In addition, portable equipment can be set up in a wide variety of configurations for special tests. Test targets at Mainsite can be mounted on polystyrene foam columns of various height on rotating tables. The rotating tables accept a wide variety of targets ranging from small missiles and reentry vehicles to full-size aircraft and ground vehicles weighing up to 60,000 pounds. Measurements at Mainsite can be made at any frequency from 120 MHz to 18 GHz and at frequencies of 34 to 36 GHz and 94 GHz. Both monostatic and bistatic RCS, as well as antenna patterns, can be measured, and special measurements such as near-field, glint and Doppler are available upon request. Additionally, a tailored data package, full test reports, including analysis and interpretation of data, and special data processing are provided to range users according to their requirements. In addition to these capabilities, Mainsite has the resources to accomplish the design and construction of model targets.

Modeling standards are based on customer requirements, radar scattering principles, and fabrication techniques. Linear model dimensions of ± 0.2 percent are routinely achieved with angle accuracy of 0.05 degrees. Models have been built up to 58-ft in length with extensive detailing to provide items such as inlet and exhaust ducts, rotating turbine and compressor blades and moveable control surfaces. These columns are then attached to the appropriate sized turntable. Cranes, manlifts, forklifts and other heavy equipment are available on site for mounting of large and small targets. Typically, small, lightweight targets can be mounted to an accuracy of ±0.2 degrees in roll and pitch. Large, heavy targets can be mounted with an accuracy of ±0.5 to 1.0 degree in roll and pitch.

RAMS is a self-contained, secure test complex consisting of the Target Support facility, an 8,900-ft by 300-ft wide paved, shadowed-plane range. Monostatic RCS measurements of targets up to 70 ft in length can be accomplished. The target support pylon can be extended to 56 ft above the projected ground plane and retracted into a silo for visual security. It can accommodate targets up to 20,000 pounds.

***JUCAS C-1 Pole Model at White Sands Missel Test Range, New Mexico***



***RATSCAT (Radar Target Scatter) Advanced Measurement System (RAMS) Coherent Measurement System (RCMS)***

# 586th Flight Test Squadron

The 586th Flight Test Squadron plans, analyzes, coordinates, and conducts flight tests of advanced weapons and avionics systems primarily on the White Sands Missile Range (WSMR), New Mexico. In addition, the unit provides operational and maintenance logistics support for test aircraft staging out of Holloman AFB, New Mexico. The squadron also supports a variety of services ranging from aircraft beddown, munitions buildup and transportation; to maintenance and administration facilities providing a high level of security to its customers.

Detachement 1 (Det 1), 586th's geographically separated unit located on the WSMR garrison, provides turnkey test support for customers. Det 1 supports the customer by developing the operational requirements, scheduling range/ airspace, assessing safety issues, and coordinating the environmental assessment. Detachment 1, acting on behalf of the 704th TG/CC, is the sponsoring organization for all USAF programs testing on WSMR.

The 586 FLTS operates four highly modified T-38C aircraft equipped to support a wide variety of flight test operations. Capabilities include: several sub-meter accurate time, space, position, information (TSPI) systems; real-time telemetry (TM); chaff and flare; modern pod-hosted digital radio frequency memory (DRFM) electronic attack (EA); captive carriage of Department of Defense inventory and customized external stores; weapon or towed target carriage; configurable rear cockpit pallet for customer-provided test items; and multiple format photographic coverage.

The squadron also operates a highly modified C-12J (Beech 1900) with multiple external antennae and internal pallet configurations for guidance/ navigation, avionics, datalink, and electronics testing. A one-of-a-kind external pylon mount allows for the development and use of EA pods, sensors, advanced targeting pods, and weapon captive carriage with corresponding internal real-time operator interface.

The 586 FLTS has access to both full and sub-scale unmanned aerial targets and a vast array of challenging ground targets at WSMR, the largest over-land test range in the Department of Defense.

The squadron controls test missions utilizing a modern control room with real-time aircraft and weapon telemetry, UHF, VHF, Mil-STD and customer-tailored data link via MIDS LVT-1 ground terminal, and high-speed digital fiber-optic communication with WSMR and other test facilities. Additionally, it offers secure data collection, processing, re-construction and transfer capabilities.

***Air Force T-38 used for flight test operations***

***Air Force C-12J with an inert Laser Maverick below***

| 586th Flight Test Squadron Capabilities | | | | | | | |
|---|---|---|---|---|---|---|---|
| Aircraft | Airspeed/ Mach | Altitude (ft) | Duration | Nz Load Factor | Instrumentation | Stores | Carriage/Employment |
| T-38C | 160-600 KCAS / 1.3M | 45,000 | 1.0 - 1.5 hrs | 7g | Time Space Position Information (TSPI), L/C/Ku/ Ka/S Band, Rear Cockpit Modular Pallet, Mode 4/5, Ethernet | MAU-12 Centerline Pylon | 1,000 lb capacity |
| C-12J | 110-250 KCAS | 25,000 | 4 - 6 hrs | 3g | TSPI, L/C/Ku/Ka/S Band, Targeting Pods, Link-16, ADS-B, Ethernet, Modular Customizable Racks | Dual MA-4 Pylon | 2 Store Configuration: 500 lb capacity each<br>1 Store Configuration: 750 lb capacity |

# 746th Test Squadron - Central Inertial and GPS Test Facility (CIGTF)

The 746th Test Squadron, also known as the Central Inertial and GPS Test Facility (CIGTF), provides superior test and evaluation of Department of Defense guidance, navigation and Navigation Warfare (NAVWAR) systems in support of the warfighter.

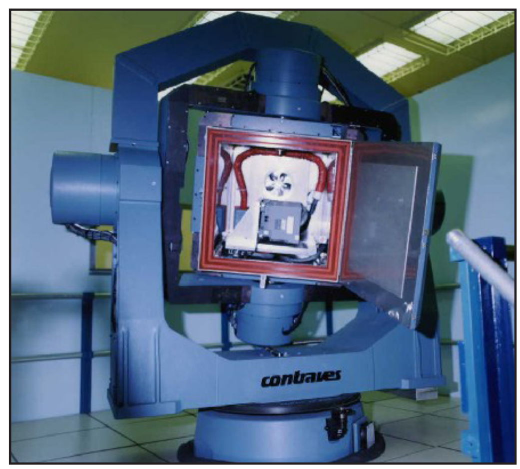
While the CIGTF mission began with inertial guidance and navigation testing, the unit has expanded its expertise to include GPS due to its success as a navigation aid. Today, the CIGTF is the established leader in inertial, GPS and blended GPS/inertial component and system testing.

CIGTF inclusive lab, field and flight-testing capabilities offer the customer a cost-effective means to evaluate their guidance and navigation systems in a variety of environments. Its Navigation Test and Evaluation Laboratory (NavTEL) is a state-of-the-art simulation facility used for testing stand-alone GPS user equipment and integrated GPS navigation systems. Following functional and performance verification in NavTEL the CIGTF can conduct ground and flight tests in diverse locations that include the adjacent White Sands Missile Range (WSMR), New Mexico, the Utah Test and Training Range (UTTR), the Nevada Test and Training Range (NTTR) and the Pacific Missile Range Facility (PMRF) in Hawaii.

*Navigation Test & Evaluation Laboratory (NavTEL) GPS user equipment hardware and software*

To accomplish accurate flight and field testing, the CIGTF provides the world's most precise Time Space Position Information (TSPI) Truth Reference Systems. If required, the CIGTF can leverage its Static Antenna Test Range to conduct multi-element GPS antenna testing using multiple jammers in a controlled, open-air environment. This additional cost-effective, repeatable environment can be useful before embarking on operationally realistic NAVWAR field testing.

The centrifuge testing in the Inertial Laboratory at the squadron uses a multi-axis test table to simulate flight conditions in a thermally controlled environment to check inertial performance on systems prior to aircraft testing. The testing provides sustained high accuracy accelerations for error identification and extraction.




*Contraves Model 53Y, 3-zxis table centrifuge*

# 846th Test Squadron - Holloman High Speed Test Track (HHSTT)

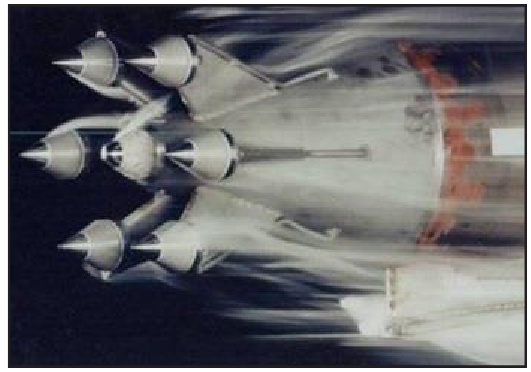
The Holloman High Sspeed Test Track (HHSTT) is the world's premier rocket sled test track operated by the 845th Test Squadron. The mission of the 846th TS is to plan and execute world-class rocket sled tests enabling critical weapon system development in support of the warfighter using world-class people, technical excellence, cost-effectiveness and agility.

At 59,971 ft, the HHSTT is the longest facility of its type in the world. Each of the three rails that form the track is continuously welded, in tension at temperatures below 120º F, and aligned to within 0.04 inches of intended position in the operational region of the track. The HHSTT serves as a critical link between laboratory-type investigations and full-scale flight tests by simulating selected portions of the flight environment under accurately programmed and instrumented conditions, often before flight-worthy hardware is available.

Test vehicles (sleds) are accelerated to mission velocities by means of solid rocket motors, frequently in multi-stage operation. Sled speeds in excess of 9,400-ft per second have been demonstrated in the past and the 846th TS is pursuing an on-going improvement program to achieve speeds in excess of 10,000 ft per second in support of future customer requirements. Sleds weighing up to 60,000 pounds have been used and heavier sleds can be operated if required. Depending on payload size, instantaneous accelerations of more than 200g have been demonstrated. For a wide range of test problems, the HHSTT provides and efficient, safe and cost-effective ground test alternative to expensive developmental flight tests.

Complementing the Test Track itself, the overall HHSTT complex encompasses ancillary facilities for artificial rain simulation, an accurately surveyed ejection test area, captive and free-flight blast test sites, impact test sites and a horizontal rocket test stand. Support facilities include buildings for electronic and photo-optical instrumentation, a telemetry ground station and engineering and shop facilities for design and fabrication of test hardware.


*High Speed Test Track*



*full-scale nosecones, multiple material samples*

# Operating Location-AC

## Aerospace Vehicle Survivability Facility (AVSF)

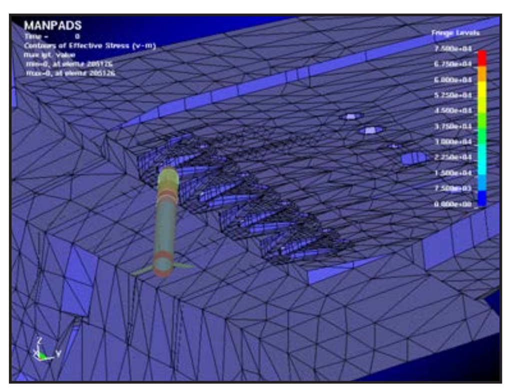
The Air Force Aerospace Vehicle Survivability Facility (AVSF) is operated by the Air Force's Aerospace Survivability and Safety Operating Location at Wright-Patterson AFB, Ohio. The mission of the AVSF is to conduct the research, development, test and evaluation of combat survivable aerospace vehicles by testing the system performance of today's and tomorrow's weapon systems and system components under realistic threat conditions. It is the Air Force Center of Expertise for vulnerability live fire test and evaluation. Recent programs have evaluated a number of aircraft at the AVSF, including the F-35, KC-46, and UAS vs High Energy Laser.

The AVSF consists of several test sites. Site 1 Indoor Test Site has the capability to modify U.S. and foreign munitions fuzes, explosive content, and reloading and storage; study threat characterization; develop and refine new projectile launch techniques; and develop threat simulation devices. The site has a 75-ft gun range teminating in an oak-lined test chamber.

Site 3 Main Site is located outdoors. This site is a covered test area used for production or replica of aircraft hardware evaluations involving high-speed airflow, tech area load simulation, and fuel fire/explosion to evaluate ballistic vulnerabilities of operating combat weapon systems. The test chamber is equipped with high-speed airflow, fuel handling and conditioning systems, fire suppression systems, loading fixtures and environmental protection systems.

Site A Indoor Ballistic Research Range is used for highly controlled impact physics testing and projectile-launch research. Studies performed here include: curvature effects on V50 and damage sustained; ballistic limit scaling-law development; stress wave attenuation studies; and ballistic energy absorption studies. The facility also has the capability for Non-destructive Laser testing.

*Generation of in-flight nacelle conditions*




*Countours of effective stress*

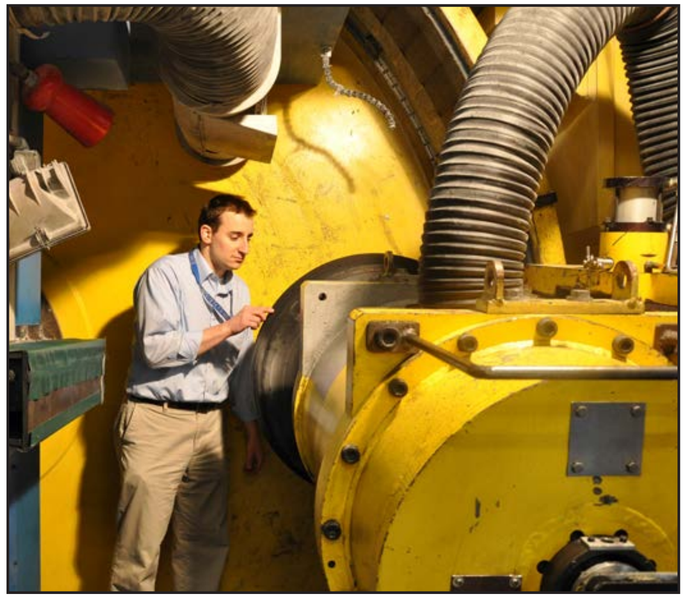
The AVSF Aircraft Engine Nacelle Facility is used to conduct research and development in aerospace vehicle engine nacelle fire initiation and sustainment. It contains a full-annulus engine nacelle fixture which provides a high degree of realism. The AEN Fire Test Simulator allows the generation of in-flight nacelle conditions, including temperature, internal airflow exchange rate and aircraft system operations.

## Landing Gear Test Facility (LGTF)

The Landing Gear Test Facility (LGTF), also located at Wright-Patterson AFB, Ohio, is the U.S. Air Force responsible test organization for landing gear testing and has served the Department of Defense, NASA, other government agencies, and commercial entities for more than 40 years. This facility is known for producing reliable, impartial test results that can be counted on for accuracy. The mission of the LGTF is to provide landing gear component testing services to customer-supplied specifications. The facility has equipment to simulate real-world operating conditions for aircraft tires, wheels, brakes, and entire integrated landing gear assemblies, so that the customer receives real-world answers.

Test instrumentation for the facility includes customized measurements of strain, load, pressure, temperature and displacement, and high-speed video.

***Control room at the Aerospace Survivability and Safety Office***



***Tire in advanced development of missionized aircraft tire wear testing for the F-35 Lightning II program***

# Operating Location-AA

## Directed Energy (DE)

The 704th Test Group Operating Location (OL-AA) at Kirtland AFB, New Mexico, provides co-located test and evaluation support for Directed Energy (DE) technology currently under development at the Air Force Research Laboratory Directed Energy (AFRL/RD) Directorate.

The OL-AA focuses on developing test concepts, planning, methodology, procedures, and techniques for emerging DE programs and serves as a bridge between research and development and the test and evaluation community. It can directly support DE technology still under development while accelerating the transition of DE technology from R&D systems to acquisition ready programs. The T&E engineers work in conjunction with AFRL/RD scientists to better understand system capabilities, providing critical requirements for long term T&E infrastructure planning.

The OL-AA does not actively manage a test facility. The T&E engineers utilize all available resources within the test community across all military services. This allows the T&E engineers to recommend the appropriate test resources that best suit the test objectives of any DE program.

OL-AA supports both High Power Microwaves (HPM) and High Energy Lasers (HEL) technology.

***Directed Energy testing on U.S. Army Bradley Fighting Vehicle***