$6.00 JULY 20, 2009

AVIATION WEEK
& SPACE TECHNOLOGY

THE FIGHT OVER F-22

A New Approach To VTOL

Page 36

Secure Collaboration On The Internet

Page 44

Page 53

The McGraw·Hill Companies

AviationWeek.com/awst

Close

Print This Page

On The Cover

On the Cover

Aviation Week & Space Technology Jul 20 , 2009 , p. 01

Aurora Flight Sciences’ Excalibur experimental vertical-takeoff-and-landing unmanned combat aircraft rises to a hover on its June 24 first flight at Aberdeen Proving Grounds, Md. The 13-ft.-long subscale proof-of-concept aircraft is the testbed for a hybrid turbine-electric propulsion system comprising a tilting jet engine and battery-driven lift fans (see p. 36). Using exclusive first-flight photographs by John Tylko of Aurora Flight Sciences, the AW&ST Art Dept. created a “time-lapse” image of the aircraft lifting off.

Find this article at:
http://www.aviationweek.com:80/publication/awst/loggedin/AvnowStoryDisplay.do?fromChannel=awst&pubKey=awst&channel=awst&issueDate=2009-07-20&story=xml/awst_xml/2009/07/20/AW_07_20_2009_p04-154173-01.xml&headline=On+the+Cover

Close

Close

AVIATION WEEK
INTELLIGENCE NETWORK

Print This Page

Unmanned Aircraft

Aurora Flies Hybrid VTOL UCAV Demonstrator

Aviation Week & Space Technology Jul 20 , 2009 , p. 36
Graham Warwick
Washington

Aurora flies turbine-electric UAV designed to combine high speed and vertical flight
Printed headline: Hovering Hybrid

One hundred feet above the U.S. Army's Aberdeen Proving Grounds in Maryland, executing pre-programmed hover maneuvers, the experimental Excalibur could be providing a glimpse of future unmanned combat aircraft. And not just because of its unusual configuration.

Excalibur hovers on jet engine and electric lift-fan power during its June 24 first flight, which lasted just under 2 min. Takeoff, hover and landing were autonomous.Credit: AURORA FLIGHT SCIENCES CORPORATION/JOHN TYLKO

Flown for the first time on June 24, the aircraft is a testbed for a hybrid turbine-electric propulsion system that developer Aurora Flight Sciences believes can efficiently combine high speed and vertical takeoff and landing (VTOL) capability. Beyond that, the Virginia-based unmanned aircraft specialist sees hybrid propulsion as "fundamentally enabling" for a wide range of missions.

"Electric propulsion has an enormous place in next-generation aircraft," says Aurora President John Langford. "Excalibur is the first flight article in a very rich vein with a lot of applications."

Also for NASA, the company conceived a series of unmanned aircraft designed to fly in the rarefied Martian atmosphere, culminating in 2002 in a high-altitude deployment in which a half-scale MarsFlyer demonstrator was released from a helium balloon above 100,000 ft. to unfold and descend autonomously.

The experimental unmanned combat aircraft is checked out before its first flight at Aberdeen Proving Grounds. Thrust-vectoring vanes under lift fans are used for yaw control.Credit: AURORA FLIGHT SCIENCES CORP./JOHN LANGFORD

The experimental unmanned combat aircraft is checked out before its first flight at Aberdeen Proving Grounds. Thrust-vectoring vanes under lift fans are used for yaw control.Credit: AURORA FLIGHT SCIENCES CORP./JOHN LANGFORD

Since it was founded 20 years ago, the company has made its name developing one-off unmanned aircraft for NASA and the U.S. military. Aurora built the Perseus and Theseus remotely piloted vehicles for NASA to test high-altitude propulsion systems; the Perseus B exceeded 60,000 ft. in 1998 on a triple-turbocharged piston engine.

Aurora has continued to focus on high altitude, designing the Orion long-loiter UAV around a liquid hydrogen-fueled propulsion system using an automotive engine modified to operate above 65,000 ft. Construction of the 132-ft.-span aircraft is under way at Aurora's Columbus, Miss., plant, but the Army-supported technology demonstration may be changing direction, with the possibility that the Orion might fly in mid-2010 with a conventional piston engine to demonstrate five-day endurance at medium altitudes of around 20,000 ft.

The company is also working under the U.S. Defense Research Projects Agency's (Darpa's) Vulture program to demonstrate technology for a solar-electric unmanned aircraft capable of staying aloft in the stratosphere for up to five years. Aurora's Odysseus concept involves three UAVs that would be launched independently to join up in flight to form a unique Z-wing vehicle designed to maximize solar energy collection by day and minimize drag by night.

Aurora was not selected to proceed into Phase 2 of the Vulture program, but it filed a protest that has forced a recompetition. Meanwhile, in May the company flew a large solar-powered unmanned aircraft, the SunLight Eagle, produced by modifying an airframe originally built as a prototype for the Daedalus human-powered aircraft. The company plans to fly the 114-ft.-span UAV to progressively longer durations and higher altitudes.

Despite its association with high altitude and long endurance, Aurora has ventured into tactical UAVs. In the late 1990s, the company built a subscale version of Raytheon's proposed unmanned combat air vehicle demonstrator. A quarter-scale tailless delta flying-wing vehicle was flown, but Raytheon did not win the contract.

Aurora then began to focus on VTOL, flying the GoldenEye ducted-fan UAV in July 2003. The autonomous aircraft was designed to take off vertically, then transition to forward flight on swiveling wings. Developed with Army funding as a clandestine UAV for deploying ground sensor packages, the initial GoldenEye 100 was a 150-lb. vehicle with 22-lb. payload, 4-hr. endurance and 160-kt. maximum speed.

The company also built several smaller GoldenEye 50s, an 18-lb. version with 2-lb. payload and 1-hr. endurance, for flight-testing and potential homeland security missions. But a 2004 contract from Darpa led to development of a third version, the GoldenEye 80, first flown in 2006.


Three 12-kw. battery-powered lift fans and a 700-lb.-thrust-class Williams F415 turbofan—developed to power the Tactical Tomahawk cruise missile—provide thrust for vertical flight.Credit: AURORA FLIGHT SCIENCES CORP./PATTI WOODSIDE

Originally intended to produce an organic UAV for the Army's Future Combat Systems program, the Darpa project was eventually terminated, but Aurora continued work and in April completed company-funded development of the Block 1 vehicle. This is Aurora's first UAV product, although the company has yet to secure a customer. The GoldenEye 80 is a 150-lb. vehicle with 18-lb. payload. Endurance ranges from a couple of hours for the Block 1 vehicle to 8 hr. for the eventual wing-equipped Block 3.

When work began on the Excalibur in 2005, there were no examples of hybrid electric aircraft. "The initial problem was how to merge VTOL with high-speed flight," says Tom Clancy, chief technology officer.

"The fundamental challenge with VTOL is that the high power required for vertical flight means the engines are oversized for cruise," he says. To avoid "carrying around too much engine," Aurora surveyed technologies and settled on a hybrid turbine-electric approach to matching the thrust requirements for vertical and forward flight.

The Excalibur uses a tilting jet engine for primary propulsion and electric lift fans for supplemental thrust and attitude control in vertical flight. "A significant portion of vertical thrust is provided by lift fans, so we can size the engine optimally for the cruise," says Clancy. For VTOL mode, the turbine engine tilts vertically and provides about 70% of the thrust. This allows use of an off-the-shelf turbine engine, reducing costs.

Battery-powered lift fans in the nose and wingtips provide the balance of vertical thrust. Pitch and roll control is achieved by differentially varying the speeds of the fixed-pitch fans, while yaw control is via vanes that vector the fan thrust. "Using the lift fans simplifies attitude control compared with more complex systems that have to extract engine power and get it some way from the center of gravity," he says.

For forward flight, the main engine tilts to the horizontal, the lift fans retract into the wingtips, doors cover the nose fan, and the aircraft rolls over so the wing is on the bottom. Subwings would carry weapons, principally four Hellfire missiles.


Aurora plans to complete low-speed testing—"waking the box" in hover mode using the lift fans for attitude and speed control—on company funding.Credit: AURORA FLIGHT SCIENCES CORP./JOHN TYLKO

Recharging the batteries from the engine in the cruise is expected to take 15-20 min. The proof-of-principle vehicle lacks the ability to recharge in flight and starts with each of the 12-kw. lithium-polymer battery packs fully charged, providing about 6 min. of power, enough for two takeoffs and landings.

"This is a VTOL vehicle and is not designed to hover," says Langford. "A takeoff and landing cycle is well under 3 min., so we should get two full cycles without recharging."

The original design mission was to deliver 400 lb. of weapons in a survivable aircraft with high speed and low signature and the ability to operate from small ships and unprepared fields. The objective design has a 4,000-lb. VTOL gross weight, a 30-ft. span reducing to 21 ft. with the lift fans retracted, and a 300-kt. maximum speed at sea level increasing to 460 kt. at 30,000 ft. Ceiling is 40,000 ft. and loiter speed 90 kt.

Aurora wanted to demonstrate the concept at a relevant scale that was large enough to use the same type of technologies as the full-size aircraft. The resulting proof-of-principle (POP) vehicle is half-scale: 13 ft. long with a VTOL gross weight of 720 lb., 10-ft. span with lift fans retracted and a 280-kt. sea-level speed capability.

"In this phase, we are not initially focused on leap-ahead technology in any area, such as energy storage or motor performance," says Clancy. "The question is, 'what can current technologies enable?' Our goal is to bring through flight test a high-speed VTOL vehicle at significant scale to demonstrate a point in the broad space of hybrid technologies."

The batteries come from the personal electronics industry, and are packaged with power control electronics and brushless direct-drive motors to produce a reliable aerospace power system. "It's pretty mature technology with relatively high specific energy and power. We got the performance we were aiming for to get a realistic impression of what the technology can do," Clancy says.

The program was begun with support from the Army's Aviation Applied Technology Directorate and the Office of Naval Research. Funding has paced development, with $20 million spent to date. Recent work, including the first flight, has been funded internally by Aurora, which is looking for additional support for the next phases.

The company plans to test the Excalibur in three flight regimes: low speed to 20 kt., medium speed to 40 kt. and high speed to 300 kt. indicated/400 kt. true airspeed. Up to 20 kt. is the hover regime, where the engine remains at a fixed angle and attitude and velocity are controlled by the lift fans.

As speed is pushed to 40 kt., control becomes a blend of aerodynamic surfaces and lift fans. Beyond 40 kt. the aircraft goes through a configuration change, retracting and covering the lift fans, retracting the gear, lowering the engine and moving to all-aerodynamic lift and control.

As built, the POP aircraft is only capable of low-speed flight and will require "minor" modifications to get to medium speed. These include making the control surfaces active. Because more significant modifications, such as retracting gear, would be needed for high-speed flight, there are plans to build a second demonstrator. While it looks for funding sources, Aurora plans to complete low-speed testing on company money.

Hybrid technology is evolving rapidly, but Aurora believes the original design concept is still valid. “We have a calibrated design point in a broad trade space. We can look at trades between jetborne and lift-fan power, electrical and fuel energy storage, etc., for a number of different roles, capabilities and concepts of operation,” says Clancy. “But for the mission the Excalibur was designed for—rapid response and survivable weapons delivery—it is quite appropriate.”

The original intent was to focus on high-speed VTOL, but Aurora sees a broad range of missions. “Overall, we see high-speed VTOL as an enabling capability for commercial and military markets. Meanwhile, specific power continues to increase, which can only improve the effectiveness of the turbine–electric hybrid configuration,” says Clancy. “We are on the leading edge of a trend toward electric propulsion. It’s a real trend, and not a flash in the pan.”