Dragonfly: Exploring Titan's Prebiotic Organic Chemistry and Habitability

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Titan offers abundant, complex, diverse carbon-rich chemistry on an ocean world (e.g., Raulin et al. 2010; Thompson & Sagan 1992), making it an ideal destination to study prebiotic chemistry (e.g., Neish et al. 2010) and document habitability of an extraterrestrial environment. Moreover, Titan's dense atmosphere and low gravity provide the means to access different geologic settings 10s - 100s of kilometers apart via exploration by an aerial vehicle.

It has long been recognized that Titan's rich organic environment provides a unique opportunity to explore prebiotic chemistry (e.g., CSWG on Prebiotic Chemistry in the Outer Solar System (Chyba et al. 1999; Lorenz 2000)), and development of mobile aerial exploration was considered a next step after Cassini-Huygens. Studies include airships, balloons, and fixed-wing vehicles (e.g., Leary et al. 2008; Barnes et al. 2012), but access to surface materials for analysis presents a challenge; and, while multiple in situ landers could address Titan's surface chemical diversity, multiple copies of instrumentation and sample acquisition equipment would be necessary.

A more efficient approach is to convey a single instrument suite to multiple locations using a lander with aerial mobility. Given Titan's atmospheric density (4x Earth's) and low gravity (1.35 m/s^2), heavier-than-air mobility is highly efficient (Lorenz 2000, 2001), and improvements in autonomous aircraft make such exploration a realistic prospect. A multi-rotor vehicle (Langelaan et al. 2017) is mechanically straightforward, as the proliferation of terrestrial quadcopter drones attests. Thus, the Dragonfly mission concept is a rotorcraft lander designed to take advantage of conditions on Titan to be able to sample materials in different geologic settings and understand how far prebiotic chemistry has progressed in environments that provide known key ingredients for life. Areas of particular interest are impact-melt sheets (Neish et al. 2017) and potential cryovolcanic flows where transient liquid water may have interacted with the abundant photochemical products that litter the surface (Thompson & Sagan 1992).

Bulk elemental surface composition can be determined by a gamma-ray spectrometer (Lawrence et al. 2017). Surface material can be sampled (Zacny et al. 2017) into a mass spectrometer (Trainer et al. 2017) to identify the chemical components available and processes at work to produce biologically relevant compounds. Seismic sensing can probe subsurface structure and activity. And meteorology (Wilson & Lorenz 2017) and remote sensing measurements can characterize Titan's atmosphere and surface.

Dragonfly is a revolutionary concept providing the capability to explore diverse locations to characterize the habitability of Titan's environment, investigate the progression of prebiotic chemistry, and search for chemical signatures indicative of water- or hydrocarbon-based life.

References:

Barnes J. W. et al. (2007) Icarus 186, 242-258.

Barnes J. W. et al. (2012) Experimental Astronomy 33, 55-127.
Chyba C. et al. (1999) LPSC 30, #1537.
Langelaan J. W. et al. (2017) Proc. Aerospace Conf. IEEE.
Lawrence D. J. et al. (2017) LPSC 48, #2234.
Leary J. et al. (2008) Titan Flagship study
https://solarsystem.nasa.gov/multimedia/downloads/Titan_Explorer_Public_Report_FC_opt.pdf.
Lorenz, R. D. (2000) Journal British Interplanetary Society 53, 218-234.
Lorenz R. D. (2001) Journal of Aircraft 38, 208-214.
MacKenzie S. M. et al. (2007) Icarus 243, 191-207.
Neish C. D. et al. (2010) Astrobiology 10, 337-347.
Neish C. D. et al. (2017) LPSC 48, #1457.
Raulin F. et al. (2010) Titan's Astrobiology, in Titan from Cassini-Huygens Brown et al. Eds.
Soderblom L. A. et al. (2007) Planet. Space Sci. 55, 2025-2036.
Thompson W. R. & Sagan C. (1992), C. Organic chemistry on Titan: Surface interactions, Symposium on Titan, ESA SP-338, 167-176.
Trainer M. G. et al. (2017) LPSC 48, #2317.
Wilson C. F. & Lorenz R. D. (2017) LPSC 48, #1859.
Zacny K. et al. (2017) LPSC 48, #1366.

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