High Hover Finds Hidden Hostiles

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Designed with low radar cross-section, low profile, low drag and low specific fuel consumption, the A160 hovers with sensors over targets up to 20 hours at 30,000 feet. The Defense Advanced Research Projects Agency (DARPA) Hummingbird unmanned helicopter's fuselage and rotor blades are made of composite materials.

Rotary-wing unmanned aerial vehicle excels, offers sensor array, communications relay.

Built for intelligence, surveillance and reconnaissance missions, the new A160 Hummingbird unmanned helicopter is designed to fly autonomously with a high-altitude endurance of 20 hours. This aerodynamically clean platform rivals fixed-wing aircraft performance to employ a suite of sensors, including foliage penetration radar that unmasks hidden troops and vehicles.

The A160 radically advances the state of the art in rotary wing aeronautical design and engineering. This $75 million Defense Advanced Research Projects Agency (DARPA)/ Army program employs an optimum variable-speed rigid rotor system that allows slower blade rotation to increase fuel economy and endurance. Designed to loiter at an altitude of 30,000 feet, the Hummingbird's range is 2,200 nautical miles, which is more than twice the endurance of other unmanned helicopters such as the Army's Fire Scout.

This aircraft can be equipped with day or night long-range optics, a laser range finder and target designator, a precision microwave synthetic aperture radar, an electronic intelligence system, a satellite communications link and an electronic countermeasures payload, according to Philip V. Hunt. He is DARPA's A160 program manager. Weapons also can be carried for armed intelligence, surveillance and reconnaissance (ISR). An unmanned aerial vehicle (UAV) ground moving target indicator (GMTI) radar is in parallel development by DARPA. This new sensor system is designed to detect enemy forces deployed beneath trees in forests or jungles.

The A160 literally flies itself using preprogrammed autonomous mission plans, Hunt points out. "The aircraft can, however, be dynamically re-tasked from anywhere in the mission area with a network connection to the groundstation. This feature enables smaller organic ground units at various levels of command to exploit the reconnaissance capability. Mission plans include three-dimensional waypoint navigation, heading locks and triggering from external events. The system also includes a programmable lost-link mission plan. The Hummingbird can be preprogrammed to account for high moments caused by winds blowing over a stiff rotor and large changes in lift that any helicopter experiences in winds," he declares.

In addition to variable speed, the lightweight high-stiffness rotor system provides low disk loading, high-lift-to-drag blade airfoils and hingeless rigid in-plane rotors for precision control and quiet operations. The rotor speed varies over a range of flight conditions, vehicle weight, altitude, airspeed and load factor to maintain the best lift/drag ratio, Hunt states.

"All of the Hummingbird's features relate to endurance, providing sensors on station for extended periods. The aircraft can fly for 20 hours at sea level with a 300-pound payload or hover out of ground effects at a 15,000-foot altitude, and it has an airspeed of 140 knots," Hunt notes. A former British Royal Navy officer who in 2002 became a U.S. citizen, he originally was assigned to the F-35 Joint Strike Fighter program. Earlier he served as an

engineering officer in fixed-wing Sea Harrier and rotary-wing squadrons at sea.

“The A160’s carbon fiber fuselage and blade design are unique, achieving the least sum of induced and profile drag,” Hunt continues. “The design leads to lower power demands throughout the flight envelope. This reduced drag means the engine works less hard so that you don’t require as much fuel, and that extends range and endurance for the fuel carried.

“The aircraft also has built-in survivability features, including a very quiet acoustic signature, in comparison to other helicopter platforms, through its rotor system design,” Hunt says. He holds a bachelor of science degree in mechanical engineering from the University of Bristol and a master’s of science degree in vibrations and dynamics from the University of Surrey, both in the United Kingdom.

“The Hummingbird is out of the DARPA Amber and Gnat/Predator stable of Abe Karem at Frontier Systems, Irvine, California,” Hunt relates. “His design goal reduces the work done to fly the aircraft and employs efficiencies that lead to reduced specific fuel consumption. Boeing Company acquired Frontier, and under an approximately $50 million agreement is now the A160 program’s prime contractor.” Karem, a former Israeli air force officer before immigrating to the United States, is widely known as an innovative aviation pioneer.

The A160’s airfoil maintains quiet by controlling the velocity over the rotor wing—very low disc loading. The UAV achieves multipoint design performance with the ability to operate at an optimized rotor speed that minimizes the effect on lower altitude performance. As an example, Hunt cites the Navy/Marine Corps CH-53 helicopter’s disc loading of 14 to 17 pounds per square foot. By comparison, the A160 flies at 5 to 6 pounds per square foot, creating much less noise. The Hummingbird’s acoustic signature is four times less than that of the Bell 407 helicopter, he reports.

The A160 rotary-wing unmanned aerial vehicle takes off to demonstrate its flight characteristics. Note the retractable landing gear is in a landing position. When airborne the gear is stowed to reduce drag. The aircraft can carry a centerline pod for sensors and supplies with sufficient ground clearance.

A retractable landing gear for the A160 enables autonomous takeoff and landing from airfields or from the decks of ships at sea. The landing gear arrangement also provides sufficient ground clearance to carry a centerline sensor or resupply pod beneath the aircraft. “With the retractable landing gear, the Hummingbird reduces drag and can carry a 1,000-pound payload to a radius of 500 kilometers for priority resupply missions. This load-carrying capability provides a possible command, control, communications, computer, intelligence, surveillance and reconnaissance [C4ISR]/resupply platform for Army, Navy, Marine Corps and other government agencies,” Hunt explains. “The UAV is also being evaluated for special operations, data relay and crew recovery missions, and it could be armed with weapons such as Hellfire and Javelin anti-armor missiles or similar ordnance.”

The Hummingbird’s concept of operations is to base the aircraft within theater using it as necessary to support dismounted troops. Lower echelon forces can provide input to the system for priority reconnaissance missions. The UAV also can carry an unmanned ground vehicle, which it would land at precise locations possibly for use in inspecting improvised explosive devices, Hunt discloses.

Advances in A160 aeronautical systems are expected to have a far-reaching effect on the U.S.

helicopter industry. System reliability enables 1,000 flight hours between air vehicle losses. Industry is developing diesel aircraft engines for the Hummingbird separately for DARPA, and these will boost loiter time on station with a full sensor payload, Hunt notes. The UAV program is conducting development tests with heavy fuel engine technologies in support of, and in coordination with, other DARPA programs. These highly efficient diesel engines would improve operational reliability and battlefield logistics compatibility.

A challenge from the beginning of the A160 program is scarcity of aero-diesel engines. Karem and Frontier began development of the KW660 diesel engine for the Hummingbird, but with Boeing's purchase of the company the engine effort is slipping. Flight tests have been conducted with a four-cylinder Subaru engine and an upgraded version of that engine that flew more than 55 hours on 24 flights. A six-cylinder Subaru engine also completed six flights. More than 1,000 hours of engine-powered ground and flight testing have been completed.

A diesel no longer is planned for installation in A160 in the current Phase 1. The focus is on a turboshaft engine in order to prove the basic aircraft performance and value. "We still have some residual diesel engine studies going on during Phase 1, and a follow-on program could include diesel engine installation into the UAV," Hunt acknowledges. "Nominally, a diesel engine, with its lower fuel consumption, could nearly double the 20-hour endurance of the turboshaft variant to allow the Hummingbird to achieve around 40 hours endurance."

The diesel engine companies include FEV, Auburn Hills, Michigan, and Achates Power LLC, San Diego, California. Meanwhile, a Pratt & Whitney 207D turboshaft engine has been installed in the A160, along with a two-speed transmission. The A160 needs longer development and is not ready to enter Phase 2, Hunt asserts. While DARPA pushes the technology out as fast as possible, the A160 is being developed efficiently and economically. Many of the pending reliability and endurance gains may be achieved in a follow-on phase.

Web Resources
DARPA A160 program: www.darpa.mil/ucar/programs/a160.htm
Boeing A160 Hummingbird: www.boeing.com/ids/advanced_systems/hummingbird.html

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