

An Israeli firm is proposing an advanced, ducted, tandem-rotor helicopter for emergency and special-operations missions. Bell Helicopter, its partner on the project, considers the concept the next thing in vertical-lift aviation.

Urban Aeronautics is using a 16.4-ft (5 m)-dia dome simulator in Israel (here and bottom inset) to size cockpit controls and establish flight control laws for its X-Hawk ducted-rotor vehicle (top inset).



BELL HELICOPTER AND AN ISRAELI FIRM are pursuing development of an advanced-technology rotorcraft that some at the U.S. manufacturer believe could change the face of vertical-lift operations.

The concept is based on the patented "fancraft" technology of the Israeli firm, Urban Aeronautics. The concept calls for a highly integrated propulsion and flight-control system that makes it possible to decouple the aircraft's movements, particularly in hover operations.

In light winds, most helicopters can easily maintain their position in a hover. But in gusts, a helicopter must roll or pitch into the wind to do that. In gusts varying greatly in speed and direction, "no helicopter can hover in one place accurately. It can also not stay horizontal," said Urban Aeronautics President and CEO Rafi Yoeli.

"Once we decouple the six degrees of freedom," he said, a rotorcraft can be developed that can serve as a stable hovering platform in such conditions.

The six degrees of freedom are the three translational ones—moving straight forward and back, up and down, and side to side—and the three rotational ones, familiar to aviators as pitch, roll, and yaw about the center of gravity.

The ability of a "fancraft" to move independently in any one of those freedoms, combined with the design's elimination of exposed rotors, creates the operational possibilities not available today. Such an aircraft theoretically could slide up to a building in midair until the hull makes contact with the structure, so people stranded by a fire below could be rescued, for instance, or a tactical team could be deployed to an advantageous position against a foe. Such an aircraft should have a great ability to operate in confined areas.

"This is the next new thing in aviation, vertical lift-wise," John Tatro, Bell Helicopter's director of advanced concept development, said of the "fancraft."

"We prefer to call it a compact helicopter," he said. "It's a tandem helicopter with high disk loading and we have the ability to put ducts on it."

Yoeli, a former aerospace engineer for Israel Aircraft Industries, set up Urban Aeronautics in 2001 in part to refine that technology. The company today is based in the Yavne industrial park about 15 mi south of Tel Aviv.

In 2003, Yoeli hovered the initial, two-seat version, the CityHawk, in Israel. "We started off with basic technological work," he said. CityHawk was just a proof of concept, but it "had no future. It had piston engines that were constantly overheating."

"So we knew back in 2003 that we needed to build a larger vehicle with turbine

By James T. McKenna

DECOUPLING THE FUTURE

engines," Yoeli said. "That's where we started talking to potential customers, the Israeli military and also people abroad—special forces."

In mid-2005, Yoeli presented the X-Hawk to Bell. By that time, Urban Aeronautics had already done initial wind tunnel tests. "So there was enough data to check the numbers, see that the weight and performance predictions are similar between us," Yoeli said.

Bell was interested and looked into the technical and operational aspects of X-Hawk, "with positive results," he said. In 2006, the companies signed a memorandum of understanding to cooperate on a phased development of the concept.

Assisting in that work is a team at Pennsylvania State University's Rotorcraft Center of Excellence under the leadership of Prof. Ed Smith. "They've been working on X-Hawk since the start of 2006," Yoeli said. "This will add some technical feasibility with some meat to the design." The school is working with funding from the U.S. Navy's Office of Naval Research.

Among the elements that appealed to Bell were Urban Aeronautics two key patents.

One is for the vane control system, which provides the ability to control the vehicle in roll and side-ward motion. The design calls for two, counter-rotating, horizontal, 8.2-ft (2.5-m) rotors in ducts fore and aft on the aircraft. Above and below each is a set of 100 small vanes. (Between the rotors would be a cabin roughly the size of that on a Bell 212 and designed to carry 10 passengers. The pilots would sit in cockpits on the outboard sides of the cabin, just behind the front rotor.)

"To suspend the 6,700 lb of the vehicle, we are obviously throwing down a lot of air very fast," Yoeli explained. "Air goes down faster in a helicopter because the disk loading is higher, but this also has positive sides. If you put a movable vane inside this flow and you rotate it a little bit, it creates a side force."

"If all these vanes are rotated like 5 deg each you can generate up to 800 lb of side force with no roll," he said. "We can have our lift vector

perpendicular to the ground and still generate side forces."

If the vanes are moved opposite to each other, that produces a pure rolling moment with no lateral translation. "Because the whole thing is fly-by-wire, computer-controlled, you can mix in any amount of side force with rolling moment," Yoeli said. "Of course, you can have yawing moment and pitch, so in essence you have a vehicle that has movement in six degrees of freedom irrespective of each other."

The other patent that interested Bell covers the sets of louvers in front of the forward rotor duct and aft of the rear one.

"Those ducts are a penalty in forward flight," said Tatso. But the louvers reduce that penalty. In cruise flight, they open to make airflow over the vehicle more streamlined and increase the aircraft's potential speed. Yoeli figures the X-Hawk would cruise at 120 kt.

"You get down to 50 to 40 kt or so," Tatso said, "you close the louvers up and that gives you that 20-30 percent lift augmentation."

As Yoeli explained, there are few more things that go into the X-Hawk beyond the vanes and louvers. One is the plan to use a very integrated flight control system.

"It's not like an aircraft that has a fuselage and a wing and they talk to each other where they mate, but not beyond that. In a helicopter, the cabin and the rotor are two separate entities," he said. With the X-Hawk, "everything is working together, so it's very, very important to make sure that this thing works as a package, that it's safe enough." Yoeli aims to eventually win FAA certification of the aircraft.

The X-Hawk's configuration creates very complex flows of air around and in the vehicle "in hover and forward flight, sideward, backward," Yoeli explained. "So this is really a very unique vehicle. Airflow is approaching this vehicle from all sides at one point or another."

That poses some challenges, "but from the testing that we've done so far, it looks really good."

Yoeli initially targeted the X-Hawk as an emergency medical services aircraft. In addition to the Israeli military and special forces abroad as potential customers, "we were also working with STAT Medevac in

Pittsburgh," he said. "They defined themselves as our design partner, and they were helping us a lot on the EMS version, trying to get this into a useful machine."

Urban Aeronautics also talked to fire departments, police units, and "many, many customers, and decided that we needed to increase the size of the vehicle" to one with at least six seats and the ability to fly at 120 kt for 2-3 hr.

"This was the minimum requirement," Yoeli said. "We started locating engines that would be suitable for that and we ended up for the higher end, realizing that as long as we're using a 1,300-hp engine, presently the LHTEC T800 family, we might as well make room for up to 10 people in the cabin and two crewmembers in the cockpit."

"This, we believe, is a vehicle that has the widest market in terms of being able to break even on the program," he said. "It probably won't suit Jim Bothwell at STAT Medevac, except that he has a few bigger helicopters."

In addition to its target max takeoff

weight, the X-Hawk now is designed for endurance, with maximum fuel of 1,300 lb, at about 2 hr with reserve. Its max range would be 330 nm and its operating radius would be 140 nm.

Yoeli said the X-Hawk won't compete with Eurocopter's EC135 and similar civilian aircraft. "But the military applications seem very bright, because you can actually fly for 2 hr with eight people on board, and wind tunnel tests have shown you can indeed go up to 140 kt, maybe more," Yoeli said. "You can hover on a single engine after having lost an engine at max takeoff weight. You can do this in gusty winds, icing conditions, so this vehicle has tremendous potential."

The drawback is higher fuel consumption. "If you're over even terrain or open ground and you have a large load to carry for a long distance, you can take a Bell 212 or similar helicopter and you'll be fine," Yoeli said. "You'll burn less fuel using that. If you're talking about short range, about utility, about being able to get into a city" or confined areas, "or you

want to be more stealthy, fly lower, create less noise, be less of a target, this vehicle is ideal."

The current configuration won't be the only one, he said. "There are some special forces looking for something smaller," he said. "Certainly, the commercial market will look for something that's smaller."

The aircraft must be certifiable to civil aviation standards, he said. "This cannot remain an experimental vehicle. This has to be fielded, marketed. So that's the horizon that we're working towards."

The company has completed the master tool for its prototype X-Hawk and is setting up shop in Yavne to begin creating the set of female molds needed to construct the vehicle's all-composite structure.

The Purdy Corp. in Manchester, Conn. is working on the X-Hawk's power distribution system. The lift rotors are also in production at Aero-Composites in Kensington, Conn. and are expected to be delivered towards mid-year. Urban Aeronautics is developing the flight control system. ■

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