Flying Nuke on Saturnian Moon Titan

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1. Introduction

Yes, I know, the title of this paper sounds like a Sci-Fi pulp novel from the fifties. But what this paper is really about is an interesting project that NASA just selected for launch in 2026. Instead of traveling around on the surface of Titan on wheels, like Mars and Lunar rovers, Dragonfly is a dual-quadcopter that will make short flights. This works thanks to Titan's dense atmosphere and low gravity.

This brief post describes this mission, and references an earlier post that describes the nuclear power generators used by NASA and potentially suitable for specialized use on Terra Firma.

2. Why Titan?

Titan is the largest moon of Saturn and the second-largest natural satellite in the Solar System. It is the only moon known to have a dense atmosphere.¹ The atmosphere of Titan is largely nitrogen; minor components lead to the formation of methane and ethane clouds and nitrogen-rich organic smog. The climate—including wind and rain—creates surface features similar to those of Earth, such as dunes, rivers, lakes, seas (probably of liquid methane and ethane), and deltas. Titan is dominated by seasonal weather patterns as on Earth. With its liquids (both surface and subsurface) and robust nitrogen atmosphere, Titan's methane cycle is analogous to Earth's water cycle, at the much lower temperature of about −290 °F.

Before the Cassini–Huygens space-research mission there was little known about Titan because of its thick, almost opaque, atmosphere. This mission was a collaboration between NASA, the European Space Agency, and the Italian Space Agency. The Huygens probe was designed to slowly parachute through Titan's clouds and gather as much data and as many images as it could before landing. The Huygens module traveled with Cassini until its separation from the Cassini probe on December 25, 2004; it then separated from an orbiter, descended and landed by parachute on Titan on January 14, 2005. It returned data to Earth for around 90 minutes, using the orbiter as a relay. This was the first landing ever accomplished in the outer Solar System and the first landing on a moon other than Earth's Moon.

Since Titan's thick atmosphere and bodies of liquid methane are rich in organic compounds, and have had billions of years to evolve life (if this is possible in this environment), one of the main missions of Dragonfly is to thoroughly survey this moon, and identify any possible signs of life.

3. Dragonfly Description

Like Huygens, Dragonfly will parachute through Titan's thick atmosphere (see figure below).

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¹ Wikipedia article on Titan (moon), https://en.wikipedia.org/wiki/Titan_(moon)
“Dragonfly is a rotorcraft lander mission – part of NASA’s New Frontiers Program – designed to take advantage of Titan’s environment to sample materials and determine surface composition in different geologic settings. This revolutionary mission concept includes the capability to explore diverse locations to characterize the habitability of Titan’s environment, to investigate how far prebiotic chemistry has progressed, and even to search for chemical signatures that could indicate water-based and/or hydrocarbon-based life.

“In under an hour, Dragonfly will cover tens of miles or kilometers, farther than any planetary rover has traveled. With one hop per full Titan day (16 Earth days), the rotorcraft will travel from its initial landing site to cover areas several hundred kilometers away during the planned two-year mission. Despite its unique ability to fly, Dragonfly would spend most of its time on Titan’s surface making science measurements.”

3.1. Dragonfly’s Power Source

As you might have gathered from the title of this paper, Dragonfly uses a well-proven, reliable nuclear power source.

“Unable to use solar power under Titan’s hazy atmosphere, Dragonfly will use a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), like the durable Curiosity rover on Mars. Flight, data transmission, and most science operations will be planned

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during Titan’s daytime hours (eight Earth days), giving the rotorcraft plenty of time during the Titan night to recharge."

The MMRTG is described in an earlier paper linked below.

https://www.energycentral.com/c/pip/amazing-voyage

A close-up of Dragonfly is below. Note that "HGA" is high-gain antennas. This picture if from the referenced source which also has detailed descriptions of the current Dragonfly design.³

Figure 3. The Dragonfly configuration for atmospheric flight (with the gray circular HGA stowed flat). Note the aerodynamic fairing in front of the HGA gimbal. The cylinder at rear is the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). A sampling drill mechanism is visible in the nearside skid leg, and forward-looking cameras are recessed into the tan insulating foam forming the rounded nose of the vehicle. The rotor wing section and planform are designed for the Titan atmosphere.

3.2. Dragonfly Science

"Dragonfly’s Surface and Atmospheric Science Measurements:"^2

- "Sample surface material and measure with a mass spectrometer to identify the chemical components and processes producing biologically relevant compounds
- "Measure bulk elemental surface composition with a neutron-activated gamma-ray spectrometer
- "Monitor atmospheric and surface conditions, including diurnal and spatial variations, with meteorology sensors
- "Use imaging to characterize geologic features
- "Perform seismic studies to detect subsurface activity and structure

"And In-flight Measurements:

- "Contribute to atmospheric profiles
- "Provide aerial images of surface geology
- "Give context for surface measurements and scouting of sites of interest"