After 60 years, the mission remains the same

Technological gains and decades of experience keep AEDC at the forefront of engine testing

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Ask Don Jones what the biggest change has been at AEDC over the last 40 years, and it won't take him long to answer.

Computers.

"We didn't have all the bells and whistles," said Jones, 68. "We still had manometer boards when I first hired in, and we used slide rules."

Jones, who works as a project engineer at the Engine Test Facility's C-1 test cell, doesn't miss those days. Corrections couldn't be made once a test started, so workers had to be diligent in setting conditions.

"The early control rooms had a balcony where the analysis personnel were stationed," Jones said. "Technicians would read the gauges and write the data down on clipboards, and you would bring the clipboards up to the balcony and use slide rules to do the hand calculations to determine test point conditions."

Once testing was complete, there was more labor-intensive work to process the test data.

"To get the pressure data back after the test, pictures of the manometer boards used to record test pressures had to be read," Jones said. "Each fluid level of the individual manometer tubes was recorded into a Dictaphone, and then you had math data aides transcribe them into paper tape and you loaded those into the computer. So it was two or three days before you got final data back from a test run. Everything was by gauges and hand calculations in the control room."

ATA project manager Tom Schmidt, left, and turbine engine test project manager Capt. Scott Rinella pose in front of an F100-PW-229 engine in the Engine Test Facility's SL-3 test cell. The engine, which is used in the F-15 Eagle and F-16 Fighting Falcon, underwent an 11-month Component Improvement Performance test to increase the lifetime of the engine. (Photo by Rick Goodfriend)

Today computers handle all the data processing, and they store all the data when turbine engines are tested in one of the eight ETF test cells online today. In a matter of decades, the technology has leaped from the equivalent of knuckle-dragging to the ability, in real time, to test all aspects of turbine engine operation.

"It seems almost caveman to you now," he said. "It wasn't that long ago. It was the 60s."

But even though Jones keeps his slide rule at home now instead of at work, he says the essentials of the job aren't any different.

"The basics of testing a turbine engine at altitude in a ground test facility have not changed, but we do so much more now," Jones said. "It used to be just basically measuring performance. But now we do all spectrums of engine testing, and the analysis can be performed in almost real-time."

Since May 3, 1954 – when the first turbojet engine test operation began in ETF's T-1 test cell – a host of other big-name fighter jet engines have come through AEDC: the A-10 Thunderbolt II's TF34-GE-100 made by General Electric, the Pratt & Whitney F119 engine for the F-22A Rap tor and most recently, Pratt & Whitney's F135 engine for the F-35 Joint Strike Fighter.

Construction on ETF began in 1950, when the Air Force began reconditioning and installing Bavarian Motor Works equipment that was dismantled and shipped to the U.S. from Germany's test plant after World War II. Some of that equipment still exists on the base, although a lot of it is inactive.

"I find it fascinating personally, that our legacy goes back that far," said Lt. Col. James Peavy, the director of the Engine Altitude Ground Test Complex.

Colonel Peavy has years of experience in many different areas of flight testing, including working and flying at the test pilot school at Edwards AFB. As a lieutenant, he spent a week at AEDC for a ground test course in the mid-90s and said he had it in his mind to come back someday, which he did about a year and a half ago.

"We have a capability that is very much unique in the world in terms of the altitudes, air speeds and mass flows that we can achieve here," he said.

Today, work at ETF is focused on a couple of different areas. Propulsion system development and qualification for the F-35 propulsion systems continues and is a major area of concentration according to Rob McAmis, the manager of turbine engine analysis.

"With the Air Force and Navy depending heavily on the F-35, it's very important that this propulsion system be well-groomed and properly assessed and ultimately qualified per the design to meet the aircraft needs," McAmis said.

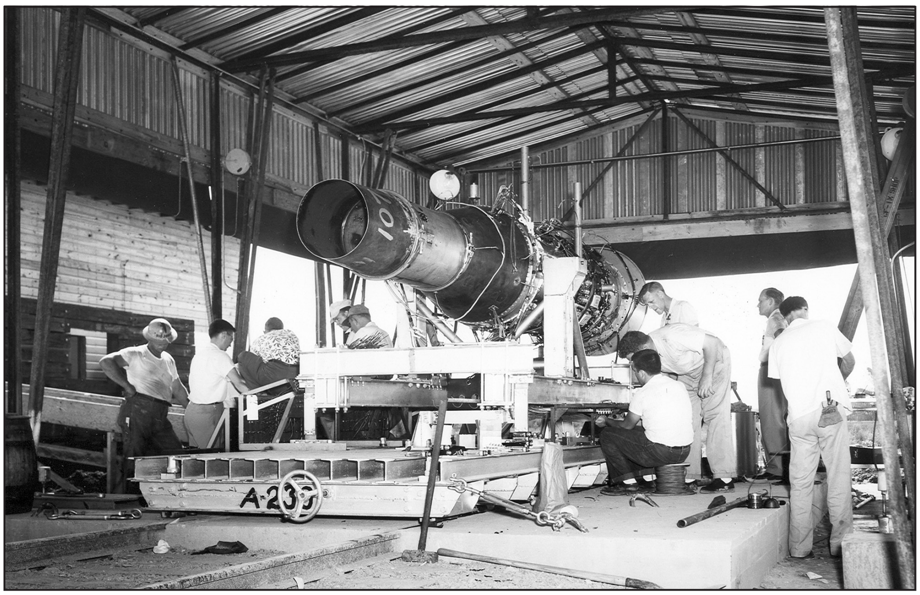
Another source of test workload is the Component Improvement Performance (CIP) program. The CIP program is responsible for improving engines that are already qualified and deployed in fielded aircraft. ETF conducts sea level and altitude testing on engines that are undergoing modifications to address minor deficiencies.

Late last year, AEDC finished its longest-running test ever: an 11-month CIP test on the F100-PW-229 engine used in the F-15 Eagle and F-16 Fighting Falcon.

The CIP test was designed to enhance durability and save money, and has the potential to save tens of millions of dollars in maintenance.

"The test was to extend the life of the engine by about 40 percent, and to do that they had to upgrade or redesign some of the hardware and prove that it could withstand the longer service life interval," said turbine engine test project manager Capt. Scott Rinella.

ETF also performs performance and qualification testing of commercial engines for companies from around the world. Rolls-Royce has a commercial engine preparing to undergo icing tests on base.



The first jet engine test at AEDC in 1953 required design and construction of a thrust stand for the J47 turbojet engine used in calibrating the T-1 high-altitude test cell. The J47 engine powered the B-47 bomber. (File photo)

Recently, a significant source of test workload is the demonstration of alternate fuels as a replacement for the existing JP-8 fuels.

2nd Lt. Drew Miller, another project manager at ETF, has been involved with testing that mixes conventional JP-8 jet fuel with different types of alternative fuels. Testing has mixed JP-8 with fuels derived from animal tallow, the camelina plant and coal (known as Fischer-Tropsch). Some fuel blends tested at AEDC have powered test flights at Eglin AFB.

"The mission right now is to reduce foreign oil dependency," Lieutenant Miller said. "We're just trying to find something that would be viable for the future."

If the amount of work going on in ETF's facilities sounds like a lot, that's because it is.

"Meeting our sponsor's test schedules is always very challenging because these schedules are somewhat success-oriented and change with unexpected findings that so often occur in the experimental process," McAmis said. "It's just the nature of the test business where unanticipated findings occur in the experiment and adjustments in the test plan need to be made. So the direction in the experiment can change a little or a lot due to those unanticipated findings within these really complicated experiments. Our test engineers are some of the best 'maestros' in the world, orchestrating the facility and a large test team to achieve planned objectives."

The challenges of complex turbine engine experimentation are offset in part by the many advances in mechanical and electrical test support equipment, instrumentation, data acquisition systems, facility controls, data analysis tools and advanced measurement diagnostics. McAmis, who has worked in various divisions at AEDC, has seen the change in his 27 years on base. Changing test conditions occurs rapidly and acquisition of data can now occur in real time; analysts can produce trends and tabulated assessments in real time as well. This enables near real-time assessments of the quality and intent of the experiment.

Thanks to the implementation of powerful computers, flexible digital engine control (DEC) systems and advanced instrumentation and data acquisition systems that no one could have imagined three decades ago, McAmis says the amount of information generated on a given turbine engine test is staggering.

"It's like having three channels on your TV in 1970 compared to a thousand channels now," he said. "We have so much more access to the engine to direct specific systems functions. This has really enabled a higher level of experimentation and made it quite complicated in one respect, but additionally it's produced all this information about the system under test."

And that information is necessary to validate performance, operability and durability of turbine engines. Full verification often requires a suite of testing which includes rig testing, simulated ground testing at AEDC and flight testing.

ETF's test cells are capable of simulating a variety of conditions: different altitudes, temperatures and – in some cases – corrosion. The capabilities mean an engine can go through accelerated mission testing without actually flying in an aircraft.

While flight testing ultimately provides true experimental conditions including engine aircraft integration effects, the advantages of ground testing are numerous.

Ground testing allows for detailed characterization of component performance, operability and durability because extensive instrumentation can be used and recorded at high data acquisition rates necessary to resolve physics-driven phenomena.

Ground testing also allows for extensive parametric variations to define almost all influence factors. Augmentor testing, for example, requires sustained engine operation at high fuel consumption operating conditions, which is easily completed using AEDC ground test facilities with associated fuel storage and delivery systems.

"Because of our facility, our fuel supply system is continuous," McAmis said. "We can perform continuous testing. We can be much more efficient than a flight test and again, it's always connected with the opportunity to have a lot of instrumentation."

In addition to engine characterization testing, accelerated mission tests (AMT) are conducted in SL-2 and SL-3 by executing only the damage-producing flight maneuvers of every mission for the aircraft for which the engine under test supports. This enables engine hardware life limits to be validated and defined prior to these same limits being discovered in engines installed in fielded aircraft.

One of the other big factors propulsion testing at AEDC has in its favor is 60 years of experience in the industry.

"The people part of the equation is incredibly significant," McAmis said. "Many of the team members have been over here for years, and they have met challenge after challenge and made such a significant contribution to so many engine systems over the years. And we continue to do that."

The facilities on base are unique, but the real value is in the people who run them, Colonel Peavy said. He wants to see the expertise of AEDC applied even more outside the center, to other Air Force bases and even to developers in the private sector.

"The human capital is the most important thing we have here," Colonel Peavy said. "The facilities give us the ability to develop that knowledge and to do unique things that can't be done anywhere else, but the place for Arnold to excel over the next five or 10 years is in making that capital available and applying it to problems that are outside of Arnold but support the Air Force and the joint mission to develop and test new systems."

It's an advantage Don Jones refers to as the "gray beard factor," and he puts it right up there with the advances of technology in terms of importance.

"A machine doesn't care, but an individual does care about how the test progresses," he said. "A machine is just garbage in, garbage out. But if you have a human in the loop, sometimes when garbage comes in they say 'Wait a minute. That's garbage.'"

Jones says he and his co-workers care about what they do, which is something a computer isn't capable of. And if their computers went away tomorrow, they would still be able to get the job done the old-fashioned way.

"Sometimes you can rely too much on technology," Jones said. "I don't want to go back to the slide rule, but I could."

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