Physicist Helps Lead Drone Mission to Titan

U of I's Jason Barnes is part of the Dragonfly space mission of a drone-like rotorcraft lander that will explore Titan.

In 2025, a Dragonfly will have the opportunity to hop a rocket from Earth to Titan, Saturn's largest moon. Named for its insect shape, the aircraft is a drone-like rotorcraft specifically designed to sample Titan's atmosphere and surface. With eight rotors, the dual-quadcopter will have the ability to fly from site to site on the alien moon, potentially traveling up to 10s of kilometers at a time.

NASA announced in July 2019 that Dragonfly won the agency's New Frontiers Program competition, beating 11 other teams. The federal space agency will support the mission's development with a cost cap of $850 million.

University of Idaho Associate Professor Jason Barnes is a founding member of the Dragonfly project. He serves as deputy principal investigator of the international team, which is led by the Johns Hopkins Applied Physics Laboratory (APL) and includes 35 co-investigators.

"NASA's missions of planetary exploration are one of the coolest things that we humans do, as a species," said Barnes, who is in the College of Science's Department of Physics. "To have our idea be selected to actually fly is what every planetary scientist dreams about."

Pictured above: Dragonfly is a dual-quadcopter lander that would take advantage of the environment on Titan to fly to multiple locati sample materials and determine surface composition to investigate Titan′s organic chemistry and habitability, monitor atmospheric to investigate geological processes, and perform seismic studies. Photo Provided by Johns Hopkins University Applied Physics Labor

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Titan joins Venus, Earth and Mars as the only places in the solar system with substantive atmospheres and solid surfaces. And compared to Venus and Mars, Titan's atmospheric properties are closest to Earth. The moon's dense atmosphere and low gravity actually make flying easier than it is on Earth.

Sending a quadcopter to a distant moon is a fairly daring idea, Barnes said, but he thinks the design will allow researchers to answer questions that would be difficult for a stationary probe or a rolling rover. Titan has a smoggy atmosphere, so researchers don't know if the terrain would limit a driven vehicle. Flying increases Dragonfly's mobility, allowing the team to efficiently sample a diverse set of locations across a much greater area, according to Shannon MacKenzie, who serves as a co-investigator on Dragonfly and worked in Barnes' lab until she received her doctorate from U of I in 2017.

Team Dragonfly has spent the past year perfecting its designs, planning individual investigations and experiments, and incorporating ideas from the proposal's reviewers. In addition, team members tested some of Dragonfly's components at Titan temperatures and a half-scale model built by Pennsylvania State University

"Everything has to work the first time," Barnes said. "You can't send someone up with a wrench."

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Sidebar: About NASA's New Frontiers Program

In the early 2000s, NASA created the New Frontiers Program to enhance the exploration of our solar system. The space community objectives as top priorities. New Frontiers missions tackle these goals. A principal investigator, who is often associated with a researc project, and the team comprises scientists and engineers from small business, industry, government and higher education.

New Frontiers missions are considered medium-sized projects and are larger enterprises than NASA's Discovery missions. Teams m costs of space exploration with the production of new scientific insights.

Dragonfly is the fourth winner of the New Frontiers Program, with past winners being New Horizons' exploration of Pluto, its moons a investigation of Jupiter; and OSIRIS-REx, which will sample an asteroid.

Dragonfly's Destination: An "Ocean World"

In 2004, the Cassini spacecraft gave researchers their first close look at Titan during its study of the Saturn system. Cassini also sent the Huygens probe to the moon's surface, where it gathered information for 72 minutes. The moon appeared to have rain, rivers, lakes and seas, although the liquid is likely ethane and methane. Cassini observations also indicate that a layer of ice covers Titan's surface, and that this icy crust hides a global ocean.

At the equator, gigantic dunes sit atop the ice. Instead of being made of sand, the dunes are likely piles of complex organic compounds called hydrocarbons. The complex hydrocarbons likely form when sunlight breaks apart atmospheric methane and the resulting bits and pieces combine, then fall to Titan's surface.

Dragonfly: A Proposal to Explore Titan, Saturn's Largest Moon, via Quadcopter

Dragonfly program manager Peter Bedini of Johns Hopkins APL explains the technology and science of the proposed dual-quadcopter mission to Titan. On Dec. 20, Dragonfly was chosen as a finalist for NASA's New Frontiers mission. Video Provided by Johns Hopkins University Applied Physics Laboratory.

Scientists haven't been able to discern the exact composition of the material on the surface.

"If you were to ask me what exactly is on the surface of Titan, I wouldn't be able to tell you," MacKenzie said. "The atmosphere that's blocking the way is probably the source for much of the organic gunk that's down there."

Enter Dragonfly. The quadcopter is designed to sample the icy crust and hydrocarbon sands. It is outfitted with a vacuum to suck up samples, a drill for coring, and instruments that will identify the precise chemical composition of samples. Dragonfly should answer many of the questions raised by the Cassini mission, MacKenzie said.

MacKenzie's position as a co-investigator on the mission was uncommon for a doctoral student. A member of Dragonfly's science team, MacKenzie helps determine the mission's questions and design experiments to answer those questions. Since graduating from U of I, MacKenzie continues to work on Dragonfly in a postdoctoral position with the principal investigator of the Dragonfly mission, Elizabeth Turtle at APL.

There are several possible scenarios where liquid water could periodically come in contact with hydrocarbons at Titan's surface, MacKenzie said, creating a concoction similar to the primordial soup that led to life on Earth. By studying Titan's chemistry in action, researchers may be able to answer questions about how the building blocks of life initially formed on Earth.

"One of the high-level goals is to understand what makes a planet or moon habitable and what chemical processes led to the development of life," Turtle said. "Titan has been doing chemistry experiments for billions of years and basically the goal of Dragonfly is to go down to the surface and collect the results."

In addition, Dragonfly will take atmospheric chemistry samples, meteorological measurements, and pictures of the landscape. The quadcopter will also carry an onboard seismometer to record any Titan seismic activity.

What Cassini Can Teach Us

U of I discoveries about Saturn continue as mission ends.

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Jason Barnes talks in 2017 about the potential of the Dragonfly mission.

Far From Home

Landings are always white-knuckle events for researchers involved in space exploration. Like a Mars lander, Dragonfly will fly through space, slam through the atmosphere with a heat shield, and be slowed down with parachutes. While a Mars lander also requires rockets to slow its descent, Dragonfly will ditch its parachute and fly to Titan's surface. Thanks to observations by Cassini-Huygens, the team has identified safe landing zones, as is done for Mars landers using satellite pictures.

Once within the landing zone, "we have cameras and onboard systems that can look for and identify a safe landing site and put down," Barnes said. "It has to do all this onboard, because we can't be joy-sticking it."

Unlike its insect doppelganger, Dragonfly won't buzz about continuously. The quadcopter will thoroughly sample each landing site before zipping off to a new location. Moves will likely occur once per Titan day — about every two weeks on Earth.

"We have lots of interesting targets to go next within hopping distance," MacKenzie said. "We have a plan for what we want to do, but we're adaptable, which is pretty exciting. We'd be able to explore."

Dragonfly's primary mission will last for over two years. However, the nuclear-powered quadcopter could conceivably continue working for much longer. Dragonfly will launch in April 2025 and arrive in December 2034.

"It takes a long time to get to the outer solar system if you are trying to get there on the cheap," Barnes said with a laugh. "I'll be 60 by the time the mission is over."

More information on the Dragonfly mission and U of I's research in space is available at uidaho.edu/dragonfly.

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Article by Leigh Cooper, University Communications and Marketing.

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