DRAGONFLY

A NEW FRONTIERS MISSION TO TITAN AND BEYOND

By McKenna Clement

In June 2019, NASA announced that they will be sending a drone to Titan, Saturn's largest moon. It's enough to make anyone giddy with excitement, scientist or not. With liquid lakes, complex sand dunes, and a dense atmosphere like Earth's, the surface of Titan may hold answers to our most basic questions about life. The mission, called Dragonfly, was selected as the newest installment of the New Frontiers program—a project designed to tackle specific exploration goals to better understand our solar system. Among the team of scientists working on the Dragonfly project is Dr. Jani Radebaugh, planetary scientist and geology professor at BYU.

In order for a mission to be dubbed a "New Frontiers Mission," it must meet a very high standard. New Frontiers projects are awarded $1 billion and a high level of priority. Two of Saturn's icy moons, Titan and Enceladus, were recently identified by NASA to be an exploration priority. With liquid oceans beneath their surface and possible organic materials above, they just might help NASA learn about how life begins. Over the last year, Dragonfly and one other project competed for the prestigious distinction. After a long deliberation process, NASA selected the Dragonfly project—opening the floodgates to a whole new kind of space travel.

The Dragonfly team is led by the Johns Hopkins University Applied Physics Laboratory (APL) and is comprised of leading engineers and Titan scientists, including Radebaugh. These professionals have decades of experience in their respective fields, and will work together to establish the specific goals of the mission.

Because of the complexity of the spacecraft's functions, the drone is set to launch in 2026. During that time, the engineers and scientists will be working together to ensure that the drone has all the features it needs to accomplish the tasks at hand. Once launched, it will take an estimated eight and a half years to reach Titan.

The Dragonfly spacecraft is the first of its kind. The dense, stable atmosphere of Titan is an ideal environment to explore via flight. The machine deployed to this icy moon will be a type of multi-rover vehicle with eight blades that flies like a drone. After the initial landing, Dragonfly will navigate from location to location on the moon's surface, collecting data at each stop. While large SUV-type robots have been the focus of some of the most popular NASA missions, the Dragonfly spacecraft brings to life new avenues for space exploration. Dragonfly will travel more than double the distance that the Mars Curiosity and Opportunity rovers did combined, traveling over 20 kilometers in the first "hop" alone—a feat that took Opportunity over 13 years to accomplish.

Onboard this spacecraft will be countless tools for data collection and analysis. The instruments will study how far prebiotic chemistry may have progressed, while also analyzing the properties of Titan's atmosphere and surface that are analog to those of the early Earth.

The mission is focused on answering questions about what happens before life can begin. Because of Titan's significant similarities to Earth, the team of

Dragonfly logo courtesy of Johns Hopkins APL. Used by permission.

scientists hopes that the mission will provide answers to how life may have arisen on our own planet.

"Titan is like Earth in the sense that we probably had these organic materials on the surface that were swimming around, and trying to figure out how to become life," Radebaugh explained. "But, how did they make their way into RNA, or DNA, or lipids? How do they make enough of those complex building blocks so that life starts?" These unanswered questions are central to NASA's space exploration purposes. In essence, Titan resembles what scientists believe the very early Earth to have been like before any life existed here. As such, it is a prime destination for further study into how life begins.

"The Dragonfly spacecraft brings to life new avenues for space exploration."

During the next several years, Dragonfly's impressive team of scientists will make plans about the specifics of the expedition. Radebaugh will act as the team's landscape geology expert, and deservedly so—Titan has been an interest of hers for her entire career. She began studying Titan when she was a graduate student at the University of Arizona Lunar and Planetary Laboratory, and has been fascinated by the colossal moon ever since. After completing her PhD, she continued to research Titan in her post-doctorate work and throughout her career.

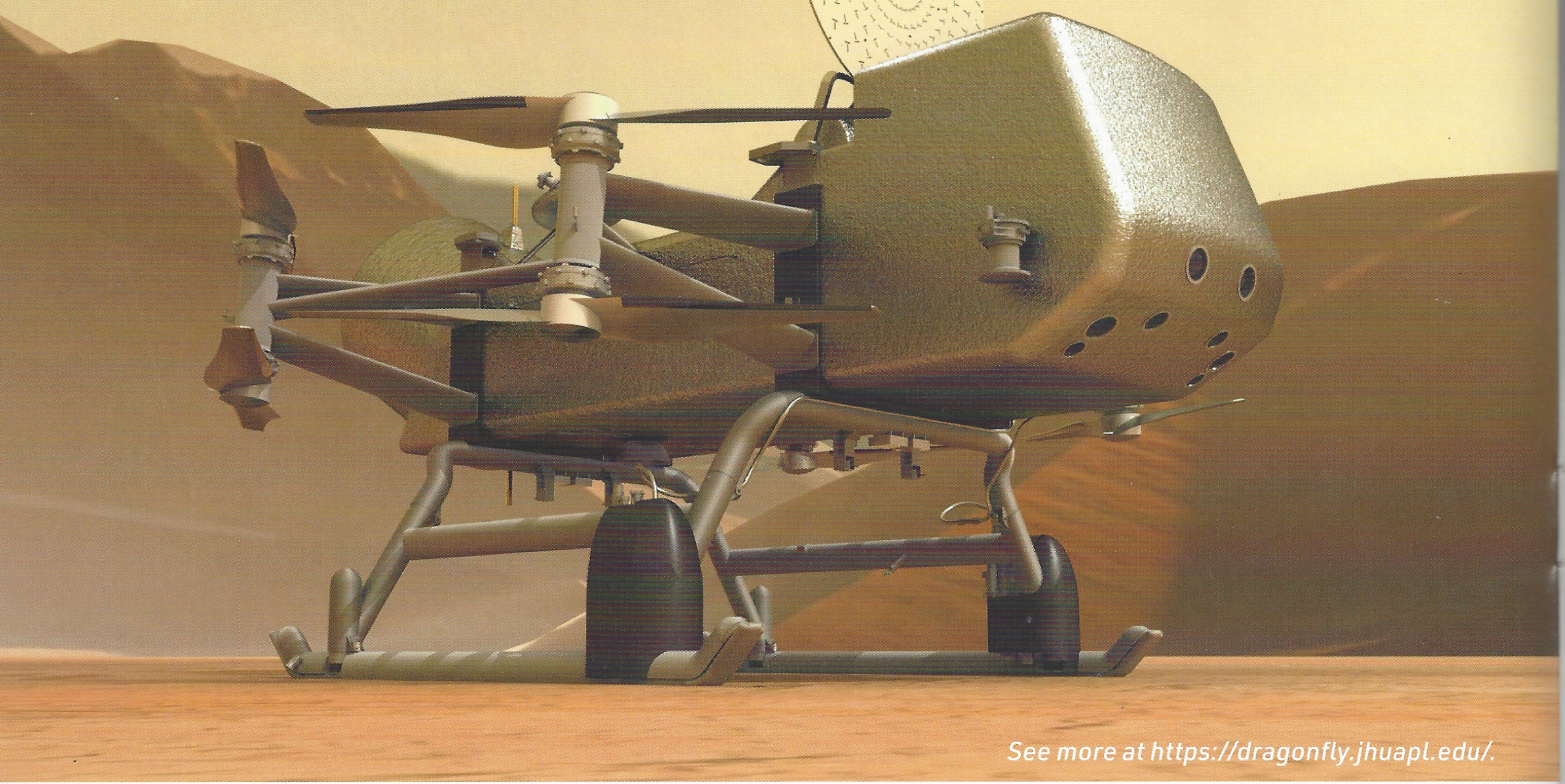
In 2004 Radebaugh began working on the Cassini Radar Science Team, which uses advanced radar technology to see through Titan's hazy atmosphere and create synthetic images of its surface. The radar instrument sends and receives a series of signals to and from the surface. These images allow scientists to understand various surface processes that form some of Titan's trademark features such as sand dunes, lakes, rivers and cryovolcanoes—which have been the focus of Radebaugh's research.

Radebaugh researching in Campo de Piedra Pomez, Argentina. Photo by Jonathon Sevy.

That research has led Radebaugh to all corners of the earth. Her research group has traveled to Hawaii, Ethiopia, and Vanuatu to study lava lakes and lava flows which serve as analogues for landscapes on other planets. Titan's surface is peppered with lakes and rivers of liquid methane, as well as cryovolcanoes—a type of volcano that erupts volatiles such as water, ammonia or methane, instead of molten rock. Though Titan's -290°F surface temperature eradicates the possibility of the existence of lava, the geologic processes happening on Earth allow Radebaugh to understand more about how those processes occur on the icy moon.

Radebaugh has also spent significant time researching sand dunes. The dunes on Titan are remarkably similar to those found in Namibia, Arabia and the Sahara. In 2013, Radebaugh and her students, along with several other members of the Dragonfly team, embarked to Namibia to study its geography. In Namibia's southern desert lies the Roter Kamm meteor impact crater, spanning over one-and-a-half miles across. The crater has giant linear sand dunes stretching through its center, much like the dunes on Titan. "We brought an instrument called a ground-penetrating radar—it sends a signal down through the sand dunes and shows us the layers afterwards," Radebaugh recalled. The instrument then allows them to see how the dunes move and change shape. This kind of field work enables scientists to more easily understand other planets.

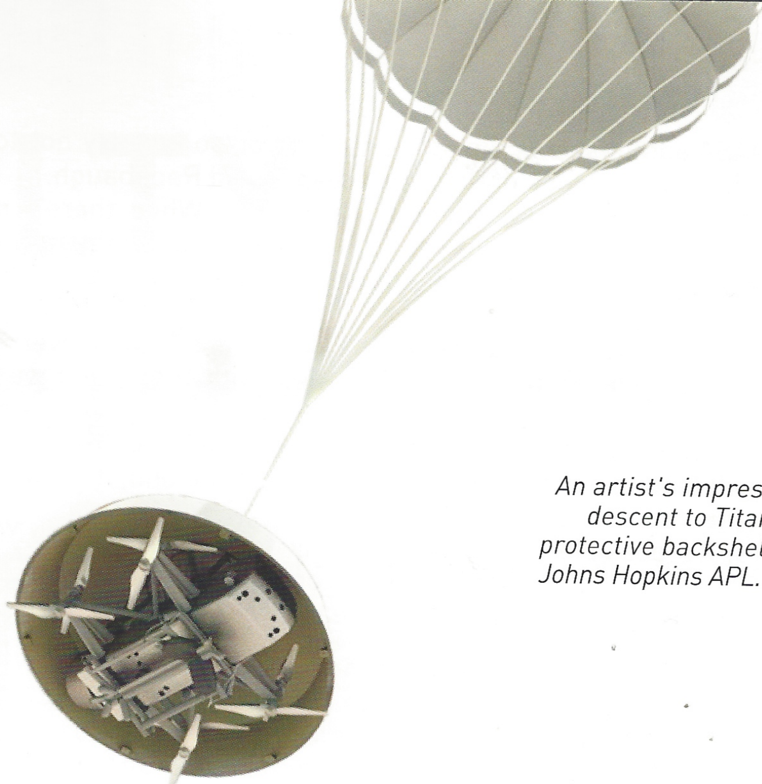
Radebaugh's research of the Namibian dunes will prove invaluable to establishing the day-to-day plans



See more at https://dragonfly.jhuapl.edu/.

An artist's impressions of Dragonfly on Titan's surface. Images courtesy of Johns Hopkins APL. Used by permission.

"Visiting this mysterious ocean world could revolutionize what we know about life in the universe."



An artist's impression of Dragonfly on descent to Titan, poised to leave its protective backshell. Image courtesy of Johns Hopkins APL. Used by permission.

of the mission. The linear dunes of the Roter Kamm crater bear striking resemblance to Titan's equatorial *Shangri-La* dune fields, a region sometimes referred to as a sea of sand. In between the main dunes are smaller dunes called interdunes. Radebaugh has studied what goes on under the surface of the area between the dune and interdune. "There are areas in the Sahara that are really quite bleak, and can reach up to 130°F in the summer. But just below the surface is a whole bunch of life, because there is water deep beneath the ground," Radebaugh explained. "So if you can find these really rugged kinds of bacteria in those spots, would we be able to find the same kind of thing on Titan?" While it would be reverse conditions on Titan due to its frigid climate, perhaps the moon could sustain life beneath the dunes' surface like in the Sahara. These questions will guide where the Dragonfly drone will explore.

As Dragonfly's seasoned geology expert, Radebaugh will help identify the best locations on Titan for the drone to land. One purpose of the mission is to learn more about the surface of Titan and what it's made of. For Radebaugh, gathering that first sample of sand and analyzing its composition is the most exciting part. In fact, sprawled across her office wall are countless vials of sand, each with labels identifying from where it came. "I've collected sand from different dunes and beaches around the world. Sand helps you understand a lot about the environment—not only the nearby environment, but from far away, too," Radebaugh explained. "It's likely that the sand came from somewhere far away, and got processed, and then ended up in that spot. It can tell you a lot about the history of the area. Even just the initial stages of that mission, just picking up that first handful of sand and studying it, we'll suddenly understand a huge amount about Titan that we don't know right now," she said.

Radebaugh has no shortage of other questions she'd like to answer. "Titan has so many features that are like Earth; the landscapes are like Earth, the processes, but the materials are totally different. So, what are the materials?" she wonders. This question, along with her continued field research, will help establish the mission protocols and design of the project, and help to answer her other questions: "I just really want to know what is that sand made of, and how did it get there? Why is there so much of it all over the body? If it's organic, is it useful to something like life? And if it is, could we look in those areas between the dunes where liquid methane—or maybe even water—has erupted onto the surface through cryovolcanoes? You have water, you have organics, you have liquid, there's sunlight, so all the conditions are right for life as we know it."

While the drone won't make it to Titan until 2034, Radebaugh is not the only one who is optimistic about what the next few decades will bring. "With the Dragonfly mission, NASA will once again do what no one else can do," NASA administrator Jim Bridenstine said. He concluded that, "Visiting this mysterious ocean world could revolutionize what we know about life in the universe. This cutting-edge mission would have been unthinkable even just a few years ago, but we're now ready for Dragonfly's amazing flight."[1]

Although much of the mission preparation will fall on the engineering side of the spectrum, the Dragonfly scientists will be anything but idle in the coming years. Continued research and field visits from everyone involved will lead to a better, more prepared expedition. Since the launch is not scheduled for several more years, it's possible that Dragonfly may catch a ride on a faster rocket like SpaceX's Falcon Heavy. "We'll see what happens in the next five years or so—we try not to think about how far away it is," said Radebaugh.

While there's no way NASA could send people to Titan right now—it's so far away, and not many people would want to take a ten-year journey—they can, however, send robots. "It's almost like the robots are bringing everybody else along on this journey with them, and we can go to that distant place, and maybe find that answer to these big life questions," Radebaugh reflected. "And, if we did find that answer, in the end, it's really not all that long to wait." ■

1. "NASA's Dragonfly Will Fly Around Titan Looking for Origins, Signs of Life," NASA, June 27, 2019, https://www.nasa.gov/press-release/nasas-dragonfly-will-fly-around-titan-looking-for-origins-signs-of-life.

The Dragonfly team. Radebaugh is in the second row, third from the right. Image courtesy of Johns Hopkins APL. Used by permission.