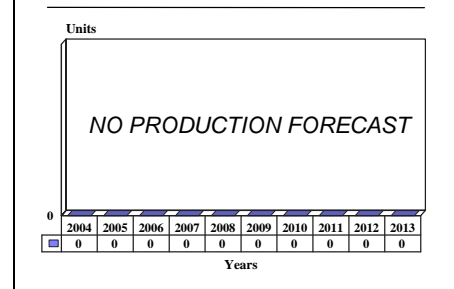


Versatile Affordable Advanced Turbine Engine (VAATE) - Archived 3/2005

Outlook

- VAATE will identify means of making turbine engine technologies and engine operation more affordable
- First results planned for 2006 demonstration, then 2010 and 2017
- Small- and large-core demonstrators to support aviation, marine and industrial turbine development, both military and civil
- DoD has committed major funding

10 Year Unit Production Forecast
2004 - 2013



Orientation

Description. VAATE is the Versatile, Affordable Advanced Turbine Engine initiative, a planned technology cost reduction program for U.S. military and commercial gas turbine engines, both small and large, whether air, ground, or marine based.

Sponsor. The primary sponsor of VAATE is the U.S. Department of Defense (DoD), Washington, DC, USA.

Participating Agencies. Participating agencies and/or service branches include the U.S. Air Force, U.S. Navy, U.S. Army, National Aeronautics and Space Administration (NASA), and Advanced Research Projects Agency (ARPA) (formerly known as the Defense Advanced Research Project Agency, or DARPA).

Status. In preparation to succeed the Integrated High Performance Turbine Engine Technology (IHPTET) program.

Total Produced. While developmental engine cores will be produced, VAATE is not an engine production program.

Application. All gas turbine engines, both military and commercial.

Price Range. Not applicable.

Contractors

Allison Advanced Development Company (AADC), <http://www.aadc.com>, 2059 S. Tibbs Avenue, Indianapolis, IN 46241 United States, Tel: 1 (317) 230-3100, Fax: 1 (317) 230-3110, RDT+E

GE Aircraft Engines, 1 Neumann Way, Evendale, OH United States, RDT&E

GE Aircraft Engines, 1000 Western Ave, Lynn, MA 01910-0001 United States, RDT&E

Honeywell Aerospace, 1944 East Sky Harbor Circle, Phoenix, AZ 85034 United States, RDT&E

Pratt & Whitney, 400 Main Street, East Hartford, CT 06108 United States, Tel: 1 (860) 565-4321, RDT&E

Teledyne Continental Motors Turbine Engines, P.O. Box 6971, 1330 W. Laskey, Toledo, OH 43612-0971 United States, Tel: 1 (419) 470-3000, Fax: 1 (419) 470-3052, Email: japel@teledyne.com, RDT&E

Williams Intl Co LLC, 2280 W. Maple Rd., P.O. Box 200, Walled Lake, MI 48390 United States, Tel: 1 (248) 624-5200, Fax: 1 (248) 669-0040, RDT&E

Technical Data

Large Versatile Cores (LVC) and Small Versatile Cores (SVC) are both to be developed under VAATE as technology testbeds. The LVC is to be applicable to low- and high-bypass turbofans. The SVC is to be applicable to expendable turbojets, turboshafts, and small turbofans. Baseline is about year 2000 technology. Improvement ratio goals for each of the cores, by engine type, include:

	Expendable Turbojet	Small Turbofan	Low-Bypass Turbofan	High-Bypass Turbofan
Thrust/Weight	60 percent increase	2.2 x increase	3.1 x increase	1.4 x increase
Specific fuel consumption	-30 percent	-33 percent	-25 percent	-20 percent
Cost	-65 percent	-62 percent	-64 percent	-32 percent

	500 - 700 shp Turboshaft	3,000 shp Turboshaft	15,000 shp Turboshaft
CCI*	3 x improvement	2.5 x improvement	5 x improvement
SFC	-20 percent	-25 percent	-40 percent

* CCI = Capability-to-Cost Index, see **Program Review**, below.

Variants/Upgrades

Several engine types (turbofans, turboshafts, etc.) are likely to be tested using either of the two cores developed, as listed at the top the chart above.

Program Review

Background. The Versatile, Affordable Advanced Turbine Engine initiative succeeds the Integrated High Performance Turbine Engine Technology (IHPTET) program, which began in the 1980s. IHPTET is a basically a U.S. Department of Defense and turbine industry program to improve military aviation gas turbine capability. It aims to increase operating temperatures and reduce weight through the pursuit (and eventual completion) of evolutionary aerothermodynamic, structural, and advanced-materials efforts.

VAATE is to take on a much broader scope than IHPTET. It will focus not only on aviation turbines, but on marine and power generation turbines as well. In addition, it will not focus on performance improvement, but will give equal, if not greater, consideration to reducing the cost of engine technologies as well as greatly improving their durability. The result will be the development of engines that cost less to produce, operate, and maintain; are safer; and can be in service longer. An unspoken consideration will also be enhancements to reduce noise and noxious emissions.

While IHPTET trickled technologies down to civilian engine use, VAATE will consider the civil application of its technologies from their developmental start. The program is to offer a more direct route for technologies to transit from military engine evolution to civilian

applications. Power-generation turbines in particular are widely used and are an increasingly important part of civilian business for companies that produce military turbines.

Another new R&D facet to IHPTET's successor is that the VAATE program will focus on cost issues, including reductions in development, production, and maintenance costs. The chief thrust will be increasing engine affordability by reducing the cost of all applied technologies. Just which technologies are applied will be measured against their cost. If the cost is deemed too high, whether in manufacturing, material, or the projected life-cycle of a given technology, then it will not be adopted. This method of measuring the relative value of a technology for possible use in VAATE is termed a capability-to-cost index (CCI). A mathematical formula is used to determine the CCI.

Development costs will be lowered through the application of virtual design/testing, rapid technology maturation, early engine/airframe integration, and shared system development. Lower production costs will be achieved through the use of multisystem hardware, advanced manufacturing, lower-cost parts, innovative assembly, and fewer parts. Maintenance costs will be reduced through a maintenance-free focus, damage-tolerant design, reduced unscheduled removal

rate, health management, increased hot-time (i.e., running at high temps) capability, and use of repairable components and improved inspection methods.

It is hoped that in the initial demonstration phase of VAATE, engine affordability can be increased by a factor of four by 2006, using the latest engines as a baseline (cost basis in FY00 dollars). A six-fold improvement is desired by 2010, and a ten-fold improvement over the baseline is hoped for by 2017.

Ideas regarding high-impact technologies are to be generated by U.S. government scientists (such as at the National Energy Technology Laboratory, Department of Energy, etc.) feeding ideas for increased affordability technologies into the program for research and possible development by the USAF Research Lab's Propulsion Directorate and participating companies.

Funding

No funding for VAATE has yet been approved.

Recent Contracts

Recent, unclassified contracts directly related to IHPTET include the following:

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
Williams	13.3	August 8, 2002 – Williams International Corp was awarded a US\$13,300,000 indefinite delivery/indefinite quantity contract to investigate high-impact technology concepts involving combustors, other hot section components, fuels, materials, and control methodologies that can lead to the development and demonstration of affordable, advanced, high-performance, low-emissions engines that have application to current and future aero and aerospace propulsion and power systems. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than that amount. At this time, US\$160,000 of the funding has been obligated; further funds will be obligated as individual delivery orders are issued. This work will be completed by August 2007. The Air Force Research Laboratories, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-02-D-2211)
UTC (P&W)	13.3	September 27, 2002 – United Technologies Corp, West Palm Beach, Florida, was awarded a US\$13,300,000 indefinite deliver/indefinite quantity contract to investigate high-impact technology concepts involving combustors, other hot section components, fuels, materials, and control methodologies that can lead to the development and demonstration of affordable, advanced, high-performance, low-emissions engines that have application to current and future aero and aerospace propulsion and power systems. This program will focus on innovative concepts that could lead to the development of advanced air-breathing engines for aircraft, missiles, and power systems, and of hybrid engines that offer dual-stage affordable access to space. The USAF can issue delivery orders totaling up to the maximum amount indicated above, although actual requirements may necessitate less than that amount. To date, US\$412,000 of the funding has been obligated. Further funds will be obligated as individual delivery orders are issued. This work will be completed by September 2008. The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-02-D-2296)

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
Northrop Grumman	20.0	August 11, 2003 – Northrop Grumman has been awarded a US\$20,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. US\$33,219 of the funds had been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by August 1, 2011. Solicitation began November 2002, and negotiations were completed July 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-03-D-2361)
Honeywell	70.0	August 13, 2003 – Honeywell International was awarded a US\$70,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. So far, US\$57,236 of the funds had been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by March 1, 2005. Solicitation began November 2002, and negotiations were completed August 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-03-D-2355)
Pratt & Whitney	200.0	August 15, 2003 – Pratt & Whitney, Hartford, Connecticut, was awarded a US\$200,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. At this time, US\$51,846 of the funds had been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by August 2011. Solicitation began November 2002, and negotiations were completed August 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-03-D-2354)
Williams International	40.0	September 24, 2003 – Williams International Corporation, Walled Lake, Mich., has been awarded a US\$40,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. To date, US\$5,350,000 of the funds have been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by January 2007. Solicitation began June 2002, and negotiations were completed September 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-03-D-1461)
Florida Turbine Technologies	10.0	September 29, 2003 – Florida Turbine Technologies, Jupiter, Florida, has been awarded a US\$10,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. US\$25,000 of the funds have been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by September 2011. Solicitation began November 2002, and negotiations were completed September 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (F33615-03-D-2359)

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
Teledyne Technologies Inc	10.0	November 24, 2003 – Teledyne Technologies Incorporated, Toledo, Ohio, has been awarded a US\$10,000,000 indefinite-delivery/indefinite-quantity contract to provide for VAATE Phase I. The USAF can issue delivery orders totaling up to the maximum amount indicated above, though actual requirements may necessitate less than this amount. At this time, US\$53,695 of the funds have been obligated; further funds will be obligated as individual delivery orders are issued. Work under this contract award will be completed by November 2011. Work will be performed in Toledo, Ohio. Solicitation began November 2002, and negotiations were completed November 2003. The U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is the contracting agency. (FA8650-04-D-2400)

Recent Activity

The USAF R&D Propulsion Directorate's Combustion Science Branch is working in conjunction with academia to develop sensor platforms for optical diagnostic measurements of the hot exhaust gases of advanced combustors. These advanced combustors are under development for the Integrated High Performance Turbine Engine Technology and Versatile Affordable Advanced Turbine Engine programs.

One platform under development involves triple-pump coherent anti-Stokes Raman scattering for measuring temperature and major species concentrations. The second platform involves small solid-state lasers and non-linear crystals for detecting trace species, namely carbon monoxide (CO) and nitric oxide (NO), through line-of-sight absorption measurements.

The program is being funded through a Phase II Small Business Innovation Research initiative. Other companies involved include Innovative Scientific Solutions Inc (ISSI) of Dayton, Ohio, and Texas A&M University (TAMU).

Representatives of the TAMU team recently visited Wright-Patterson Air Force Base to demonstrate the CO and NO sensors in the directorate's Well-Stirred Reactor (WSR) facility. Burning a lean mixture of ethylene/air, the WSR provided a stable exhaust plume for sensor evaluation.

Timetable

<u>Year</u>	<u>Major Development</u>
1997	Formulation of IHPTET successor program begun
2000	Agenda for VAATE program announced
2005	All IHPTET activities to be concluded; VAATE to formally commence
2006	Four-fold increase in engine technology affordability to be realized
2010	Six-fold increase in engine technology affordability to be realized
2017	Ten-fold increase in engine technology affordability to be realized

Worldwide Distribution

All preliminary work conducted in the United States.

Forecast Rationale

The VAATE program will gain momentum over the next year as its predecessor, the Integrated High Performance Turbine Engine (IHPTET) program, approaches its scheduled 2005 completion date. The major participating engine builders have been awarded substantial USAF contracts to fund the upcoming

12 year quest for lower cost, more durable gas turbine engines.

Pratt & Whitney's latest IHPTET contract, valued at US\$12.7 million and issued by the U.S. Navy last year, calls for a demonstrator engine based on the PW800 core. That engine will also be utilized as one of P&W's

baseline configurations for the VAATE program, according to a Pratt statement. Company officials hope the ongoing project will provide its military and civilian customers, with “a cost-effective approach to cutting-edge technology.”

Pratt & Whitney’s research will focus on military engines, while GE will pursue advances in both military

and civil turbofan applications. Honeywell will investigate improvements in turboprop and turboshaft engines, with an emphasis on military uses. Williams is expected to focus on small turbofans for expendable vehicles, and could develop small turboshaft technology for vertical take-off UAVs or light helicopters.

Ten-Year Outlook

The VAATE program began in 2002 with awarding of initial contracts. Major funding was committed in 2003. The affordability of the engine technology is set to increase by four, six, and 10 times in 2006, 2010, and 2017, respectively.

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