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Military

ONE STEP BEYOND

The Pentagon's defense research agency is funding a key project to explore how fast rotorcraft can go.

By James T. McKenna

U.S. DEFENSE RESEARCHERS ARE BANKING ON A LONG-NEGLECTED ROTORCRAFT TECHNOLOGY as the best bet for overcoming the practical helicopter speed limit under 200 kt.

The Defense Advanced Research Projects Agency (Darpa) is funding a team led by Salt Lake City-based autogiro maker Groen Brothers Aviation to design a proof-of-concept, long range, vertical takeoff and landing (VTOL) aircraft capable of cruising at 350 kt. It is to have an unrefueled range of 1,000 nm. It is also to be capable of carrying a 1,000-lb payload. Darpa's objective is to achieve performance with a rotary-wing aircraft comparable to that of a fixed wing one.

The work is part of a multi-year, $40-million, four-phase program. Groen Brothers is working on phase one of that program, a 15-month effort funded at $6.4 million. Darpa is scheduled to do a preliminary design review and system requirements review of the team's proof-of-concept aircraft in April.

That concept combines the "gyroplane," varieties of which Groen Brothers has been working on since the late 1980s, with a fixed-wing business jet. The team is using the A700, in the very-light-jet class, which has been developed by Adam Aircraft Industries. Darpa has dubbed the combination the Heliplane.

The Groen Brothers team amounts to a powerhouse of rotorcraft research. "Each member of this team has spent their lives becoming the best there is at their subjects."

A gyroplane flies by using a rotating wing, just as a helicopter does. But unlike a helicopter, its rotor system is not driven by the main engine, which only provides forward thrust by driving a propeller.

In the gyroplane's basic design, air forced through the rotor blades by the aircraft's forward movement causes the rotor to turn in autorotation to provide lift. Since the gyroplane in flight is always in autorotation, advocates argue, it is inherently safer, simpler and quieter than a helicopter.

The Groen Brothers team's concept modifies that approach, proposing to fit a main rotor to the A700 that is powered by small jet engines mounted on the rotors' tips for takeoff, hover, and landing. This variety is called a gyrodyne.

The work draws on the pioneering efforts of Juan de la Cierva, the Spanish aeronautical engineer who invented the autogiro in 1923 in his pursuit of a stall-proof aircraft. As Groen Brothers Chairman, President and CEO David Groen puts it, de la Cierva also solved the problem of dissymmetry of lift, thus clearing the way for the success of helicopters. De la Cierva's aircraft were widely used in France, Germany, Japan, and the United States until World War II, when they were eclipsed by helicopters.

Other notable related initiatives include the Fairey Rotodyne, the compound helicopter built in the late 1950s in anticipation of a British Royal Air Force order that never materialized. "We have taken a 40-year-old concept and revived it," said Darpa's Heliplane program manager, Don Woodbury.

"Most of the rotorcraft world has been blinded by their own history to the potential of the gyrodyne," Groen said. Darpa is not among that group.

The agency had funded two proofs of concept. The other was Boeing's canard rotor wing, a stop-rotor design embodied in the X-50A Dragonfly unmanned aerial vehicle. The X-50A used a conventional turbofan engine that diverted engine exhaust through exit nozzles in the rotor tips during rotary-wing flight. Once in full forward flight, the engine exhaust was diverted through a nozzle at the rear of the aircraft. The rotors then stopped spinning and locked in place to become wings, providing lift.

But that aircraft had a short and troubled track record.

The first crashed in March 2004, the result of a cross-coupling of controls.

In April 2006, the second crashed at the U.S. Army's Yuma Proving Ground, Ariz. on the sixth of 11 planned flights in the test program.

An investigation found its fuselage had an aerodynamic pitch moment that was extremely sensitive to airspeed and wake strength, including wake from the rotor. At low speeds, this produced a strong pitch-up moment that the flight controls could not counter.

Neither X-50A had performed the conversion to forward flight before it crashed.

In September 2006, DARPA withdrew its backing for the canard rotor wing concept.

Groen Brothers came to the Heliplane project in a roundabout way. Adam Aircraft had been the lead on the project, but was having problems with its main-rotor supplier. Groen Brothers was invited to supply that rotor. As a result, it drafted a memo to Darpa outlining the technical challenges before the project.

That led to Darpa asking it to take the lead on the initiative.

The Groen Brothers team amounts to a powerhouse of rotorcraft research. In addition to Adam Aircraft and Williams International, which is providing the turbofan engine for the aircraft, it includes the Georgia Institute of Technology and a renowned team of aerospace consultants, including key members of the rotorcraft faculty at Washington University in St. Louis, Penn State University, and the University of Maryland, as well as top rotary-wing scientists from throughout industry.

Georgia Tech has researched the gyrodyne extensively.

On the government side, the team is receiving support from NASA's Ames Research Center and the Army's Aero-Flight Dynamics Directorate there, as well as from leading rotorcraft technologists who for decades led much of this nation's advanced rotor-wing aircraft development efforts.

"Each member of this team has spent their lives becoming the best there is at their subjects," Groen said.

Boeing's Canard Rotor Wing concept appealed to Darpa, but two crashes led the agency to cut off funding.

Groen Brothers' concept mates a main rotor to the airframe and powerplant of Adam Aircraft's A700.

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The progress of the program is bittersweet for Groen. In October 2006, his brother and co-founder, Jay, died after a two-year battle with cancer.

"Jay's passing leaves a void within us all, but at the same time furthers our resolve to succeed in this endeavor to celebrate his dedication, devotion and persistence," said Groen.

Phase one of the program requires the Groen Brothers-led team to perform trade studies, develop appropriate risk mitigation, perform extensive advanced computer modeling of the entire Heliplane vehicle, develop the preliminary design for the Heliplane, and complete the rotor system design.

In its assessment of the technical challenges before the program, Groen Brothers listed five technical challenges, from toughest to easiest. First was aero-elasticity issues. Last was reducing rotorhead drag.

It turned out to be the opposite, Groen said.

"We were able to solve the aero-elasticity challenges fairly easily," a reflection of the confluence of ongoing rotorcraft research, computing capability—both in terms of analysis and modeling and in automated flight controls—and the talent of the assembled team

Reducing rotorhead drag, which accounts for half the vehicle's total drag, proved much more challenging.

In 1999, Groen Brothers manufactured and flew its first piston-engine version of the four-seat Hawk 4 gyroplane. This was followed by the five-seat, Rolls-Royce Model 250 turbine-engine version in 2000, the world's first turbine-powered gyroplane. It came to be called the Hawk 5

In 2002, the Hawk 4 was used to provide perimeter patrol around the Salt Lake City International Airport during the Winter Olympics and Paralympics.

In February 2003, having shelved plans to gain FAA certification of the turbine Hawk, Groen Brothers set up American Autogyro to produce "kit-built" Hawks. Last month, the company tentatively agreed to transfer the Hawk 4/5 program to a joint venture with the Spanish state of Aragon.