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on behalf of the Dragonfly Team
Johns Hopkins Applied Physics Laboratory

OPAG, 3 February 2020
Multidisciplinary science measurements

• Prebiotic chemistry
  - Analyze chemical components and processes at work that produce biologically relevant compounds

• Habitable environments
  - Measure atmospheric conditions, identify methane reservoirs, and determine transport rates
  - Constrain processes that mix organics with past surface liquid water reservoirs or subsurface ocean

• Search for biosignatures
  - Search for chemical evidence of water- or hydrocarbon-based life
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Multidisciplinary science measurements

- DraMS: Mass Spectrometer
- DrACO: Drill for Acquisition of Complex Organics
  - GSFC, Honeybee – *MSL* SAM, *ExoMars* MOMA
- DraGNS: Gamma-ray Neutron Spectrometer
  - APL, LLNL – *MESSENGER* GRNS, *Psyche* GRNS
  - GSFC, Schlumberger – Pulsed Neutron Generator
- DraGMet: Geophysics & Meteorology Package
  - APL sensor suite + JAXA *Lunar-A* seismometer
- DragonCam: Camera Suite
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- **DragonCam**: Camera Suite
Lander configuration and payload accommodation

- Science measurements on surface and in flight
  - Aerial imaging, atmospheric profiles

- Direct-to-Earth communication
  - HGA articulation used to target cameras to build up panoramas of surrounding terrain; stowed for flight

- Designed to use MMRTG to charge battery
  - “Waste” heat maintains nominal thermal environment in lander interior

- Refining and updating design
  - Testing and technology maturation activities, test chambers
  - Defining requirements flowdown
  - Directed to 5-m fairing
Mission elements

Spacecraft = Cruise Stage + Entry Vehicle

Entry Vehicle = EDL Assembly + Lander

EDL assembly includes aeroshell (heatshield and backshell), parachutes, ESI, and support equipment.

Rotorcraft Lander
Flight configuration with HGA stowed
Mission timeline

• Launch in 2026 → Titan arrival in 2034
  - Refining trajectory design for 2026, backup launch, launch vehicle options
  - Launch mass defined by back-up launch window
Initial landing site provides access to multiple geologic settings

- Organic Sand
- Interdune Materials
- Ejecta Blanket
- Impact Melt
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Exploration strategy

- Over 2.5 years of exploration
  - ~60 Tsols of science operations
  - Traverse distance up to ~180 km
  - Exploration of ≥24 unique sites
  - Leapfrog strategy allows scouting of future landing sites

Approximate landing ellipse
Exploration strategy

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Tsol in the life of Dragonfly

• Downlink of data and uplink of direction from science team
• Weather measurements as part of pre-flight checklist
• Flight profile and landing-site assessment:
  - Take off from A, survey landing zone C, land at site B, downlink data for analysis/selection of landing site B
• Downlink of flight data and images of the landing site
• Thermal and electrical measurements using DraGMet landing-skid sensors estimate physical characteristics of surface material
• DraGNS measurement of bulk composition discriminates among basic surface types (e.g., organic dune sand, solid H2O ice, frozen NH3-hydrate)
• DragonCam imaging of surroundings; DraGMet atmospheric monitoring
• Sampling and DraMS analysis
• Downlink of data and uplink of direction from science team
• Overnight recharge of battery by MMRTG
• DraGMet seismic and meteorological monitoring
• DragonCam imaging using LEDs for color discrimination of materials; UV to identify organic material via fluorescence (e.g., dune sand, polycyclic aromatic hydrocarbons)
Comprehensive study of the chemical complexity and diversity of Titan’s solid surface

• Sample surface materials for detailed chemical analyses with DraMS
Comprehensive study of the chemical complexity and diversity of Titan’s solid surface

- Analyze chemical components & processes that produce biologically relevant compounds
- Complementary sample analysis modes:
  - Laser Desorption MS: Broad survey and structural analysis
  - Gas Chromatography MS: Definitive molecular detection, chirality

Investigation 1A2:

Determine the types, relative abundances, and enantiomeric ratios of any amino acids in the sampled material.

Some compounds employed in Earth’s biochemistry – for example, sugars and most amino acids – are chiral. Chiral compounds can exist in either of two configurations (enantiomers) that represent non-superimposable mirror images of one another (Figure 4.1.6). In the case of amino acids, known abiotic mechanisms of synthesis generate nearly equal amounts of the two possible enantiomers (D and L). In meteorites, the D and L forms are generally also present in approximately equivalent amounts, although excesses of the L enantiomer ranging from 1–15% have been observed among the \(-\)-methyl amino acid series (Pizzarello, 2006) and up to 21% for the non-proteinogenic amino acid isovaline (Elsila et al., 2016). In an analysis of the Tagish Lake Meteorite, unusually large L-enantiomeric excesses ranging from 43–45% were reported for glutamic acid in which the \(^{13}\)C-content confirmed its meteoritic origin (Glavin et al., 2012).

In contrast, biological materials on Earth are composed almost exclusively of the L-enantiomer (D/L ~0.02; Aubrey, 2008) and recent work suggests that such homochirality is required for the proper folding and function of proteins in biochemistry across the three domains of life on Earth. For this reason, it is suggested that a large enantiomeric excess (ee) in multiple different amino acid types would constitute strong evidence for biology (Halpern, 1969; Kvenvolden, 1973; Bada et al., 1996; Bada and McDonald, 1996).

Bacteria however, also incorporate non-proteinogenic D-amino acids (aspartic acid, asparagine, glutamic acid, glutamine, serine, and alanine) as components of bacterial biomolecules such as peptidoglycan, polypeptide, teichoic e.g., amino acids

(Trainer et al., 2017) (Hand et al., 2017, Europa Lander SDT Report)
Classification of surface materials

- Measure bulk elemental surface composition
  - Classify surface material
  - Detect minor inorganic elements
  - Reveal near-surface stratigraphy

Simulation of 1-hour meas. on Titan's surface

OPAG, 3-4 February 2020
Meteorological and seismological monitoring

- Monitor atmospheric conditions, identify CH$_4$ reservoirs, and determine transport rates
  - T, P, CH$_4$, wind speed & direction
  - Diurnal and spatial variations; atmospheric profiles

- Constrain regolith properties (e.g., porosity)
  - Thermal diffusivity, dielectric constant

- Constrain processes that mix organics with past surface liquid water or subsurface ocean
  - E-Field (Schumann resonance), seismic activity
Meteorological and seismological monitoring

• Detection and characterization of seismic activity
• Variation with orbital phase
Characterize landforms and surface processes

Panorama

LED illuminated mixture of water ice (white)
and two tholin flavors (orange + yellow)

RGB = 0.935, 0.770, 0.455 μm

Mission updates and current activities

• requirements refinement and flowdown
  - PDR Nov 2021

• trajectory refinement for 2026 launch, backup date

• schedule and budget updates

• tech maturation, testing, design refinement and updates, e.g., 5-m fairing
  - APL Titan test chamber

• implementation of SEO for student and early-career guest investigators

• coordination with RPS, NEPA, planetary protection
Presentations at LPSC 2020

- Zacny et al., Drill for Acquisition of Complex Organics (DrACO) for Dragonfly, a New Frontiers Mission to Explore Titan
- Panning et al., A Seismic Signal and Noise Budget for Titan: Preparation for Dragonfly
- Hedgepeth et al., Tracking Organic Molecules in Crater Melt Ponds on Titan
- Turtle et al., Dragonfly: In Situ Exploration of Titan’s Organic Chemistry and Habitability
New tools for sharing mission information