JOHNS HOPKINS APPLIED PHYSICS LABORATORY

HONEYBEE ROBOTICS
Spacecraft Mechanisms Corporation

Drilling and Pneumatic Transfer of Titan Surface Materials

Ralph Lorenz (APL, Laurel, MD)

Fredrik Rehnmark, Tighe Costa, Joseph Sparta, Bernice Yen, Kris Zacny (Honeybee Robotics, Pasadena CA)

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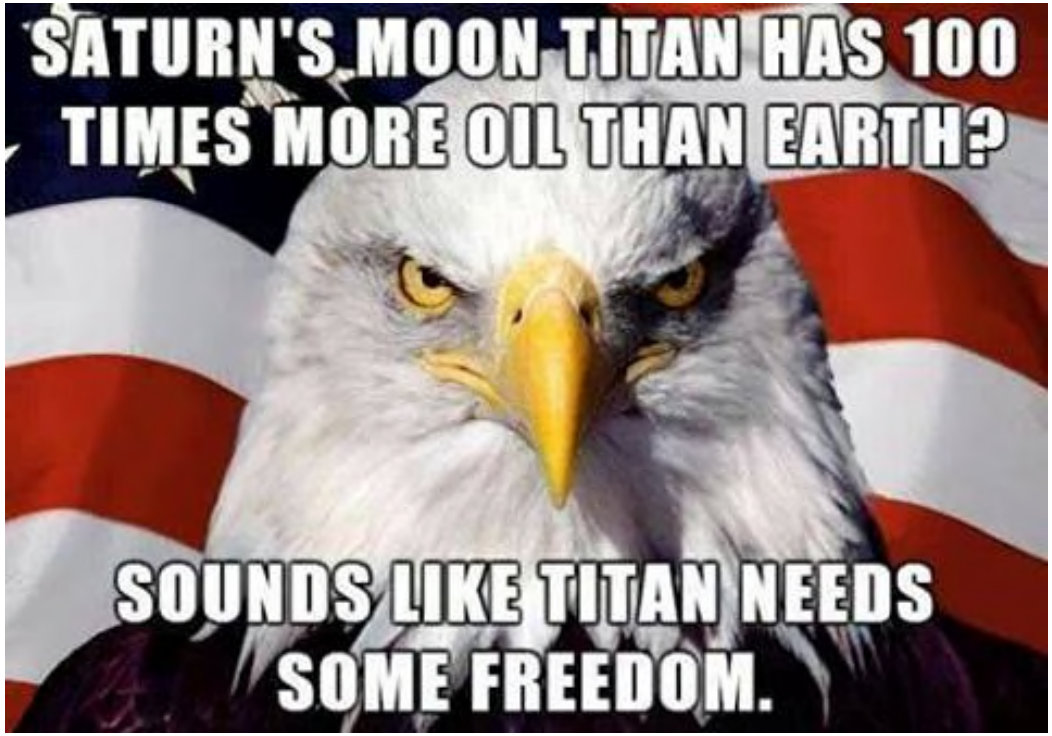
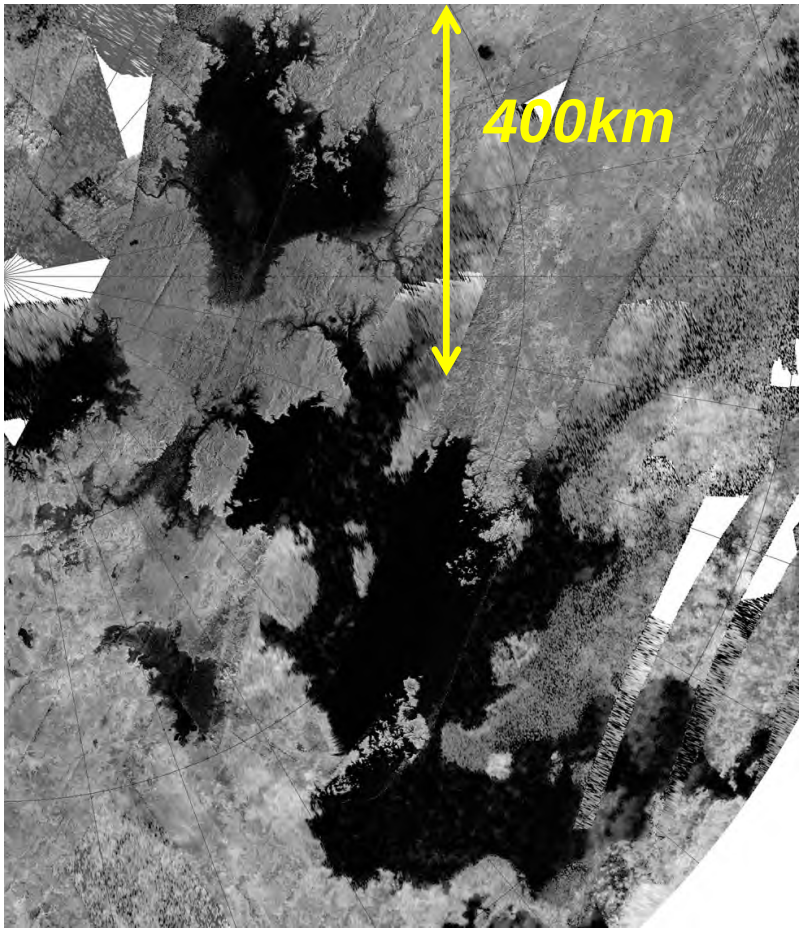
Titan – A Resource Hub in the Outer Solar System

DRAGONFLY

Titan's methane-rich atmosphere (+seas) offer an accessible source of propellant, as noted by A.C. Clarke in 'Imperial Earth' in 1976.





Titan Environment

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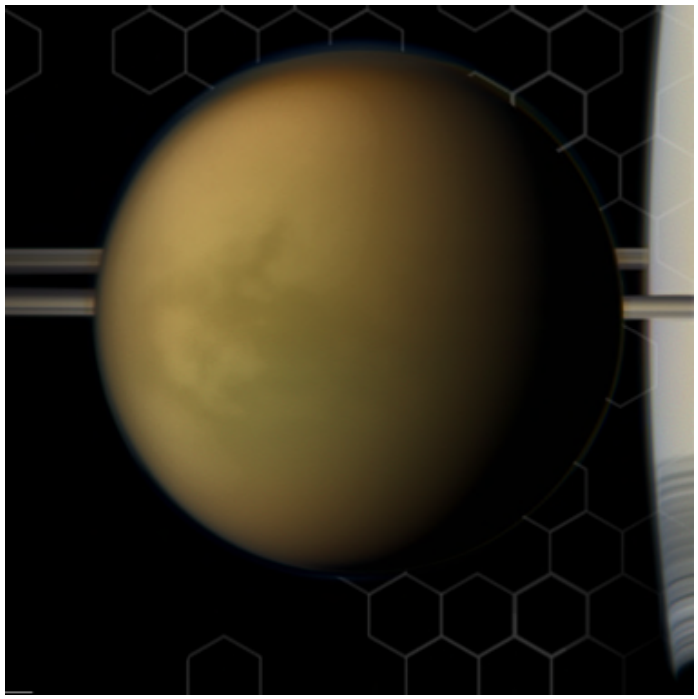
Global Survey from Cassini over 13 years, plus ground truth from the Huygens Probe

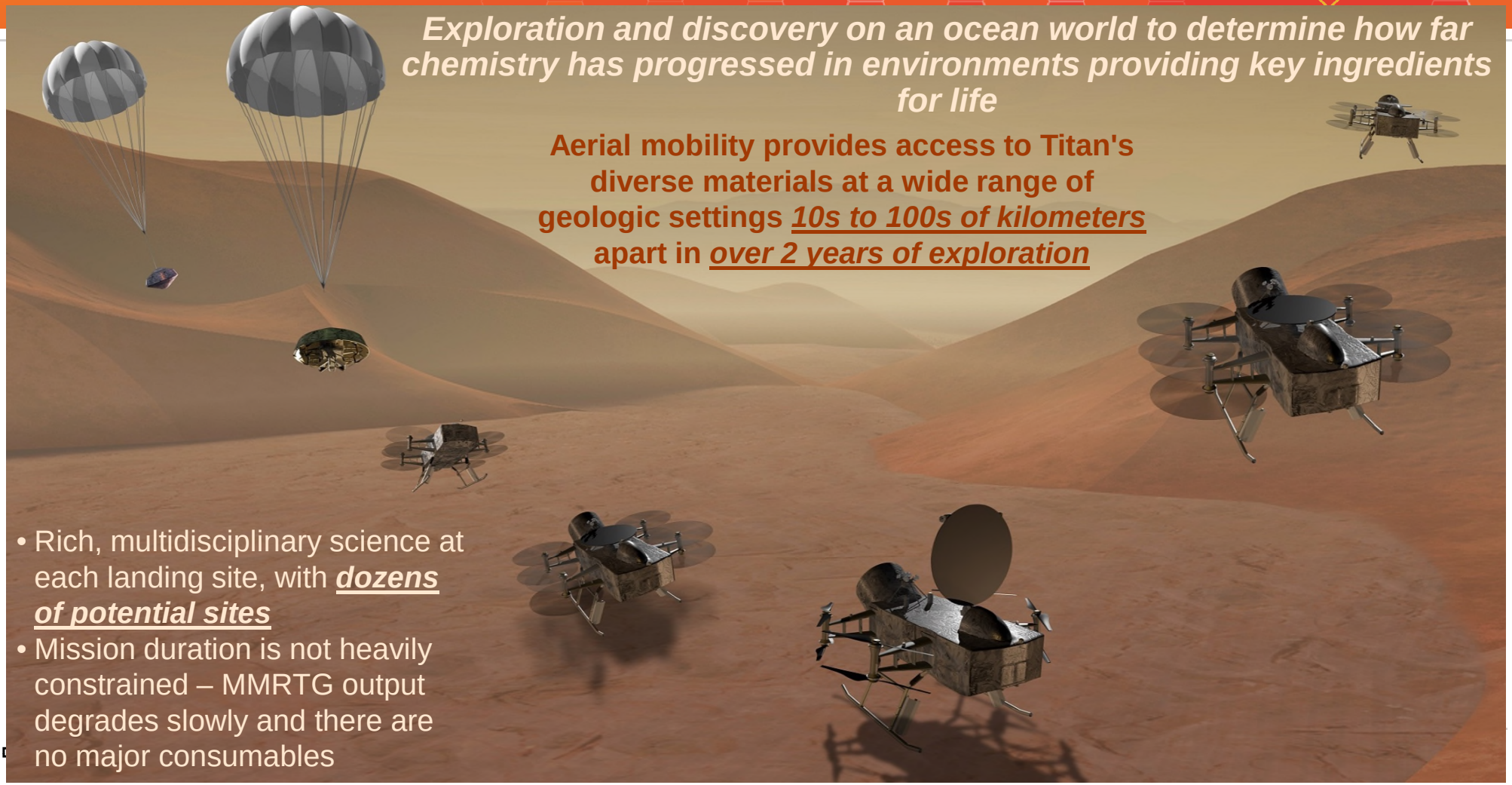
- ***1/7 Earth Gravity (cf 1/6 on Moon)***
- ***4x Atmospheric density (95% Nitrogen, 5% Methane)***
- ***94 K Surface Temperature***

- ***Granular (sand) and solid materials expected, gravels & dust also possible***
- ***Water Ice, Ammonia-Water ice, Solid organics***
- ***Methane, Ethane are liquids at Titan conditions***



New Frontiers mission concept: rotorcraft lander for in situ investigation of Titan's prebiotic chemistry and habitability

DRAGONFLY



Exploration and discovery on an ocean world to determine how far chemistry has progressed in environments providing key ingredients for life

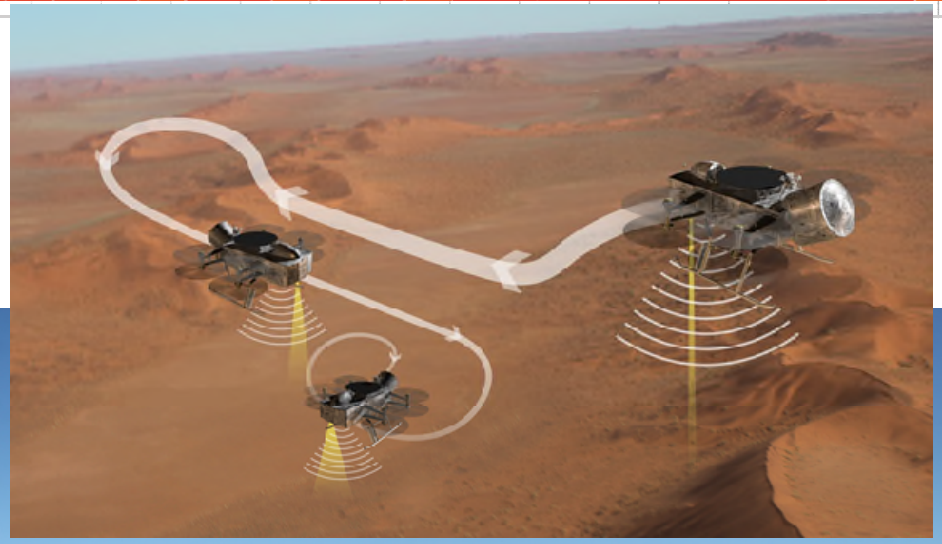
Aerial mobility provides access to Titan's diverse materials at a wide range of geologic settings *10s to 100s of kilometers* apart in *over 2 years of exploration*

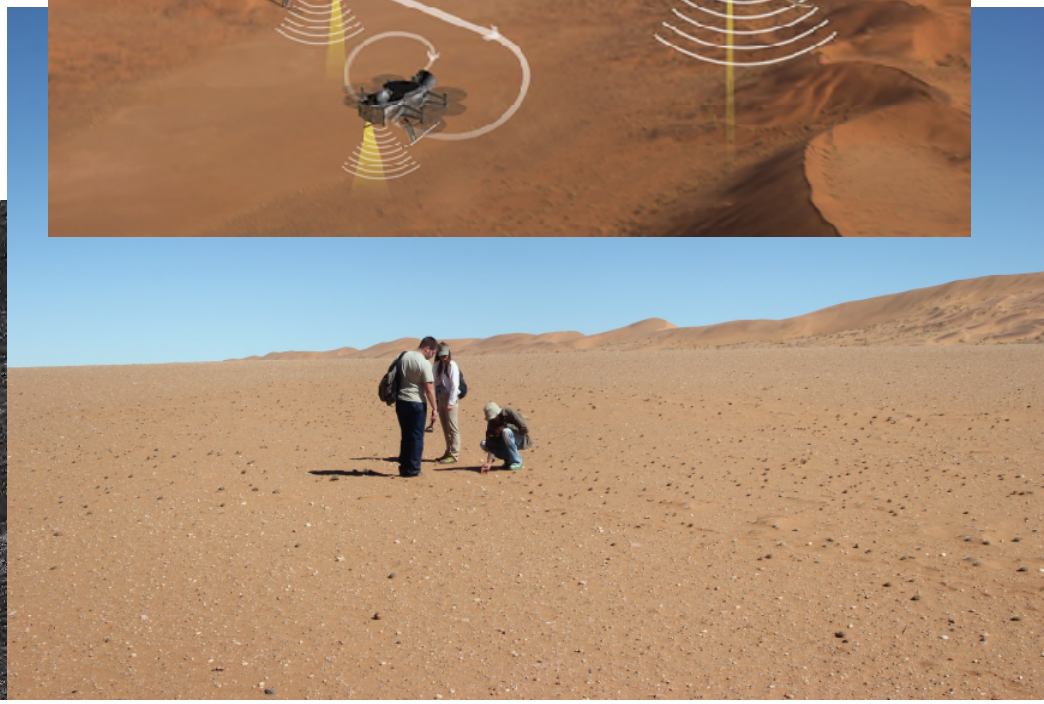
- Rich, multidisciplinary science at each landing site, with ***dozens of potential sites***
- Mission duration is not heavily constrained – MMRTG output degrades slowly and there are no major consumables

Mission timeline

DRAGONFLY

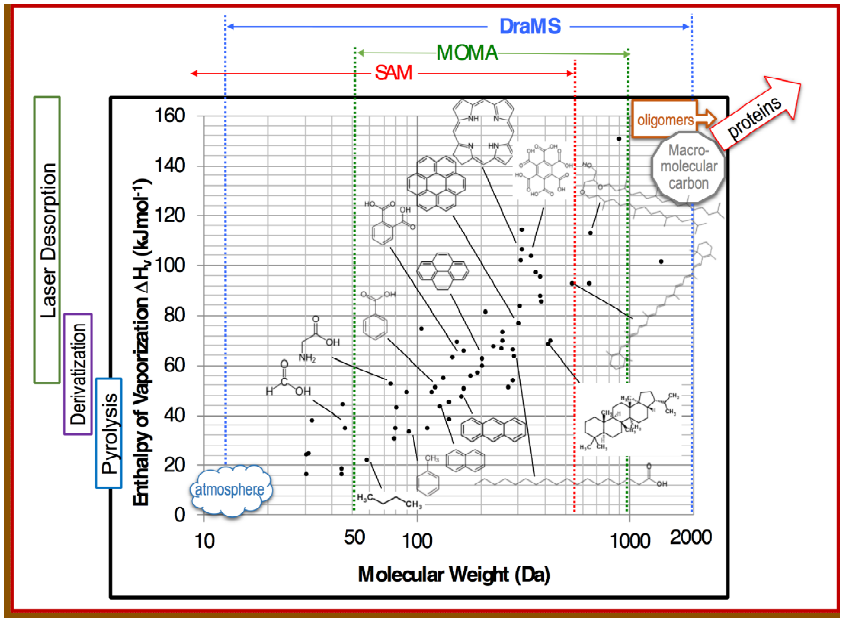
- Titan arrival in 2034
  - landing in equatorial interdune plains
  - Organic dunes ~100-m-high, several-km spacing
  - well characterized by *Cassini*
  - *Close morphological analogs exist on Earth (e.g. Namib)*
  - similar latitude and time of year as *Huygens* probe
  - **Ice-rich material nearby**



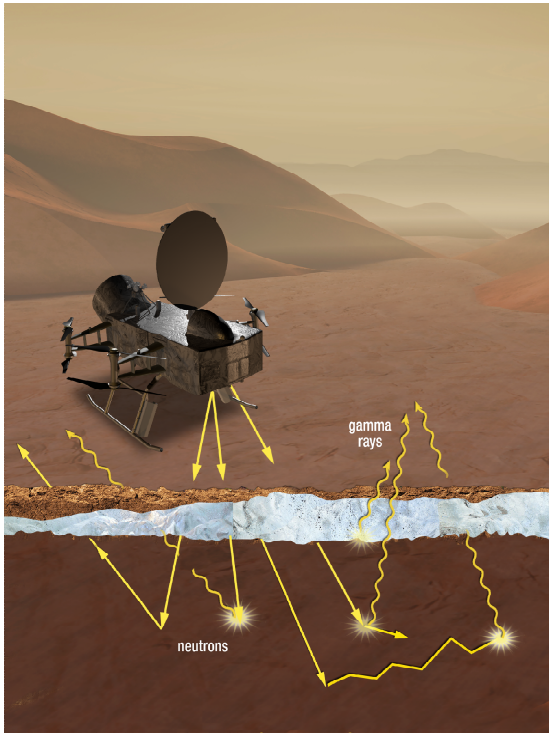


Focussed Payload – Science Value multiplied by Diverse Sites

- **DragonCam:**
  - *Forward, downward, panorama and microscopic imagers*
- **DraGNS**
  - *Gamma Ray and Neutron spectrometer with Neutron generator*
- **DRACO + DraMS :**
  - *Drill/pneumatic sample transfer to Mass spectrometer with laser desorption and pyr/GC front ends*
- **DraGMet**
  - *Geophysics and Meteorology Package (incl. seismometer)*

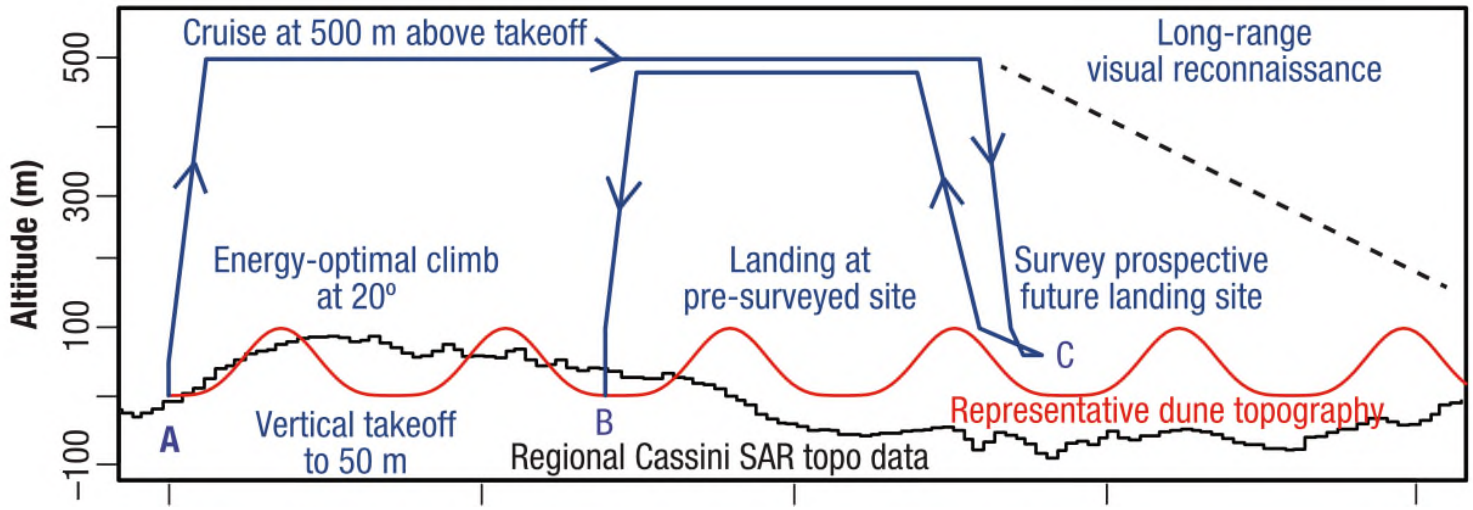


SAM = Sample Analysis at Mars (on MSL)[10] MOMA = Mars Organic Molecule Analyzer (on ExoMars)[11-14]
DraMS leverages development funded through NASA/MatISSE [15-16]



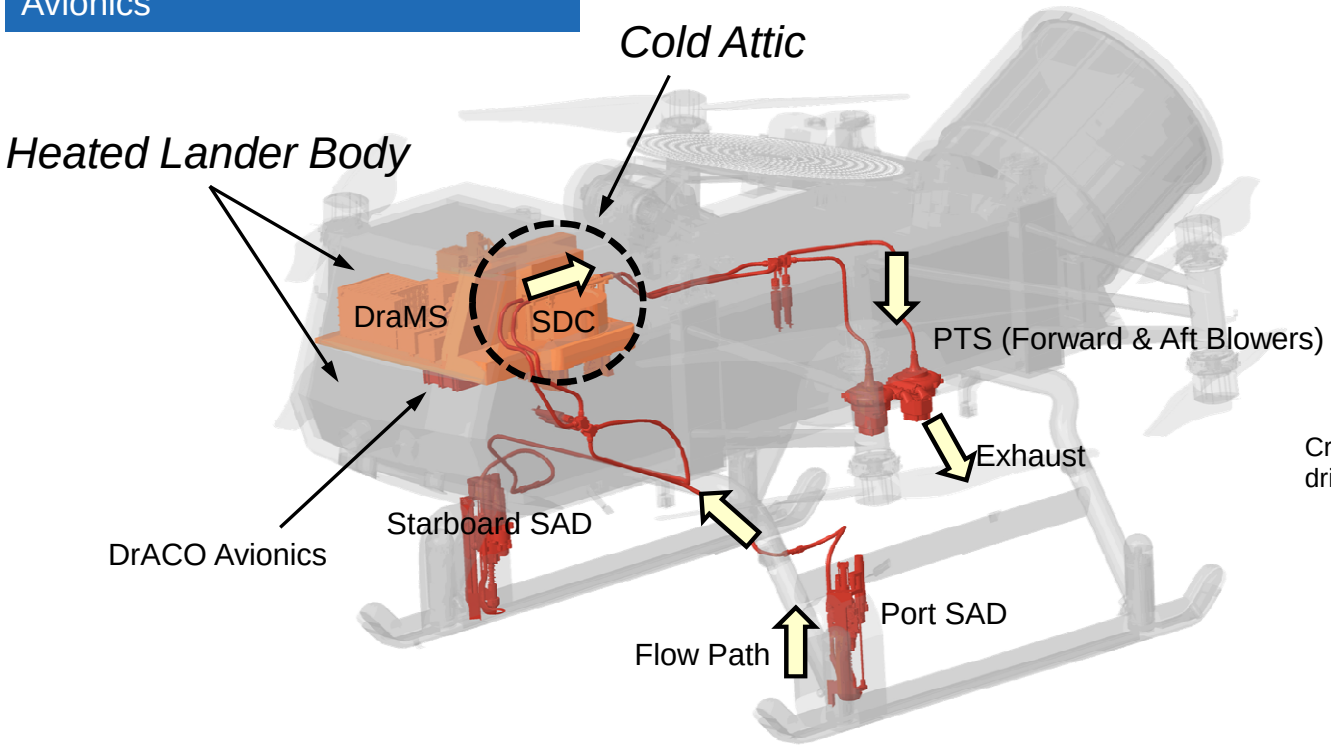
Operations Concept

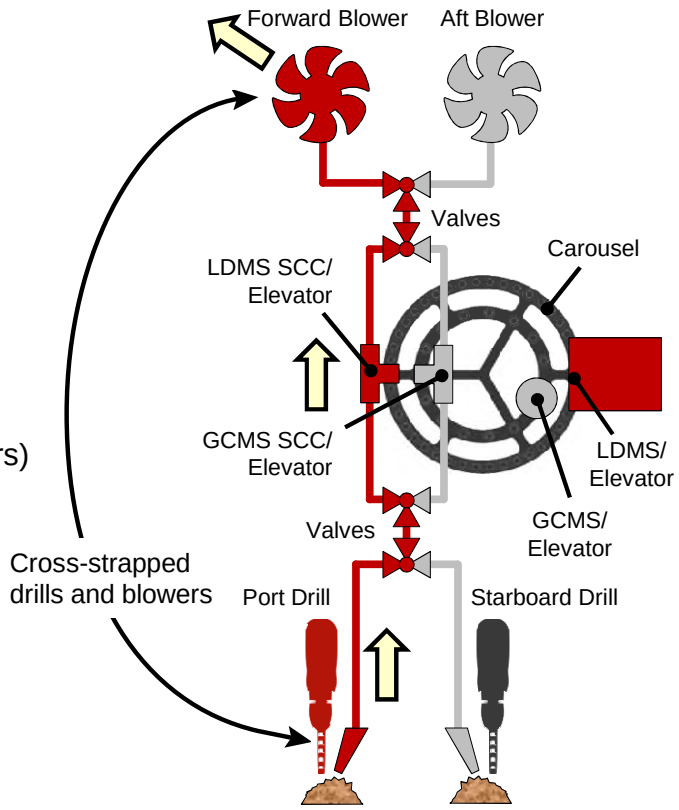
- ***Flying only ~0.1% of the time. Spend ~2 Titan Sols (~1 month) at each landing site***
- ***Ample time to conduct multiple sampling operations and downlink data. Also meteorological, seismomological monitoring***
- ***'Leapfrog' flight strategy allows scouting of prospective future landing sites, no need to commit to unknown terrain***

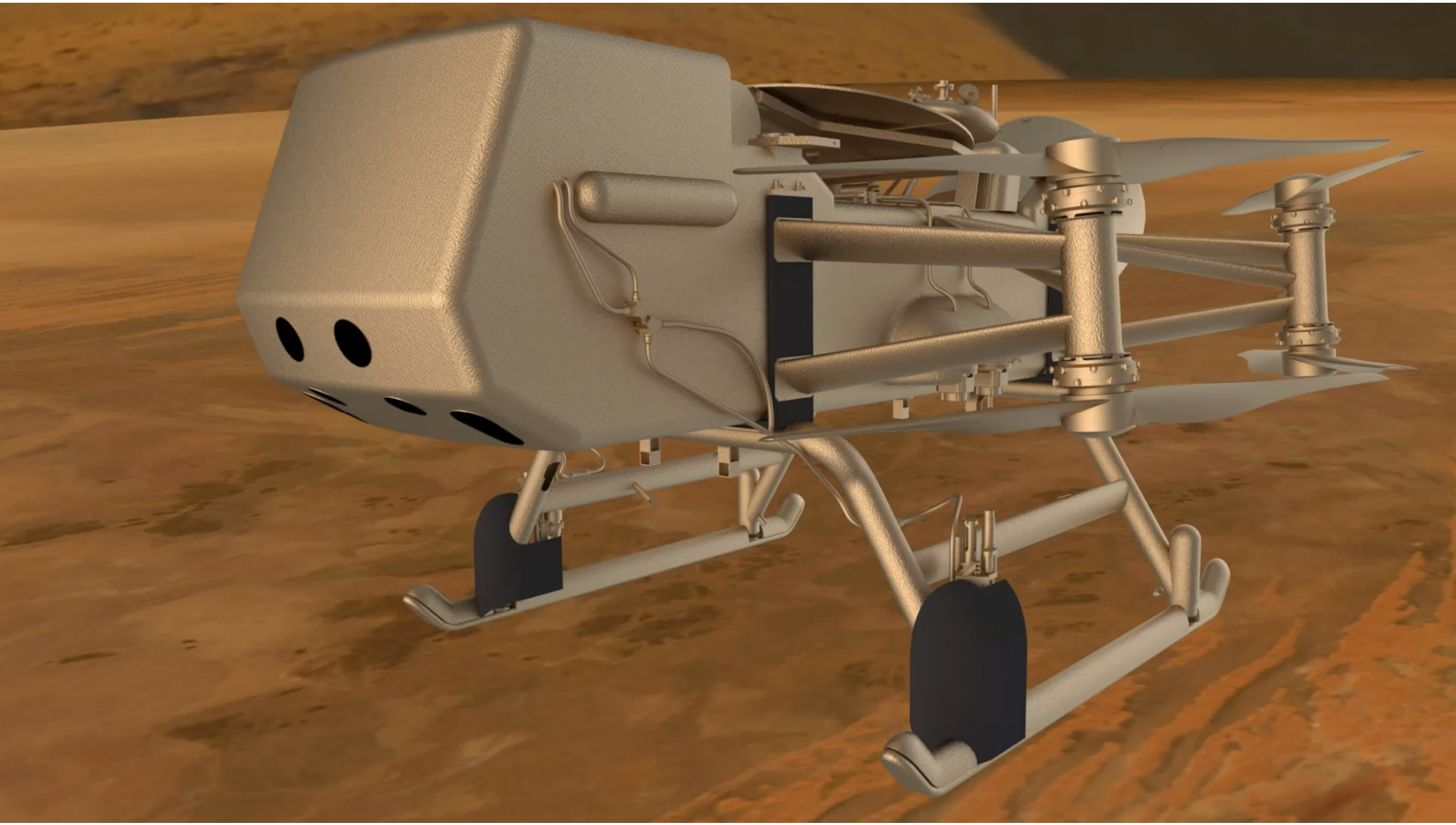


DrACO System Overview

SAD: Sample Acquisition Drill
PTS: Pneumatic Transport System
SDC: Sample Delivery Carousel
Avionics

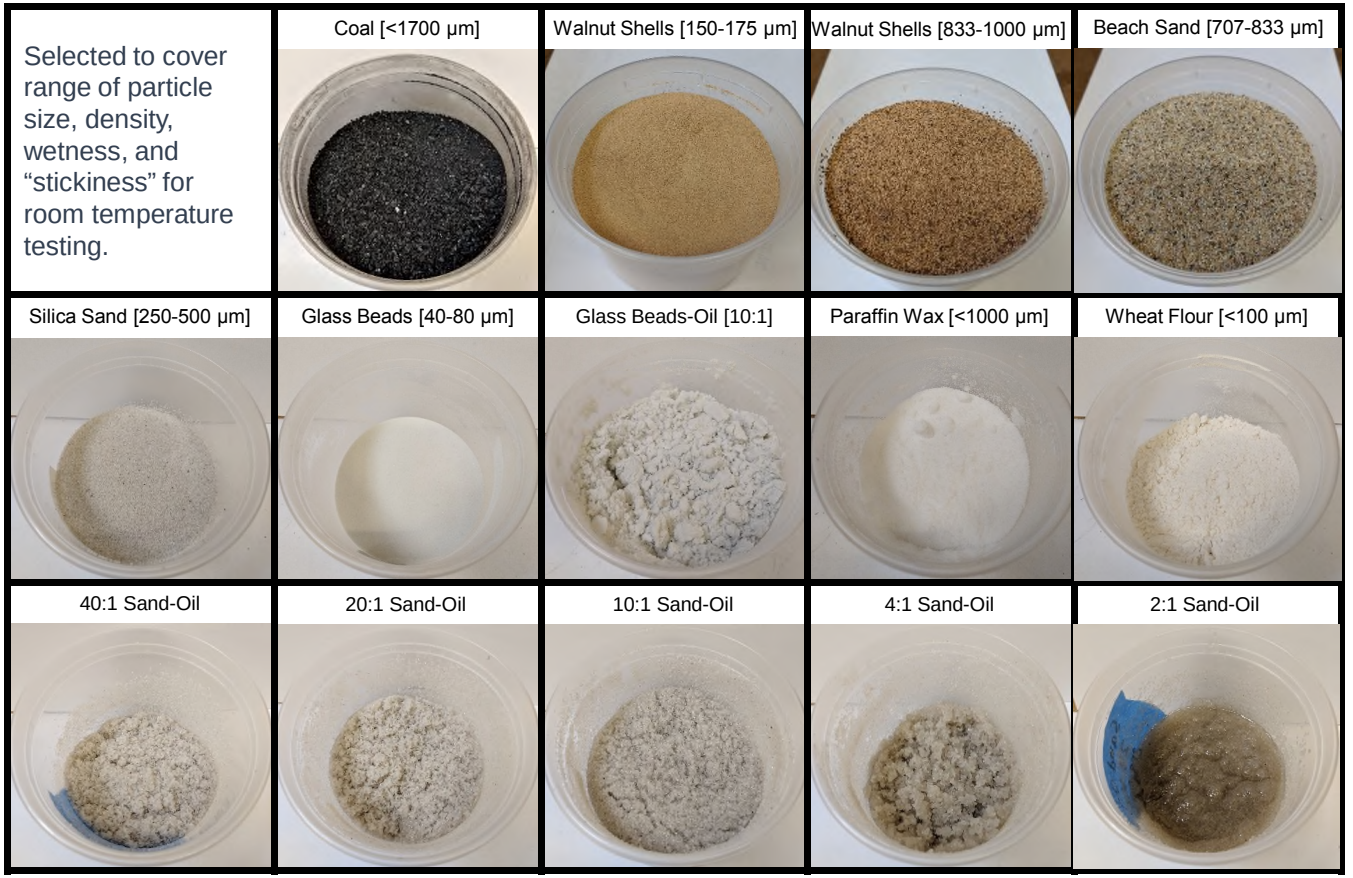






Development Testing

- ***A wide range of simulants have been tested for both drilling and pneumatic transfer***
- ***Tests have included cryogenic (~90K) tests at 1 bar including hydrocarbon wax, water ice, ammonia-rich ice etc.***
- ***Sticky simulants used to challenge system***



Dragonfly New Frontiers Concept

- ***Conceived in response to January 2016 community announcement of Titan as permissible target for NF 4***
- ***Proposed to NF 4 in April 2017***
- ***Selected (with one other mission) for Phase A study in December 2017***
- ***Concept Study report delivered December 2018***
- ***Site Visit at APL in April 2018***

- ***NASA decision expected July 2018***

- ***Dragonfly launch in 2025 or 2026***
- ***First landing in 2034, more landings in the following 2+ years***

More details at

http://dragonfly.jhuapl.edu


DRAGONFLY