Flights of Exploration on Titan, an Organic-Rich Ocean World

Dragonfly is a NASA New Frontiers mission, led by the Johns Hopkins Applied Physics Laboratory (APL), to send a rotorcraft lander to Saturn's exotic moon Titan. Designed to sample surface materials and determine compositions at multiple locations, this revolutionary concept offers the capability to explore diverse geologic settings and characterize the habitability of Titan's environment, investigate the progression of prebiotic chemistry building blocks, and even search for chemical hints that would tell us whether water-based or hydrocarbon-based life had developed on Titan.

CLOUDED IN MYSTERY

The Voyager spacecraft observed Titan in 1979 and 1980 but could barely detect the surface through the moon's thick, hazy atmosphere. Hubble Space Telescope revealed large bright and dark surface regions, but the details of Titan's landforms remained a mystery until the arrival of the Cassini spacecraft in 2004. In more than 120 close flybys, using radar and near-infrared imaging, Cassini mapped much of Titan's surface and studied its atmosphere in detail. Cassini also delivered the Huygens probe, which in 2005 touched down on Titan, measuring the atmosphere and imaging part of the surface close-up during and after descent. Cassini observations point to a liquid-water ocean beneath the moon's water-ice crust.

AN EXOTIC WORLD

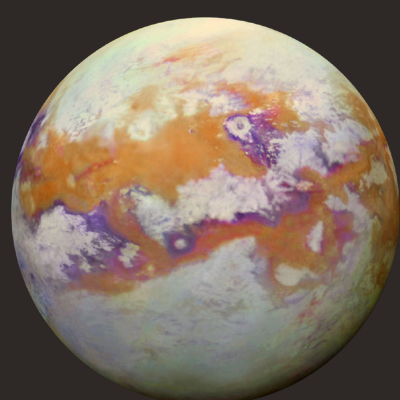
Titan's surface has rivers, lakes, and seas of liquid ethane and methane—the main component of natural gas—as well as vast expanses of organic sand dunes. In Titan's atmosphere, the methane can form clouds and even rain, following seasonal patterns that are in some ways similar to Earth's weather. Titan's atmosphere is four times denser, making atmospheric activity much more "sluggish" than on Earth, and gravity is about 1/7th of what we experience.

When exposed to sunlight, the methane and nitrogen molecules in Titan's atmosphere are split apart by ultraviolet light and recombine to form a variety of complex organic compounds. Organic molecules are the building blocks for life, and their presence on Titan adds to its intrigue—what compounds are on Titan, and what might they form, especially when mixed with liquid water in the past on Titan's surface?

Titan is in many ways the most Earthlike world in the solar system. Larger than the planet Mercury and covered with a thick nitrogen atmosphere laden with organic smog, Titan's surface is partially hidden from view. Far from the Sun, Titan is cold enough that methane plays the active role that water plays on Earth, serving as a condensable greenhouse gas, forming clouds and rain, and pooling on the surface as lakes and seas. Titan's carbon-rich surface is shaped not only by winds that sculpt drifts of aromatic organics into long linear dunes but also by methane rivers and possible eruptions of liquid water ("cryovolcanism").

OCEAN WORLDS

As an ocean world, Titan offers a rare opportunity to explore the origins of prebiotic chemistry outside of Earth's environment. NASA's Ocean Worlds mission theme focuses on characterizing potential habitability, examining prebiotic chemistry, and searching for signs of life. Titan's unique combination of abundant, complex, carbon-rich chemistry on its largely water-ice surface makes it an ideal location for such investigations.



View of Titan in infrared wavelengths taken by the Cassini spacecraft shows the wide variety of terrains on its surface (NASA/ESA/ASI)

The Dragonfly mission concept (APL)

POWERED FLIGHT

Launching in 2026 and reaching Titan in 2034, the Dragonfly rotorcraft lander will spend over two years performing science investigations at multiple locations across Titan's diverse surface. Titan's dense, calm atmosphere and low gravity make flying an ideal way to travel. Over the mission, Dragonfly will fly from its initial landing site to explore dozens of different sites, tens to hundreds of miles (kilometers) apart.

Like the durable Curiosity rover on Mars, Dragonfly is designed to be powered by a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG).

CRITICAL SCIENCE

Dragonfly will carry instruments to perform a multidisciplinary science investigation of Titan's surface and atmosphere:

- Sampling surface material at multiple locations and using a mass spectrometer to identify chemical components available and processes at work to produce biologically relevant compounds
- Measuring bulk elemental surface composition in different areas with a neutron-activated gamma-ray spectrometer
- Monitoring atmospheric and surface conditions with meteorology sensors
- Characterizing geologic features via imaging
- Performing seismic studies to detect subsurface activity

In flight, Dragonfly will make atmospheric profile measurements and image the surface to examine geology, provide context for ground measurements, and scout potential landing sites of interest.

AN EXPERIENCED TEAM

Led by the Johns Hopkins Applied Physics Laboratory, Dragonfly is a NASA New Frontiers planetary science mission. Key mission partners include NASA Goddard Space Flight Center, Lockheed Martin Space, NASA Ames Research Center, NASA Langley Research Center, Penn State University, Malin Space Science Systems, Honeybee Robotics, Jet Propulsion Laboratory, and the Japan Aerospace Exploration Agency. New Frontiers is managed by the Planetary Missions Program Office at NASA's Marshall Space Flight Center in Huntsville, Alabama, for the agency's Planetary Science Division in Washington.

LEARN MORE ABOUT DRAGONFLY:

http://dragonfly.jhuapl.edu

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