AEDC Highlights

Arnold Engineering Development Center
Arnold Air Force Base, Tenn. 37389

Understanding Tomorrow Today

New AEDC Facility Provides both Sea Level and Ram Testing Capabilities

The addition of comprehensive sea-level test cells at the AEDC's Engine Test Facility provides aircraft developers with a new set of capabilities to enhance engine development and sustainment. The combination of the new sea level and ram inlet capabilities along with the existing altitude capabilities at a single site provides the DoD with an economical "one-stop" approach for aeropropulsion test and evaluation (T&E).

Test cells SL-2 and SL-3 are AEDC's newest aeropropulsion test and evaluation facilities giving customers "one-stop shopping" for T&E services.

Two of the new AEDC test cells, designated SL-2 and SL-3, have the capability to operate at either ambient sea level conditions, variable temperature ram inlet conditions, or heated inlet sea level conditions without ram and to rapidly transition between these test configurations. The third new AEDC test cell, designated SL-1, has the capability to operate at sea level conditions in an economical T-9 hush house configuration (see page 4). These capabilities are especially critical for economically simulating flight conditions in a ground test facility and rapidly accomplishing Accelerated Mission Testing (AMT) or Accelerated Simulated Mission Endurance Testing (ASMET). These tests evaluate engine durability by duplicating the types of missions the engine will actually fly in operational service.

Recently, cell SL-2 played a key role in the AEDC and Pratt & Whitney team's meeting an Initial Service Release (ISR) milestone of the Defense Acquisition Board (DAB) criteria of 2,165 Total Accumulated Cycles (TACs) on the F119 engine for the Air Force's new Lockheed Martin F-22 Raptor fighter.

The versatile SL-2/SL-3 test cells are capable of testing up to 50,000 pound thrust engines at ram speeds up to Mach 1.25 and temperatures ranging from minus 65° to 350° F (see page 3). A fuel conditioning system provides fuel up to 210° F. The latest AEDC Engine Data Acquisition and Processing System, termed EDAPS, is utilized to provide real-time monitoring of data parameters with increased reliability and availability.

> ***"It is a distinct pleasure to acknowledge the outstanding contributions AEDC has made to the F-22/F119 program. Without their 'can-do' attitude and unsurpassed drive, the F119 Engine Program would not have completed testing vital to the overal F-22 program."***
>
> ***Brig. Gen. Michael Mushala***
> ***F-22 System Program Dir.***

Test cells SL-2/SL-3 are similar to those formerly at the Naval Air Warfare Center-Aircraft Division's facility in Trenton, NJ, which was closed as part of the 1993 Base Realignment and Closure Act. A Navy F110-GE-100 was used to provide initial cell checkout of SL-3 at AEDC.

The first test customer for the new test capability was the F119-PW-100 development engine in SL-2, which resulted in delighted customers.

Above, the F119 engine recently completed a Defense Acquisition Board Initial Service Release milestone criteria of 2,168 Total Accumulated Cycle tests in SL-2.

"We subjected the developmental engines to extended periods at AEDC in worst case conditions to prove adequacy of the design and manufacturing process and resistance to high cycle fatigue," said Brig. Gen. Michael Mushala, the F-22 SPD. "This testing extends our understanding of engine durability. Congratulations to the entire engine and AEDC teams for a very successful [test] period."

Jim Yankel, ASC F119 test coordinator, rated his test in SL-2 a 5.9 of a possible 6.0 on AEDC's comprehensive customer satisfaction survey. The outstanding performance of the SL-2/F119 team also earned two AEDC Outstanding Technical Achievement Awards.

AEDC has set new standards of productivity in Accelerated Mission Testing. During F119 testing, the team demonstrated changing between sea level testing and ram inlet in 15 minutes. This capability provides AEDC customers with a very fast and cost effective way to accomplish both types of AMT testing in a single test installation. AEDC has also demonstrated SL cell thrust calibrations in less than five minutes, repetitive engine installation within four days and removal in two days. As a result of our outstanding productivity, USAF's Aeronautical Systems Center (ASC) plans additional F119 and F100 testing in SL-2 and SL-3.

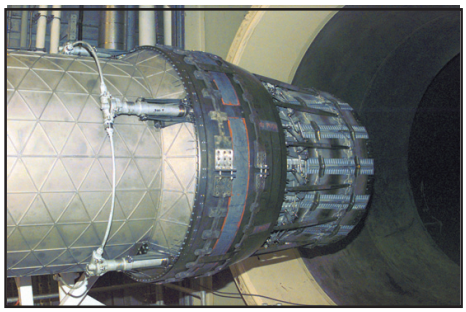
> ***"We subjected the engine to all of the hot time at full power, all of the afterburner time and all of the throtle cycles that it will see in four to five years of operational service."***
>
> ***Tom Farmer***
> ***P&W Vice President***
> ***F119 Programs***

The most recent successes of the SL-2/SL-3 teams have resulted from SL-2 testing of the F119 for Initial Service Release (ISR) and SL-3 testing of the F100-PW-229 as part of the Aeronautical System Center's Component Improvement Program (CIP). The SL-2/F119 team's challenge was to help meet the DoD Defense Acquisition Board's criteria for ISR of the F-22's engine of 2,165 Total Accumulated Cycles (TACs) by November 30, 2000.

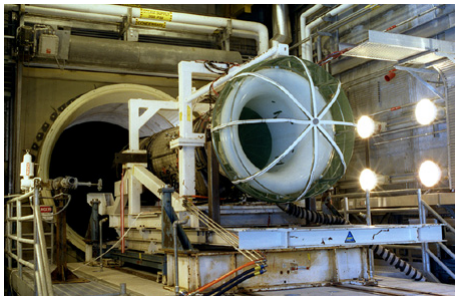
The Air Force, Sverdrup Technology and Pratt & Whitney team accomplished the milestone completing 2,168 TACs November 1, 2000, one month early, and delivered on-cost an unprecedented test pace and test complexity. Beginning in September 2000, the SL-2 team conducted AMT tests at sea level and ram conditions, testing six days a week and three shifts per day. Day seven was devoted to engine, facility and people maintenance. Using this approach, the SL-2 team accomplished a pace of 4.2 TACs per engine run hour, a rate unprecedented in AEDC and F119 history. Upon completion of the DAB milestone criteria, the AEDC and P&W team removed the engine from the test cell and disassembled it for layout and inspection by the P&W project team, F-22 SPO personnel and an Executive Independent Review Team (EIRT). The team's timely accomplishment of the DAB milestone criteria received widespread recognition including that from Mr. Dave Edmunds, F119 IPT co-lead, ASC/LP.

> ***"We are very appreciative of the long hours and teamwork that you put in. The engine turned out to be a success, but more importantly, the testing that we've done here has really turned out to be a success."***
>
> ***Dave Edmunds,***
> ***F-22 Engine IPT co-lead***
> ***USAF/ASC***

"Let me thank everyone here for the outstanding job they have been do-



Above, the F100 engine awaits testing in SL-3. Below, the F110 is installed in SL-3.



ing," Edmunds said. "We've asked a lot more of you than we deserve. We are very appreciative of the long hours and teamwork that you put in. The engine turned out to be a success, but more importantly, the testing that we've done here has really turned out to be a success."

AEDC Test and Evaluation Technology

AEDC conducts an Applied Technology program focused upon aeropropulsion modeling and simulation, structural analysis, facility and test technology, information technology and test measurement/diagnostics. The SL test cells are primary beneficiaries of these investments. One typical product is the Data Validation Manager (DVM), an information technology for increased automation of engine test data validation and fault detection. This same DVM ground testing technology has been extended to support F-22/F119 flight testing at the Air Force Flight Test Center and F119 testing at Pratt & Whitney's West Palm Beach test facility.

SL-2/3 control room

Another product of this program is an enhanced augmentor probe (shown in the bottom photo on page 4). The probe rake system provides interchangeable probes for the measurement of total pressure, total temperature to 3,500°F, Mach number, flow angle to 20 degrees, emissions, visible smoke, particulates and high-resolution video. The system also provides gas sampling to provide combustion gas analysis for assessment of combustion efficiency, FAA/ICAO emissions certification, engine emissions inventories, profiles of fuel/air ratio and pattern factor.

SL-1, -2, -3 Capabilities

The Test Facility Parameters for the SL-1, -2 and –3 cells are shown below. The cells offer affordable solutions for sea level, ram inlet and heated sea level testing, offering unrestricted 24-hour, 7-days a week test and evaluation programs. Ram inlet conditions provide an economical way to subject the engine to increased air pressure and air temperature at the engine inlet to fully evaluate durability at increased Mach number. Simultaneous operation of SL-2 and SL-3, using separate control rooms for each cell is common. These cells are capable of using multiple fuels, including JP-8, JP-8 plus 100 or special fuels supplied from stand-alone sources.The exhaust gas management system of SL-2 allows ± 20 degrees of transient vectored thrust nozzle testing.

The SL-2/SL-3 cells are equipped with AEDC's new Engine Data Acquisition and Processing Systems (EDAPS). Data reduction and validation are guided by the Data Validation Manager (DVM). The new data systems utilize the latest state-of-the-art personal computer technology as opposed to mainframe computer systems. AEDC is able to reduce the cost of testing due to the real-time monitoring of data parameters available through EDAPS.

Test Facility Parameters

	SL-2/SL-3	SL-1
Inlet total pressure, psia	14.2 – 38	Ambient
Mach Number	0-1.25	0
Mass flow rate, max. atmospheric, lb/sec	1,000	1,000
Mass flow rate, max. ram, lb/sec	550	N/A
Temperature range,°F	-65 – 350	Ambient
Maximum fuel flow rate, lb/hr	110K	100K
Fuel temperature range, °F	-65 – 210	Ambient
Test section height, feet	24	24
Test section length, feet	60	71
Test section width, feet	24	24
Thrust capability, pounds-force	up to 50K	up to 52.5K
Engine weight capability, lb-force	40K	10K

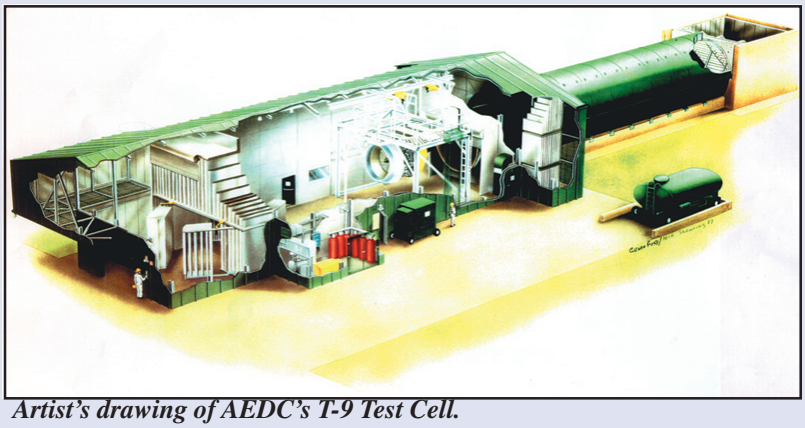
SL-2/SL-3

Ram Airflow, Pressure, Temperature Capability

	P2 = 14 psia		P2 = 38 psia	
Airflow pps	Min T2 degF	Max T2 degF	Min T2 degF	Max T2 degF
50	-65	350°	10	350°
100	-65	350°	10	350°
150	-65	350°	15	350°
200	-55	350°	18	350°
300	-30	350°	23	350°
400	-15	350°	23	350°
550	-5	350°	25	350°

Testing available in AEDC's SL-1 cell

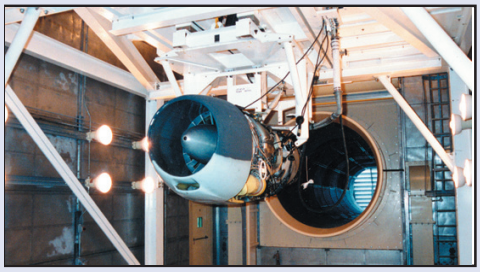
The SL-1 test cell at AEDC provides a means of testing turbojet, turbofan, turboshaft, and turboprop engines under sea level conditions. The cell is a Large Turbofan Engine Noise Suppression System (an Air Force engine test cell commonly referred to as a "T-9"). SL-1 was declared available for testing after initial operational checkouts and validation were completed with a J57-P-59W engine.



Artist's drawing of AEDC's T-9 Test Cell.

The test cell provides excellent experimental or diagnostic test capabilities. SL-1 offers a low-cost, flexible, stand-alone, sea level test cell which can be used to obtain "quick-look" engine assessment data from engine component modifications, to screen component improvements prior to more expensive altitude evaluation, to assess sea level endurance, or to conduct classified or proprietary test programs.

The large test section is sized for low air velocities and to provide adequate space for engine stands, thrust stands, load absorbers, hoists, observation cameras, infrared cameras, and other associated test hardware. An overhead thrust frame system is installed in the test cell to permit the suspension of Quick Engine Change (QEC) configured engines for testing. The test chamber is arranged such that ground support accessories such as fuel trailers, start carts, and hydraulic trailers can be placed outside of the test chamber. Feed-throughs are provided in the test cell wall for ground support hoses and cables.



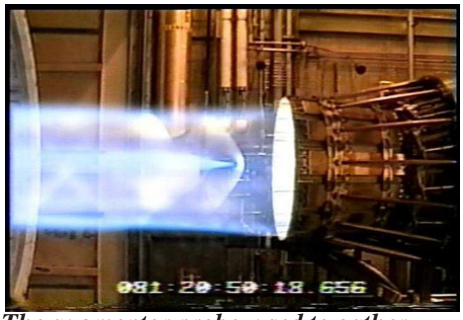
J-57 in SL-1

Engine controls are contained in a control cab sited adjacent to a cell window for engine viewing. An expandable data system currently provides basic instrumentation display and recording capability of 64 channels of temperature measurement, 128 channels of pressure measurement, and 4 channels of speed or flow measurement.

Planned Upgrades

Capability upgrades to support future F119, F119 JSF, F110, F100 and other critical engine test programs in SL-2 and SL-3 are planned. These improvements include an overhead thrust stand installation, an upgraded icing test system, sand/corrosion test systems, enhancements to the data acquisition systems to 500 samples per second and upgrades to the exhaust gas management system to allow steady-state vectored thrust nozzle testing. Additional provisions for a mini-Computer Aided Dynamic Data Measurement and Analysis System (CADDMAS) are also underway.

The mini-CADDMAS is a 48-channel data processing and monitoring system designed by AEDC to gather and analyze dynamic information as it occurs. It is typically used to process and analyze aeromechanical data online during testing, rather than the traditional analysis days after the test. The system contains multiple parallel data processors linked with personal computers to process data as they are received and to provide engineering information in real time, thereby providing the user with data analysis cheaper and faster than a mainframe supercomputer.



The augmentor probe, used to gather high-resolution augmentor performance data can be seen through the exhaust plume during an F100 test in SL-2.

Additional plans are underway to enable engine signature diagnostics to be conducted in the sea level cells. Infrared (IR) surveys of engine cavity and near-field plumes for validation of low observable design features as well as full-scale IR survey of hot parts using medium wavelength IR and low wavelength IR imagers will be possible. In addition, ultra violet (UV) and IR spectral signature of engine plumes are planned. AEDC's IR and UV plume signature prediction and analysis capability will also support this testing.

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