

Karem Aircraft

Building New Tiltrotor Ideas

US Army funds ground testing of revolutionary rotor system

By Richard Whittle

The US Army Research, Development and Engineering Command (RDECOM) didn't choose Karem Aircraft's proposed Optimum Speed Tilt Rotor (OSTR) as one of the Joint Multi-Role Technology Demonstrator (JMR TD) aircraft being built to fly by 2017, but the service continues to fund research and development of key components of the company's design for its unique type of tiltrotor.

"The Army has told us that they are very, very interested," said Benjamin Tigner, the Irvine, California, company's director of advanced systems programs. "They see a lot of potential for dramatically increasing the performance of rotorcraft and tiltrotors through our technology. Specifically what they are funding us for is to develop all the components that are needed and then to go do a ground rotor test where we put a complete copy of a rotor and a nacelle on a tilting stand in the desert and we run it through all its paces, through all its RPMs [revolutions per minute] and load cases, and verify what it can do."

An Army statement released in April said Karem would "fabricate and test subcomponent articles" including "rotor blades and hub components such as actuators, bearings and electronics" and do a "hub integration functionality test to prepare for a full-scale wing-rotor ground tie-down test in the future."

Tigner and company owner Abraham Karem, best known as father of the Predator drone, declined to say how far along they are toward building their 36 ft (11 m) diameter rotor and related components. Nor have they decided precisely when and where the test stand will be built. "We are where the Army wants us to be and making good progress," Tigner said. But the tests on the stand will demonstrate "basic rotor efficiency and all the integration of all the technologies that go into" Karem's patented rotor system, he said.



Karem's ATR-36 is the JMR/FVL attack variant, featuring 36 ft (11 m) diameter proprotors that are "very rigid, propeller-like but very light rotor". (All Karem Aircraft graphics)



The UTR-36 uses the exact same rotor system and wing mated to a utility fuselage — à la the UH-1 Huey and AH-1 Cobra.

Variable Rotor Speed Key to Efficient Flight

Rotor speed is among the fundamental challenges of tiltrotor aircraft. The proprotors must produce the lift necessary for vertical takeoff and landing, as well as hover, but then tilt forward and act as propellers, burning less fuel when they turn at lower RPM than required for vertical flight. The Bell Boeing V-22

Osprey tiltrotor, for example, reduces its rotor speed in airplane mode to 84% of vertical flight RPM. The rotor his company has designed for the JMR-TD, Abe Karem said, is lighter and more rigid than those used on the V-22 or any other prior tiltrotor and will be able to reduce its RPM for horizontal flight to less than one-half that required for vertical flight.

"All of my tiltrotor designs have two-speed transmissions," Karem added. Ordinarily, he said, "The turboshaft

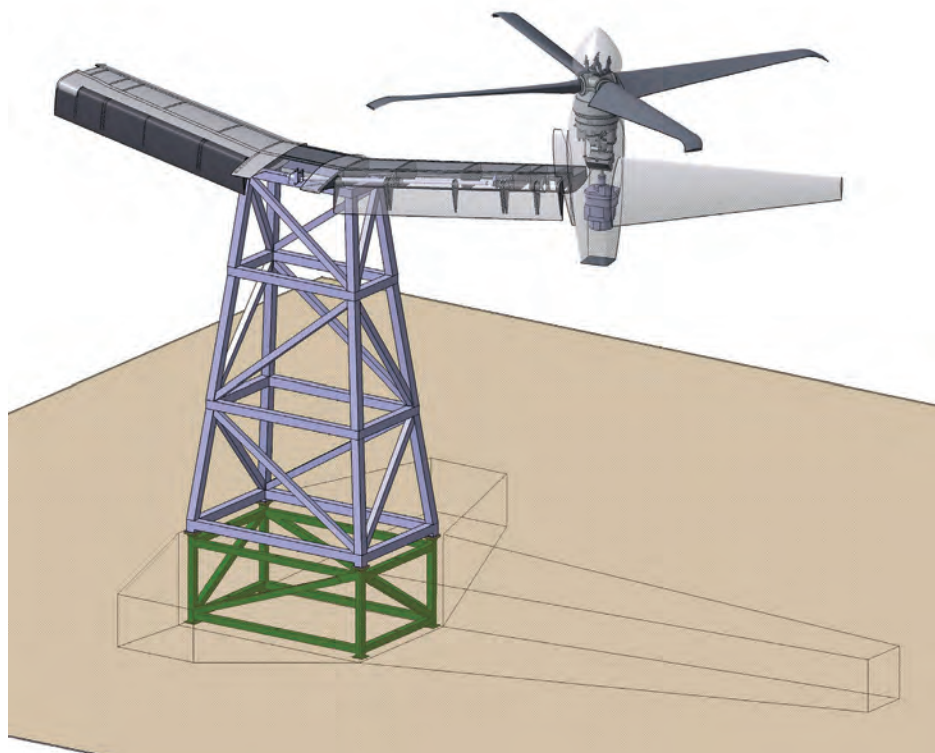
Rotors Not the Only Revolutionary OSTR Feature

Karem and Tigner emphasized that the OSTR they are developing for JMR-TD is not a set of parts that can be installed on, say, Bell's V-280 Valor to improve performance. Rather, Tigner said, "The OSTR is a holistic system solution, very different from conventional tiltrotors, offering far higher system performance through the integrated improvements in multiple technologies."

Karem elaborated, "You have not only the blade, which is unique, not only the hub, which is super-unique, but you have individual blade control, which is something people were thinking about for a long time but nobody has [solved]," he said. "You have a very rigid, propeller-like but very light rotor [on which] each blade, very much like the prop, has variable pitch, but all blades move at the same angle. This is individually controlled, so each one of them moves separately — and it's not done the way a helicopter is doing with a swashplate." Being able to change the pitch of each blade individually in forward flight can be used to dampen vibration in the aircraft and offers other advantages as well, he said.

Holistic Design Produces New Kind of Tiltrotor

Tigner emphasized that, "What makes OSTR tiltrotor aircraft so efficient is not just the rotor, it's a combination of all the technologies in the rotor and all the other technologies" in the aircraft, such as extensive use



The US Army is funding Karem "to develop all the components that are needed and then go do a ground rotor test ... on a tilting stand in the desert".

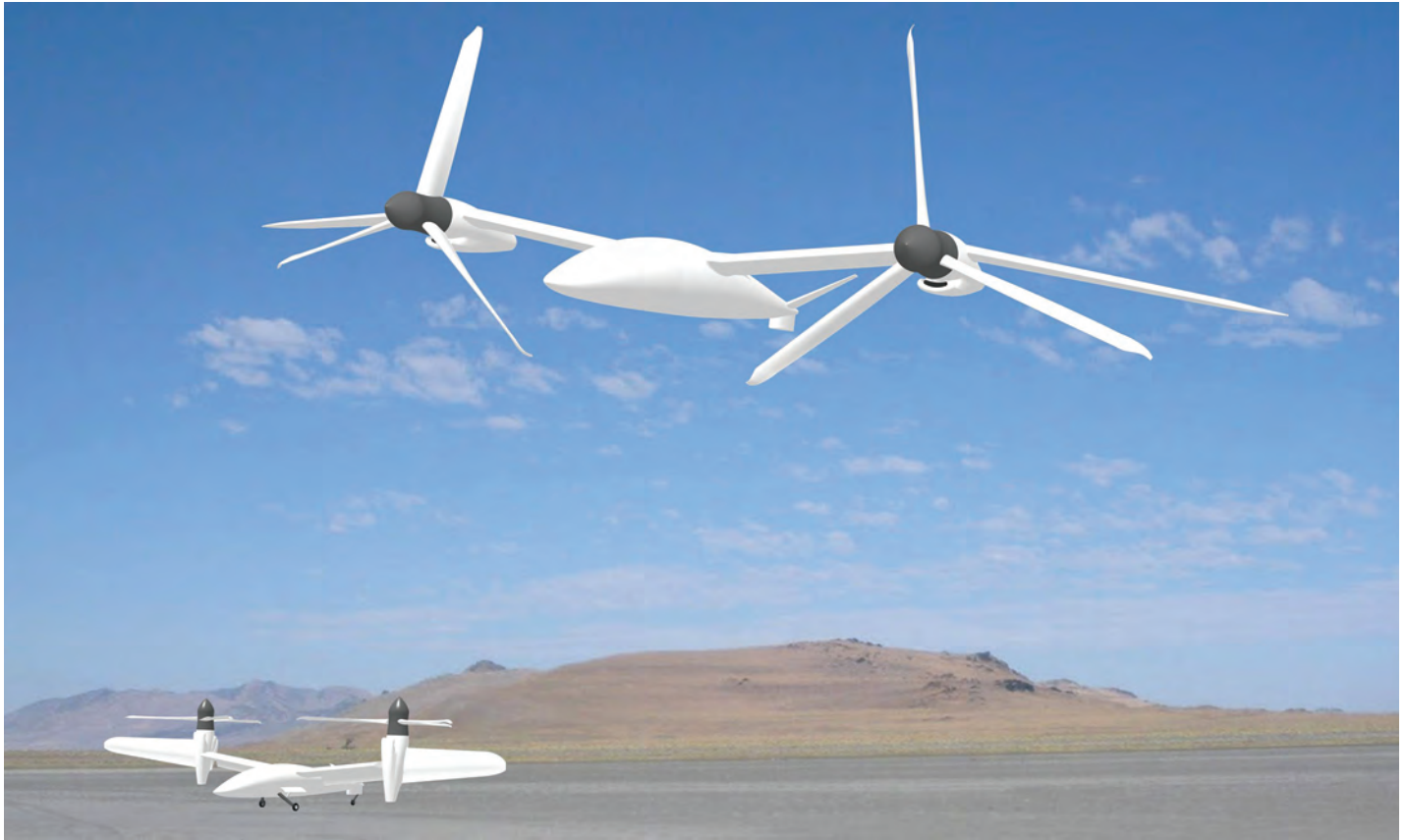
engine is not efficient when you reduce the RPM," but his two-speed transmission "allows the RPM of the turbine engine to be where the specific fuel consumption is right."

Karem Aircraft has been working on tiltrotor designs for a number of years. Previously, they offered a version of the OSTR able to carry 41 tons of payload for the now-defunct Joint Heavy Lift program, another Army project that predated the Future Vertical Lift initiative. Karem also has designed OSTRs as civilian passenger aircraft concepts and for the Defense Advanced Research Projects Agency's

VTOL X-Plane ("Vertical Take Off and Landing Experimental Plane") program, now underway. The latter competition sought designs for an optionally manned VTOL aircraft weighing 10,000 – 12,000 lb (4.5 – 5.4 t), able to cruise faster than 300 kt (550 km/h) and capable of even greater hover efficiency than conventional helicopters. Karem Aircraft's DARPA VTOL X-Plane design, though much lighter, uses the same diameter rotor as their JMR-TD. As with their other OSTR designs, Karem's development work on the DARPA VTOL X-Plane is reflected in their ideas for their heavier JMR-TD concept.



A comparison of scale models that all use comparable Optimal Speed Rotor Systems: the TR-36XP, ATR-36 and UTR-36.



The TR-36XP is Karem's proposal for the DARPA VTOL X-Plane. It also uses a 36 ft (11 m) rotor, but for an aircraft about one-third the weight.

of lightweight composites and "high efficiency aerodynamics."

"All the other technologies are things that are much more common elsewhere in the world of aerospace, so they're not high risk things that need to be tested on the rotor test stand," Tigner said. But, integrated into a "holistic" design with Karem's rotor, he said, the combination of those technologies makes the OSTR aircraft unique.

One example is the OSTR's interconnecting driveshaft, Karem

said, which keeps its rotors in sync and ensures that one engine can turn both rotors. The V-22 and V-280 interconnecting driveshafts also do that, but Karem said the OSTR interconnecting driveshaft also can be used in the opposite way — to disconnect the rotors, so the aircraft can fly on just one of them.

"It has the advantage of being able to fly for the whole range of the aircraft with one rotor stopped and the blades feathered like a prop aircraft

with two engines," Karem said. "You can disengage the cross-shaft from one nacelle, you can disengage it from the other nacelle, or both nacelles, so if you have a broken and whipping cross-shaft, you can stop it."

Karem said such features should be of great interest to the military, because they can increase the OSTR's survivability in combat. "If you hit a blade on a (conventional) tiltrotor, or for that matter you hit a blade on a CH-47, you're out of luck," he said. "We can continue flying for another 1,000 or 2,000 miles and come home."

His company developed such features, Karem said, partly by working on the civilian airliner version of the OSTR, which has to offer safety comparable to the Boeing 737 or Airbus 320. "What we have," he said, "is a really complete portfolio of technologies and smart designs that create a lot of pieces of that tiltrotor aircraft that in combination help each other, and in combination, they do a big step."



Karem continues its work on its AeroTrain civil airliner, which was developed in tandem with its Joint Heavy Lift concept. The TR53 model is a well-known display in Karem's AHS Annual Forum exhibit.

