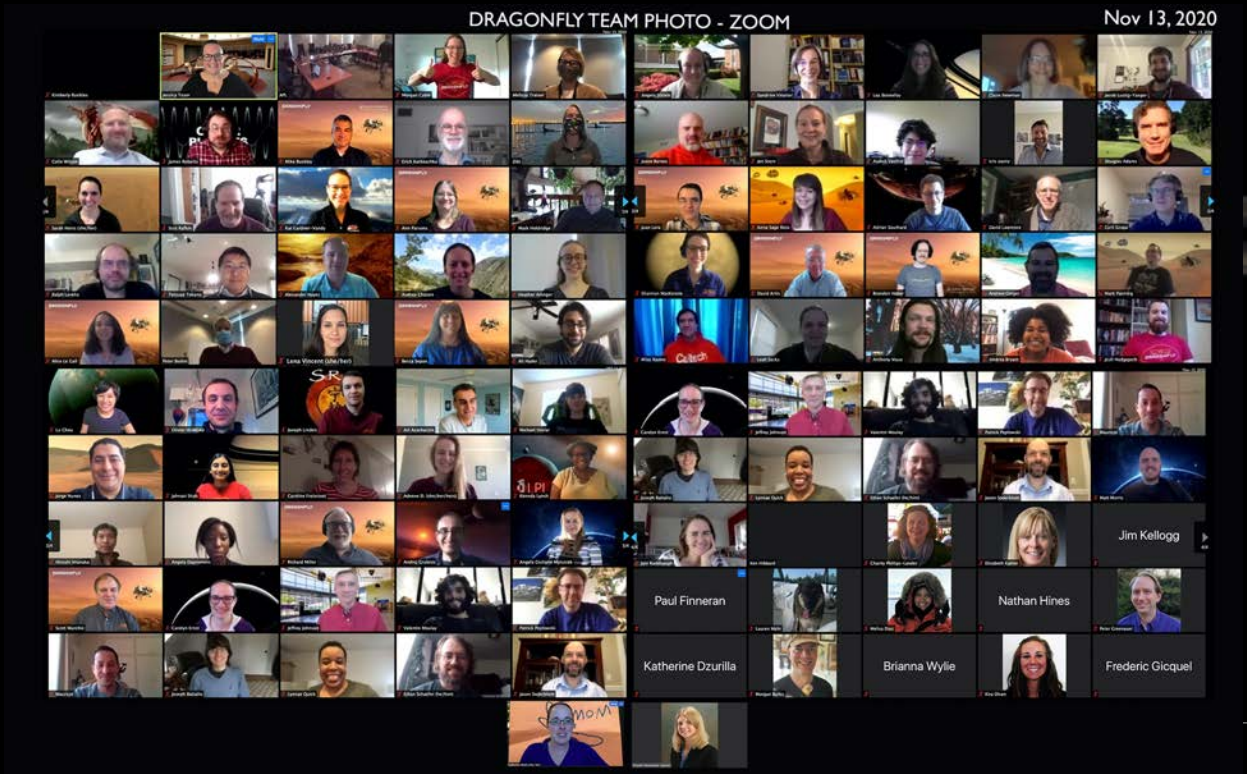
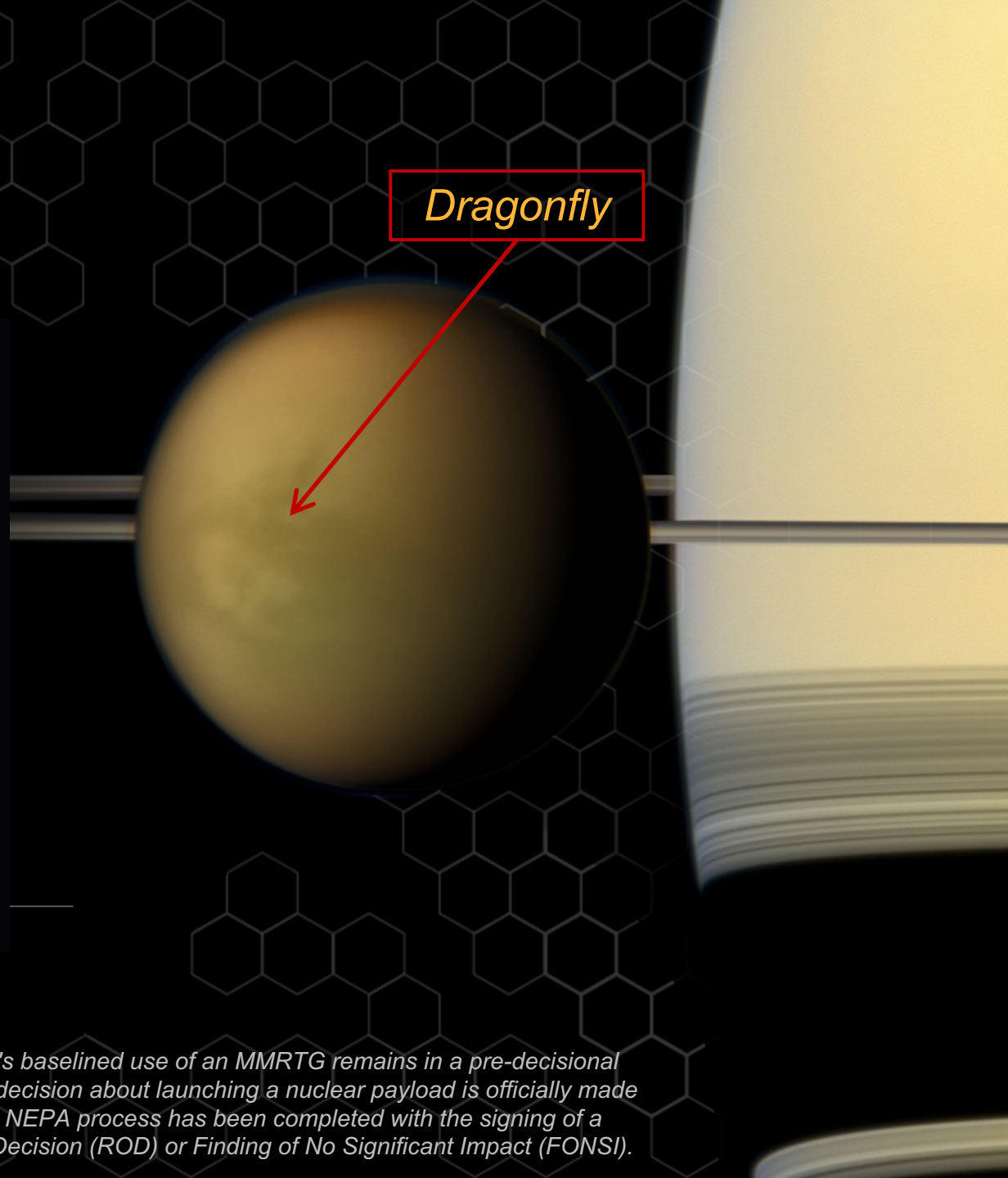
DRAGONFLY



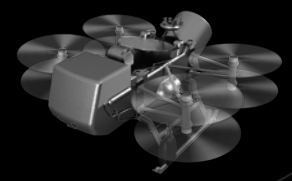
Zibi Turtle, Dragonfly PI, JHUAPL
on behalf of the Dragonfly Team

OPAG, 31 August 2021

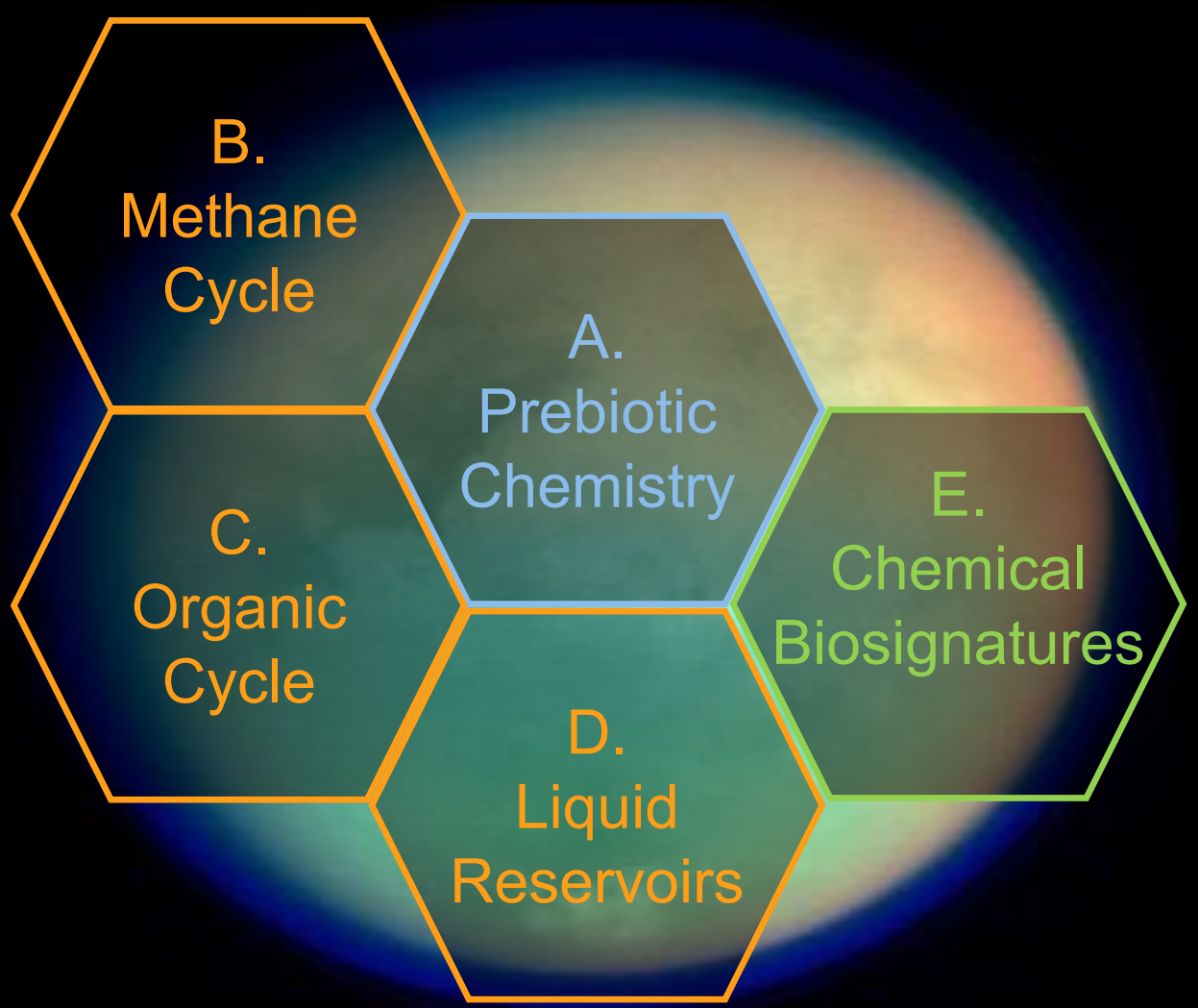


Dragonfly's baselined use of an MMRTG remains in a pre-decisional state. The decision about launching a nuclear payload is officially made after the NEPA process has been completed with the signing of a Record of Decision (ROD) or Finding of No Significant Impact (FONSI).

Dragonfly mission science



- 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



Dragonfly mission science

Barnes et al., 2021
https://doi.org/10.3847/PSJ/abfdcf

The Planetary Science Journal, 2:130 (18pp), 2021 August https://doi.org/10.3847/PSJ/abfdcf

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Science Goals and Objectives for the Dragonfly Titan Rotorcraft Relocatable Lander

Jason W. Barnes[1], Elizabeth P. Turtle[2], Melissa G. Trainer[3], Ralph D. Lorenz[2], Shannon M. MacKenzie[2], William B. Brinckerhoff[3], Morgan L. Cable[4], Carolyn M. Ernst[2], Caroline Freissinet[5], Kevin P. Hand[4], Alexander G. Hayes[6], Sarah M. Hörst[7], Jeffrey R. Johnson[2], Erich Karkoschka[8], David J. Lawrence[2], Alice Le Gall[9,10], Juan M. Lora[11], Christopher P. McKay[12], Richard S. Miller[2], Scott L. Murchie[2], Catherine D. Neish[13,14], Claire E. Newman[15], Jorge Núñez[2], Mark P. Panning[4], Ann M. Parsons[3], Patrick N. Peplowski[2], Lynnae C. Quick[3], Jani Radebaugh[16], Scot C. R. Rafkin[17], Hiroaki Shiraishi[18], Jason M. Soderblom[19], Kristin S. Sotzen[2], Angela M. Stickle[2], Ellen R. Stofan[20], Cyril Szopa[5], Tetsuya Tokano[21], Thomas Wagner[22], Colin Wilson[23], R. Aileen Yingst[13], Kris Zacny[24], and Simon C. Stähler[25]

[1] University of Idaho, Department of Physics, Moscow, ID 83844-0903, USA; jwbarnes@uidaho.edu
[2] Applied Physics Laboratory, Johns Hopkins University, Space Exploration Sector, Laurel, MD 20723, USA
[3] NASA Goddard Space Flight Center, Mail Code 690, Greenbelt, MD 20771, USA
[4] NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91126, USA
[5] LATMOS/IPSL, CNRS, Guyancourt, F-78280, France
[6] Cornell University, Department of Astronomy, Ithaca, NY 14853, USA
[7] The Johns Hopkins University, Department of Earth and Planetary Sciences, Baltimore, MD 21218, USA
[8] Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 84721, USA
[9] LATMOS/IPSL, UVSQ Université Paris-Saclay, Sorbonne Université, CNRS, France
[10] Institut Universitaire de France (IUF), Paris, France
[11] Yale University, Department of Earth and Planetary Sciences, New Haven, CT 06511, USA
[12] NASA Ames Research Center, Space Science Division, Moffett Field, CA, USA
[13] Planetary Science Institute, Tucson, AZ 85719, USA
[14] The University of Western Ontario, Department of Earth Sciences, London, ON, N6A 3K7, Canada
[15] Aeolis Research, Pasadena, CA 91101, USA
[16] Brigham Young University, Department of Geological Sciences, Provo, UT 84602, USA
[17] Southwest Research Institute, Boulder, CO 80503, USA
[18] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, 252-5210, Japan
[19] Massachusetts Institute of Technology, Department of Earth and Planetary Sciences, Cambridge, MA 02139, USA
[20] National Air and Space Museum, Washington, DC 20560, USA
[21] Universität zu Köln, Institut für Geophysik und Meteorologie, Köln D-50923, Germany
[22] NASA Headquarters, Washington, DC 20546, USA
[23] Oxford University, Atmospheric, Oceanic and Planetary Physics, Oxford, OX1 3PU, UK
[24] Honeybee Robotics, Pasadena, CA 91103, USA
[25] Institute of Geophysics, ETH Zürich, Zürich, Switzerland
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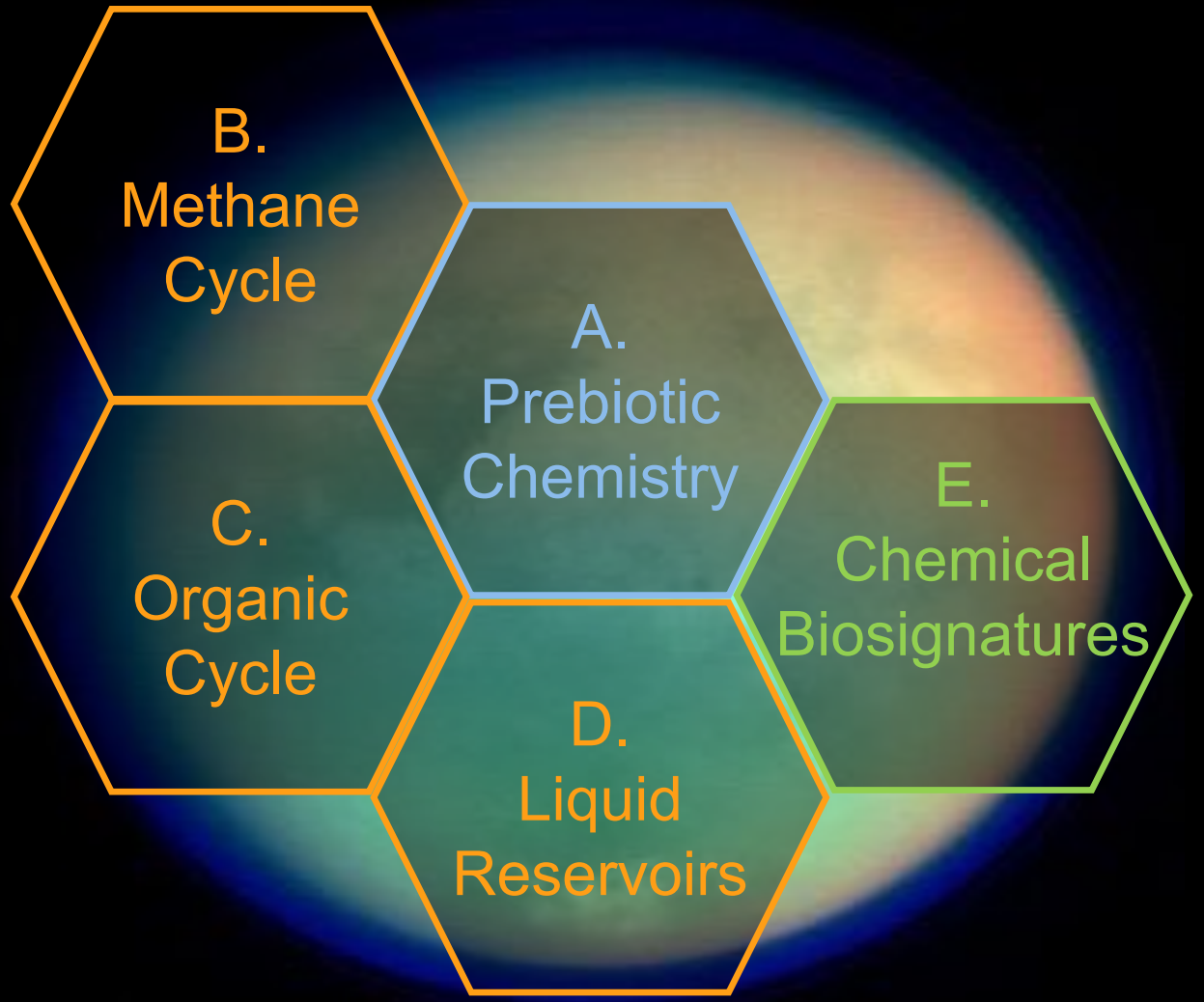
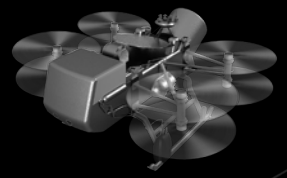
Abstract

NASA's Dragonfly mission will send a rotorcraft lander to the surface of Titan in the mid-2030s. Dragonfly's science themes include investigation of Titan's prebiotic chemistry, habitability, and potential chemical biosignatures from both water-based "life as we know it" (as might occur in the interior mantle ocean, potential cryovolcanic flows, and/or impact melt deposits) and potential "life, but not as we know it" that might use liquid hydrocarbons as a solvent (within Titan's lakes, seas, and/or aquifers). Consideration of both of these solvents simultaneously led to our initial landing site in Titan's equatorial dunes and interdunes to sample organic sediments and water ice, respectively. Ultimately, Dragonfly's traverse target is the 80 km diameter Selk Crater, at 7° N, where we seek previously liquid water that has mixed with surface organics. Our science goals include determining how far prebiotic chemistry has progressed on Titan and what molecules and elements might be available for such chemistry. We will also determine the role of Titan's tropical deserts in the global methane cycle. We will investigate the processes and processing rates that modify Titan's surface geology and constrain how and where organics and liquid water can mix on and within Titan. Importantly, we will search for chemical biosignatures indicative of past or extant biological processes. As such, Dragonfly, along with Perseverance, is the first NASA mission to explicitly incorporate the search for signs of life into its mission goals since the Viking landers in 1976.

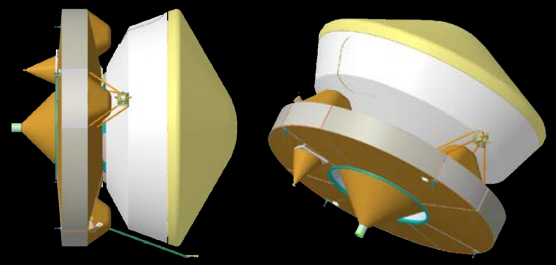
Unified Astronomy Thesaurus concepts: Titan (2186); Pre-biotic astrochemistry (2079); Astrobiology (74); Planetary atmospheres (1244); Planetary surfaces (2113)



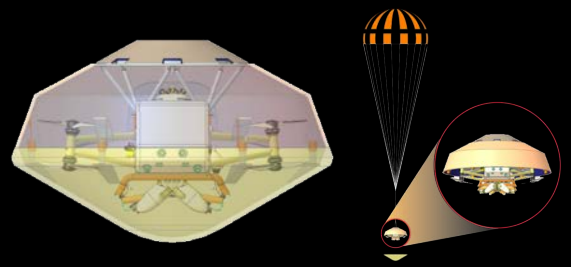
Dragonfly mission elements



Spacecraft = Cruise Stage + Entry Vehicle



Entry Vehicle = EDL Assembly + Lander



Carry entire payload from place to place

- Measurements on surface and in flight, including aerial imaging and atmospheric profiles

Direct-to-Earth communication

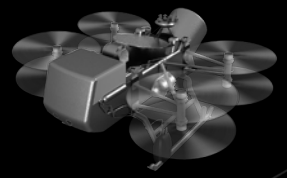
- HGA articulation used to target cameras for panoramas of surrounding terrain

Rotorcraft Lander
Surface configuration with HGA deployed

MMRTG power source

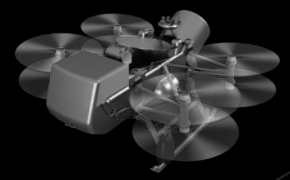
- Charges battery to power flight and science activities
- Waste heat maintains nominal thermal environment in lander

Dragonfly mission timeline

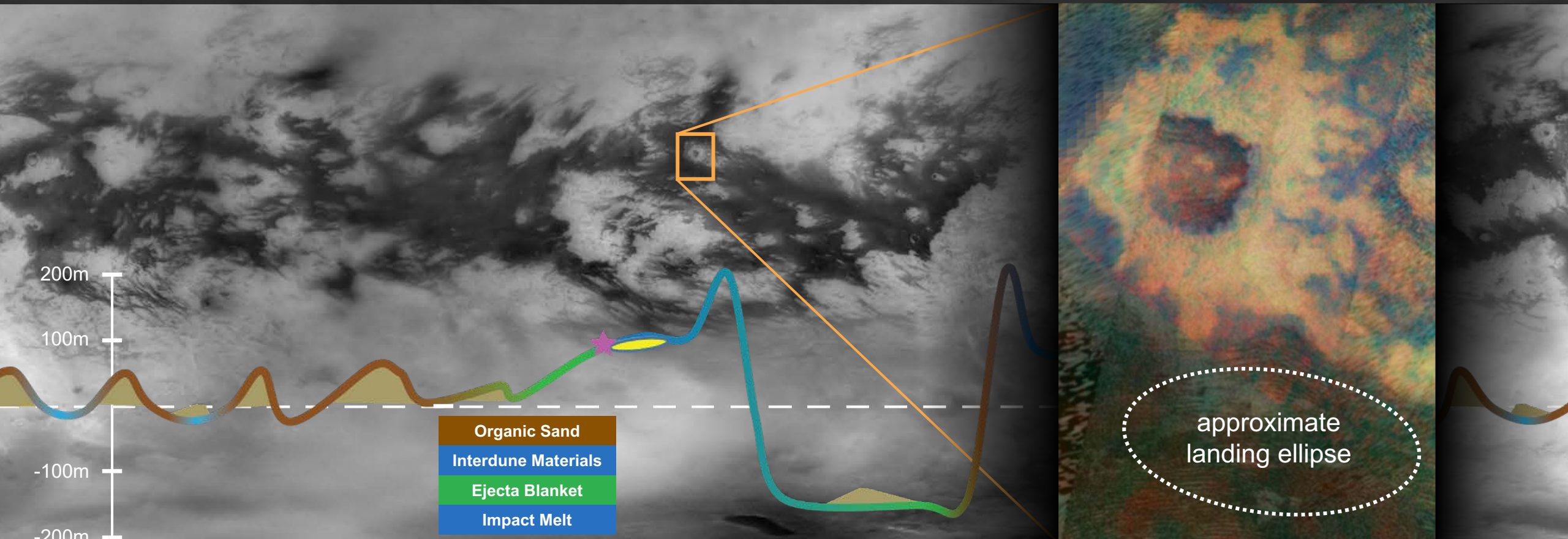


- Launch June 2027, and Titan arrival by 2034
  - Direct atmospheric entry
  - Similar latitude and same time of year as descent of Huygens probe

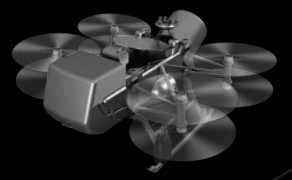
Dragonfly mission timeline



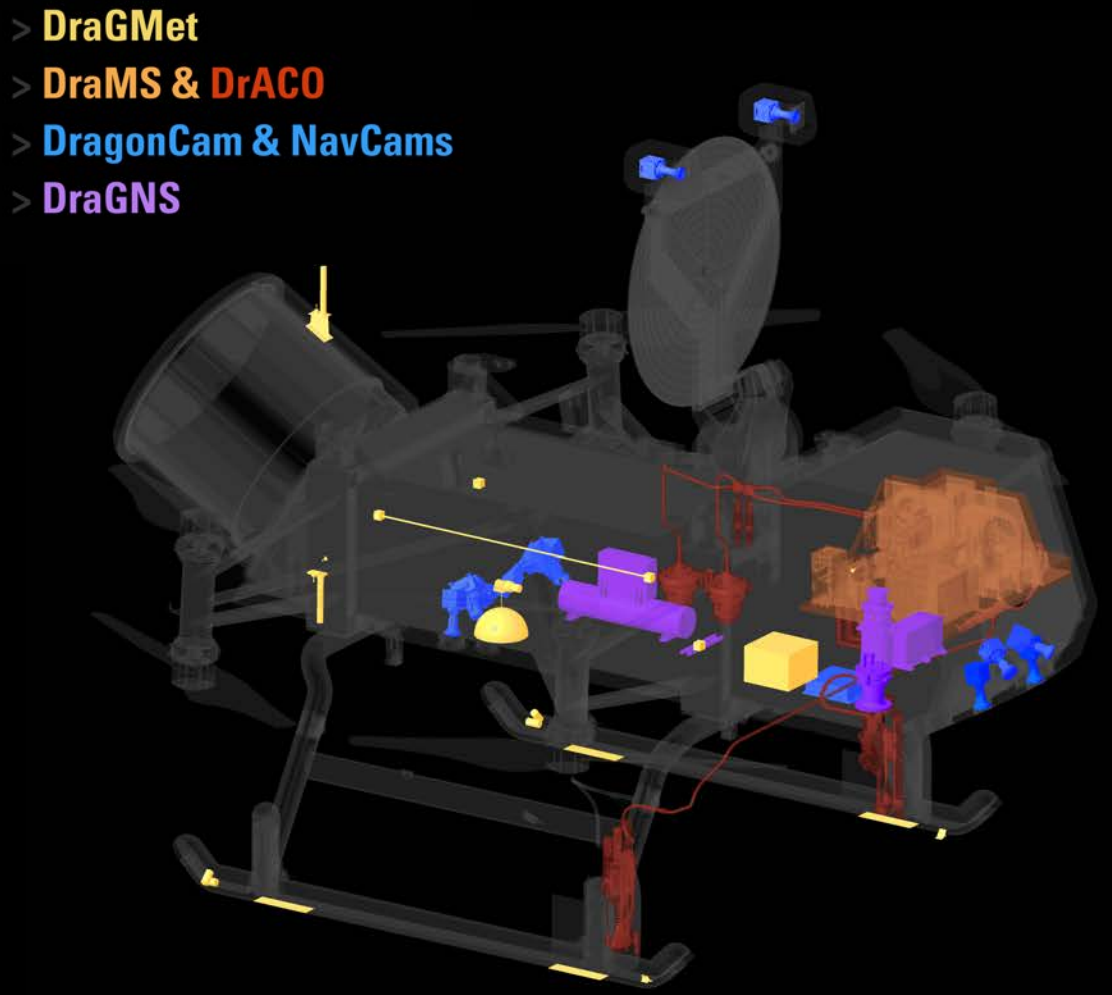
- ~3.3 years or ~74 Tsols (Titan days) of science operations
  - Traverse distance up to ~180 km
  - Exploration of ~25-30 unique sites



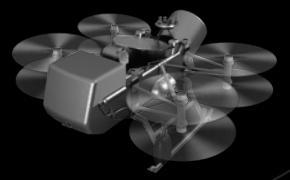
Multidisciplinary science measurements



- DraGMet: Geophysics & Meteorology Package (APL, JAXA Lunar-A seismometer)
- DraMS: Mass Spectrometer (GSFC, CNES)
- DrACO: Drill for Acquisition of Complex Organics (Honeybee Robotics)
- DragonCam: Camera Suite (MSSS)
- DraGNS: Gamma-ray Neutron Spectrometer (APL, LLNL, GSFC, Schlumberger PNG)

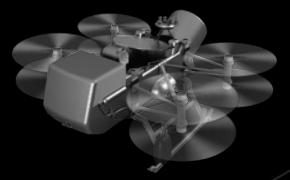


Dragonfly mission updates and recent activities



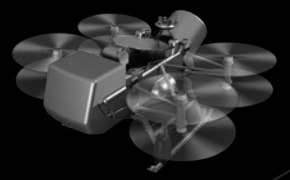
- Technical development, design evolution, and testing
  - Priority is team safety as COVID-19 pandemic continues with onsite / in-person activities being conducted as possible
  - Focus is on technology maturation activities, requirements and interface definitions, and risk reduction
- Replanning at NASA's request for June 2027 launch
  - Benefits of latest NASA update include:
    - shorter cruise trajectory accelerates and also enhances mission science return – higher MMRTG power output at arrival allows additional science measurements and increased data downlink
    - avoids inner Solar System tour, reducing spacecraft design risk, simplifying thermal and telecom design, and simplifying cruise operations
- Next milestone review is PDR in September 2022
  - L4 requirements in development and review
  - Subsystem PDRs scheduled starting in Spring 2022

Dragonfly mission updates and recent activities, cont'd



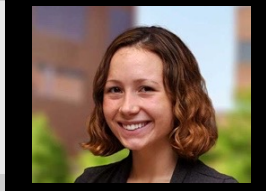
- Science requirements and operations
  - Program Level Requirements Appendix (PLRA) signed
  - Development of surface operations and ground-in-the-loop flow for different Tsol scenarios
- Rules of the Airways in development
- International agreements (CNES, JAXA, DLR) are being coordinated
- Planetary Protection and Communication Plans are being developed with NASA
- National Environmental Policy Act (NEPA) Environment Assessment (EA) under development in cooperation with NASA, RPS, DOE
- Virtual Team Meeting in November 2020
  - Welcomed Guest Observers, part of NASA trial program
- First cohort of the Dragonfly Student Guest Investigator Program selected (2020-22); selection of 2nd cohort (2021-2023) in early September

Dragonfly Student Guest Investigators – first cohort



Quick et al., 2021: https://www.hou.usra.edu/meetings/lpsc2021/pdf/2653.pdf

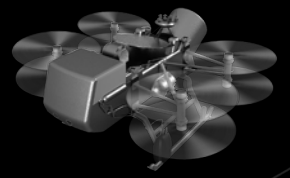
Project	Dragonfly Team Mentors	Mentees
Seismic investigation of Titan's interior using full waveform modeling	Mark Panning, JPL	**Andrea Bryant**, University of Chicago, Physics
Spectral/compositional library for interpretation of DragonCam/DraGNS measurements	Shannon MacKenzie & Richard Miller, APL	**Karla Negrete**, University of Maryland Baltimore County (UMBC), Mech. Eng.
Development of the DragonCam microscopic imager multispectral LED arrays	Jorge Núñez, APL	**Brianna Wylie**, Florida Agricultural & Mechanical University (FAMU), Mech. Eng.



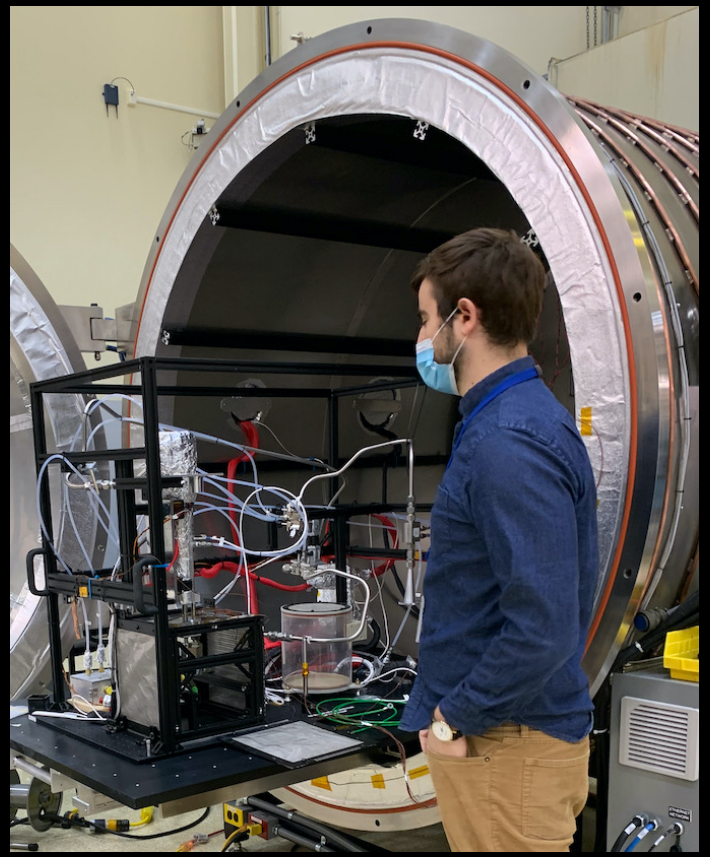
- Goals of Program
  - Extend opportunities for graduate students to work with *Dragonfly* scientists and engineers
  - Encourage broader participation by making it easier for students who **don't already** have connections to *Dragonfly* or NASA spacecraft missions and/or who **don't** have a planetary science background
  - Serve as an "on-ramp" to provide networking opportunities and to expand training of the next generation of mission team members and leaders

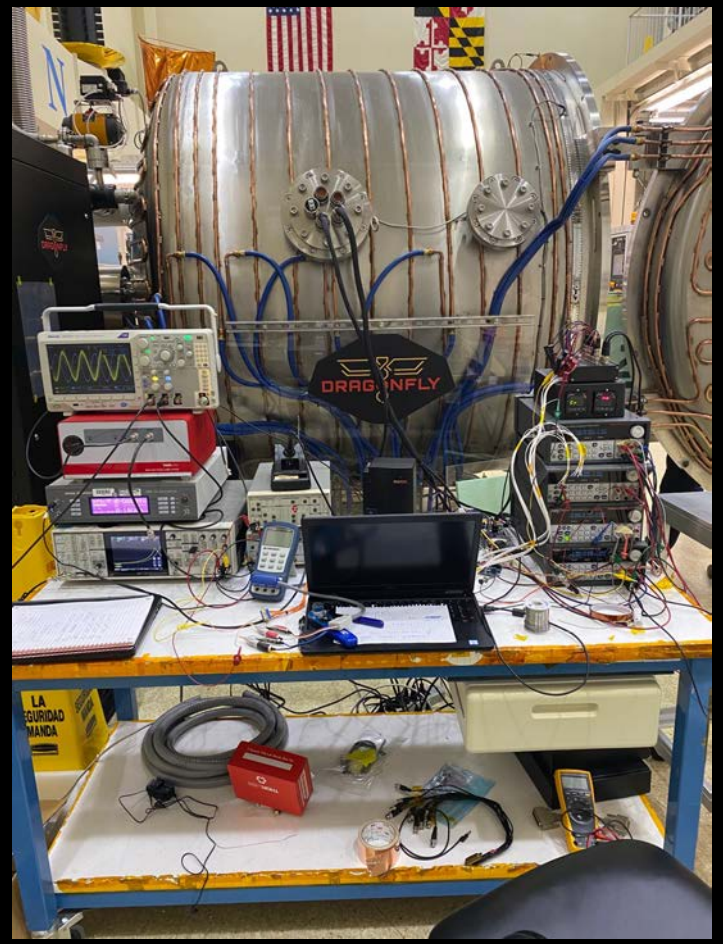
Recent activities

Preliminary design and hardware testing in the Titan environment

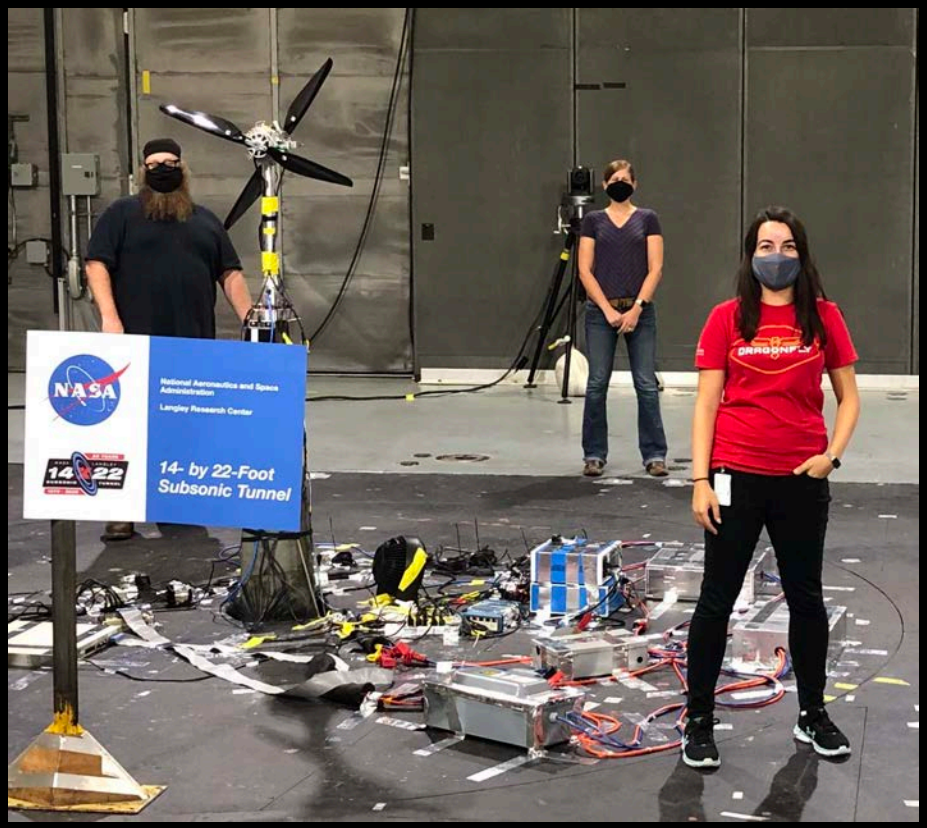


DrACO and DraGMet testing in APL's Titan environment chamber



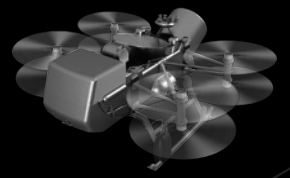


Testing in NASA Langley 14x22 wind tunnel for CFD validation



Recent activities

Octocopter platform flight testing



- Half-scale integrated test platform (ITP) demonstrated real-time NavCam imaging; guidance and control algorithms on flight-like hardware and software; close matches between optical navigation and GPS data from flight; autonomous takeoff, hover, hop, and scouting flights

Recent activities

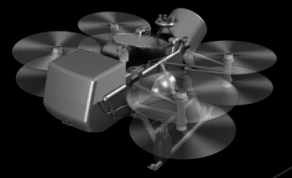
Octocopter platform flight testing

Autopilot flight test

Image stream flight test

- Half-scale integrated test platform (ITP) demonstrated real-time NavCam imaging; guidance and control algorithms on flight-like hardware and software; close matches between optical navigation and GPS data from flight; autonomous takeoff, hover, hop, and scouting flights.

Upcoming activities and engagement



- On track with technology maturation and requirements and interface definitions, leading up to subsystem PDRs in 2022 and mission PDR in September 2022
- Selections for the 2nd cohort of the Dragonfly Student Guest Investigator Program (2021-23)
  - Next Dragonfly Student Guest Investigator Program Opportunities (2022-24) expected to be posted by early 2022 https://dragonfly.jhuapl.edu/Student-Opportunities/
- Participation in NASA Here To Observe (H2O) program 2021-2022
- Completion of international agreements (CNES, JAXA, DLR), Planetary Protection and Communication Plans

DRAGONFLY

http://dragonfly.jhuapl.edu