Army pushes for higher speeds in future tiltrotor aircraft

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Army researchers working at NASA Langley Research Center in Hampton, Virginia, analyze complex flight challenges unique to rotorcraft and tiltrotor aircraft. Credit: David McNally

The U.S. Army is developing a new wind-tunnel testbed that will help

future tiltrotor aircraft attain higher speeds, improved stability and enhanced safety.

At a massive wind tunnel at NASA Langley Research Center, Army researchers are readying a unique tiltrotor model to support analysis and design of advanced tiltrotor aircraft, a possible key to achieving Army modernization goals for Future Vertical Lift.

"Tiltrotors are like the V-22 Osprey aircraft that the Marines currently use," said Matt Wilbur, a senior aerospace researcher with the U.S. Army Combat Capabilities Development Command's Army Research Laboratory. "Their benefit is they have very high flight speeds. They can transition from a helicopter configuration to a forward flight configuration that looks more like a turboprop aircraft and can go at much higher flight speeds than typical helicopters."

Current state-of-the art tiltrotors provide Army researchers with a baseline of what is possible. In the future, aircraft designers will leverage new materials, advanced propulsion and supercomputer modeling—validated by physical experiments—to deliver new combat capabilities to the Army.

"The data we're going after is completely new; it doesn't currently exist," said Dr. Jaret Riddick, director of the lab's Vehicle Technology Directorate. "We want to be able to model whirl-flutter stability, which will help us to overcome a critical limitation for tiltrotor aircraft."

Tiltrotor designs require a compromise between a spinning helicopter rotor for efficient hovering flight and a fixed wing for forward flight in airplane mode, he said. Interactions between this unique combination of rotor and wing can lead to instability at higher speeds.

"ARL researchers are bridging a scientific gap by providing

underpinning research that will validate modeling for tiltrotor aircraft of the future," Riddick said.

Using foundational aerodynamics research and computational models, Army engineers will shape Future Vertical Lift with analysis of new tiltrotor designs. Their goal: to increase reach, enhance protection and lethality, and deliver agility and mission flexibility. With an advanced tiltrotor design, the Army can get there, stay there and dominate what officials call "Multi-Domain Battle."

Army researchers Dr. Robert Thornburgh (left), Matthew Wilbur (center) and Andrew Kreshock (right) work at NASA's Transonic Dynamics Tunnel, a massive wind tunnel where they hope to provide scientific solutions to making tiltrotor aircraft attain higher speeds. Credit: David McNally

Army researchers are working with an industry partner to fabricate the Tiltrotor Aeroelastic Stability Testbed, or TRAST. The apparatus is a scaled-down tiltrotor engine assembly and partial wing loaded with sensors and designed to be attached to wall of the wind tunnel. The Army hopes to take delivery in September.

"TRAST is focused on accelerating knowledge products that will provide critical information for the Army Modernization Priorities within the Future Vertical Lift program regarding tiltrotor technology for whirl-flutter suppression to enable higher speed forward flight," said Elias Rigas, the lab's Vehicle Applied Research Division chief.

The project has the potential to provide researchers with terabytes of data, which will enable the underpinning research the laboratory can share with the aviation community responsible for the design and fielding of Future Vertical Lift.

"When it comes to a flight vehicle, it all comes down to lift," said Army researcher Dr. Robert Thornburgh. "You still have to produce lift and whether it's through a wing or through a rotor, basically lift is produced by moving air and so those fundamental physics haven't changed since the Wright brothers and so there are some limitations on what you can do with rotorcraft technology as far as performance goes."

Army researchers are working on complex flight problems. They partner with NASA because of shared interest in basic research into future tiltrotor technology.

"We may be looking at different missions for different vehicles, but as we drill down into the technology needs, they become common and so we can work very closely with the Army on some very fundamental basic research areas," said Susan Gorton, NASA's Revolutionary Vertical Lift Technology lead. "What we're always looking for is how to

improve things and how to make things faster, make them quieter and how to make them more economical to operate."

The relationship between the Army and NASA is very special, Gorton said.

"We've had this relationship for over 50 years where we've had co-located laboratories where Army people are assigned and working at NASA centers and they work hand-in-glove with us and day-to-day our research tasks are very intertwined and is a very strong relationship and I think it will remain strong in the future," she said.

As a part of the U.S. Army Combat Capabilities Development Command Aviation & Missile Center's Joint Multi-Role Technology Demonstrator Program, private companies like Bell, created a tiltrotor concept demonstrator aircraft, the V-280 Valor, which successfully achieved first flight in 2017. ARL researchers visited the company in January to see the demonstrator up close and talk with Bell engineers.

Riddick said the JMR-TD Program Office informs the requirements for the Future Vertical Lift program-of-record and has provided significant funding for the fabrication of TRAST.

"They're depending on the laboratory to deliver the foundational research to enable future tiltrotor aircraft to attain higher speeds and greater stability," Riddick said. "This is a truly joint effort between the laboratory's research scientists and its partners to produce knowledge and understanding for future decision making. It also highlights the level of collaboration across the Army science and technology community to deliver on the Army's modernization priorities."

NASA has unique facilities that the Army does not have, but with a cooperative, collaborative relationship they use the facilities and work

with NASA researchers to attain Army goals, Wilbur said. The wind tunnel lets researchers push the envelope in dynamic testing by producing winds of Mach 1.2, or 1.2 times the speed of sound.

"Obviously a rotorcraft does not fly that fast; however we do have unlimited flight velocity range for a rotorcraft, and the rotorcraft of the future will be flying faster and faster and this is one of the only facilities in the world in which rotorcraft are consistently tested that already meets and exceeds the flight range that rotorcraft are expected to fly," Wilbur said.

In addition to higher speeds, Army researchers said they are confident that advances in tiltrotor design will save lives.

"The faster you can fly, the faster you can get somebody off the battlefield and into a hospital and that could potentially save their life," said Army researcher Andrew Kreshock. "One of the biggest impacts may be on how the Army operates because a lot of bases are staged around the range of aircraft and how fast they can get to the front line and save Soldiers' lives."

The TRAST program will provide critical experimental data to enable the validation of existing engineering analysis tools and the development of new and improved analysis tools. Together, the experimental data and the improved analyses will be used to identify a tiltrotor aircraft's strengths and weaknesses.

"Where that benefits the future warfighter is that allows us to push the technology faster, farther so that they will have a tiltrotor aircraft that is significantly improved," he said. "We're always looking 20 years out into the future in terms of the technologies that we're trying to develop, but it's very rewarding when we can make good things happen and we know we've developed a viable technology for the Army."