Dragonfly: A New Frontiers Titan Dune Lander.
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Introduction: We propose a Titan lander mission for New Frontiers to sample both organic sands and water ice to assess prebiotic chemistry, to evaluate habitability, and to look for biosignatures. We carry a mass spectrometer to determine molecular masses of surface materials. A gamma-ray and neutron spectrometer will assess the bulk and inorganic atomic fractions within the regolith. We will monitor atmospheric conditions and listen for seismic activity using a meteorological and geophysics package. And a suite of cameras will characterize the landing site and provide context for each sample.

Initial Landing Site: Dragonfly will initially land within the Shangri-La organic sand sea. Titan's longitudinal dunes are typically ~50-100 m high, and are separated from one another by 2-4-km-wide interdunes. Thus the organic sand seas provide access to both organic sand sediments and potentially sand-free solid material in the interdunes within a short distance from one another.

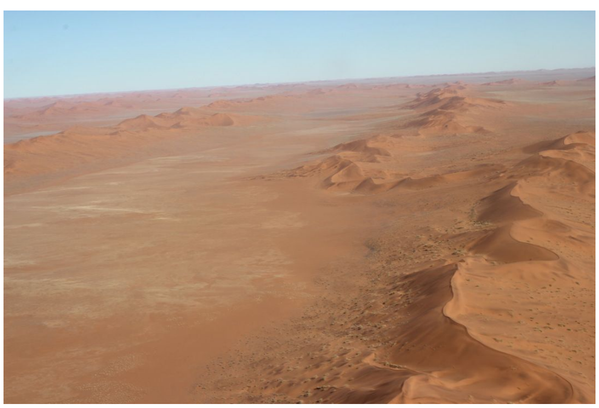

Figure 1: Aerial view of the Namib Sand Sea showing dunes (orange) and sand-free interdunes (yellower). The Namib dunes provide our best expected terrestrial analog for the Titan dunes that Dragonfly would visit.

Titan's Sand: We presently do not know (1) how Titan's sand grains are manufactured, (2) from where they are sourced, (3), under what wind regime(s) the dunes operate, and (4) if there are permanent sinks for sand. The Dragonfly mission will shed light on all of these questions. Chemistry will be a strong discriminator for the mechanisms behind sand creation (Barnes et al. 2015). The roundedness of grains, as viewed by our microscopic imager, will evidence how far they have been transported. Our on-board meteorological package will monitor wind speed and direction over the course of the mission. And exposed layering could reveal the potential existence of buried sand, potentially lithified into sandstones.

Our mission architecture a "relocatable lander": the entire lander is a quadcopter capable of taking off and flying up to tens of km in a single hop to achieve long-range mobility. We can use the rotors to empirically measure sand transport by running them at varying speeds to observe the saltation threshold (see abstract by Lorenz et al.).

Dragonfly would represent an exciting next step in the exploration of Titan, and in so doing would answer fundamental outstanding questions that we have regarding the nature of Titan's dunes and the organic sands of which they are composed.

Figure 2: Cassini near-infrared color view of Titan's globe. The dark brown areas that extend from west to east along the equator are Titan's sand seas.

Astrobiological Significance: The organic sands represent an end product of Titan's organic cycle. As such, the composition of the organic sand will reveal how far in complexity space organic chemistry can progress in the absence of life. Dragonfly will detect amino acids, lipids, and sugars if present down to the ppb level. Such a search makes sense in the organic dune sands because they represent a chemical concentration of organics -- so instead of a search for a needle in a haystack, we can look for the hay in a haystack. The solid organic compounds in the dunes also represent those that might potentially seed an impact crater's liquid water melt pool, in which aqueous chemistry might progress.

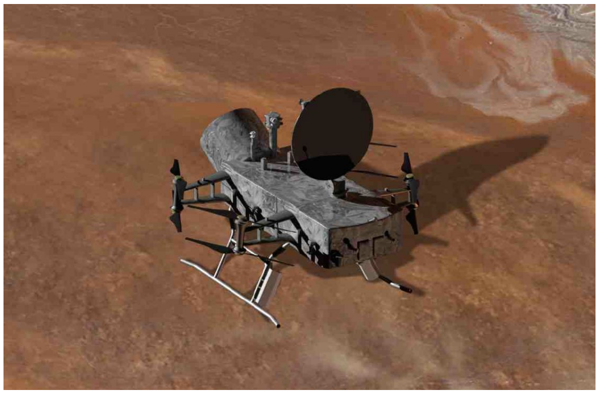

Figure 3: Artist's conception of the Dragonfly rotorcraft lander on the surface of Titan.

References:

[1] Barnes J.W. et al. (2015) *PS, 4:1*