How did Life get started?

- Environment
- Chemistry
- Opportunity

Titan Surface Mission

funded by Revolutionary Aerospace System Concepts (RASC) and now a Vision Mission Study– work in progress

University of Arizona

Jet Propulsion Laboratory

Titan as a target of Astrobiological Interest

- Organic compounds, detected in Titan's atmosphere, form as a result of the recombination of molecular fragments produced by methane (and nitrogen) photolysis.
  - Ultraviolet solar radiation,
  - irradiation by electrons in Saturn's magnetosphere
- Ultimate fate of these compounds is to condense at or near the base of Titan's stratosphere and be deposited as liquids or solids on the surface.
- Chemistry relevant to pre-biotic synthesis on Titan must occur on or near the surface, acting on the products of stratospheric chemistry and powered by sources other than direct solar ultraviolet radiation.
- Titan's atmosphere is essentially bereft of oxygen or oxygen-containing compounds like water. Lack of oxygen-bearing compounds in Titan's atmosphere is crucial for two reasons.
  - the chemistry that sustains life on Earth is mediated in liquid water - it requires liquid water as a solvent.
  - virtually every organic molecule of biochemical interest contains some oxygen
- Experiments have shown that tholins and nitriles are readily hydrolyzed by liquid water into amino acids;. Hence, if the accumulating organics on Titan's surface are exposed to liquid water, an entirely new step in chemical synthesis is introduced.

Thus, we must go to the surface and analyze the organics there in order to explore organic systems that might be direct precursors to life. It is of keen astrobiological interest to find locations on the surface that bear evidence of past episodes of liquid water.

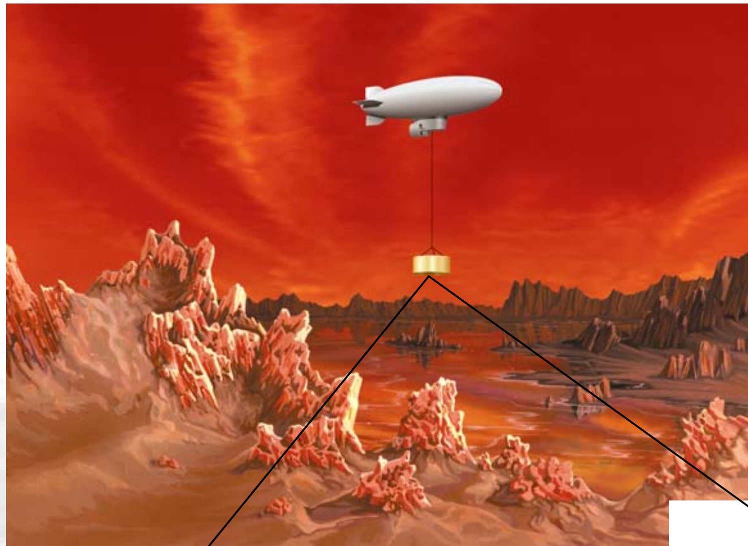
Titan Organics Explorer System Overview

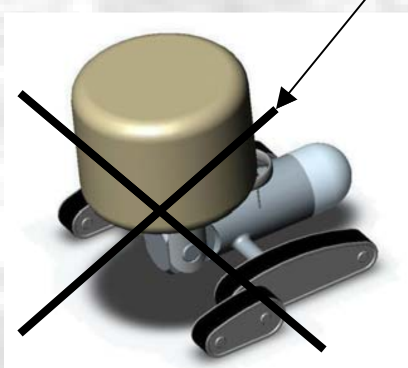
- Mission Concept
  Develop a post-Huygens extended surface science paradigm (e.g., months) for Titan which fits within the New Frontier Mission cost cap.
- Science Goals
  - Sample the Titan atmosphere close to the surface (possible tholins);
  - Sample surface material (liquid - if it exists/solids) with focus on chirality and other signatures of aqueous organic evolution;
- Science Payload
  - Organic chemistry- e.g. GCMS
  - Inorganic chemistry- e.g. Ion-µ-electrode or Raman (fiber-optic)
  - Imagers
  - Engineering sensors - Pressure/temperature etc.
- Mission Architecture/Design
  - Launch- 2012-2013 timeframe
  - Arrive- 2017-2018 during Titan summer N. latitude 80-85deg
  - Launch/cruise/EDL architecture - Atlas 551/SEP/aerocapture w/aeroshell/ chute
  - Aerial platform inflated at 10km altitude (also looking at stationary lander)
  - Orbiter deleted to save mass—aerial platform uses celestial bodies for global positioning and IMU/surface feature mapping for local position estimation
  - Sample acquisition/processing done using penetrator to retrieve samples
  - Tethered sample chamber reeled in and sample transferred to instrument suite in gondola or on lander

Results of Science Trade Studies

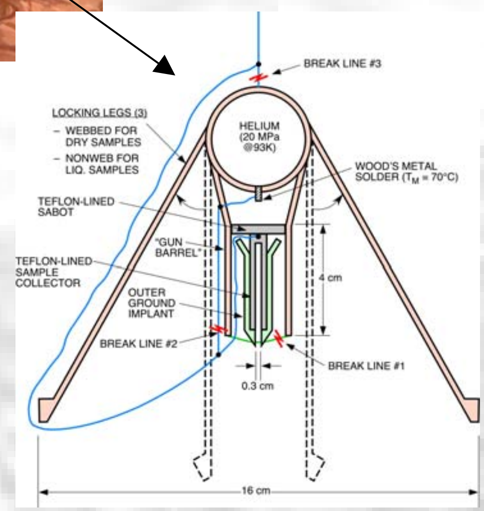
- Sample the atmospheric column from surface up to 1-2 km altitude
- Sample the surface material (top 2-3 centimeters) and any liquid if it exists
- Take samples of the immediate subsurface/liquid material
- **Prefer an aerial platform over stationary lander to allow a greater survey/surface coverage. Options are passive balloon or blimp**
- Give higher priority to the instrument payload being in the gondola rather than a drop sonde to allow flexibility in instrument packaging
- **Orbiter is optional** for global positioning (due to huge mass hit, particularly if we use a passive balloon platform)

Current Scenario of In-Situ Mission Elements





Passive/Mobile sondes w. in-situ inst's unlikely due to power (high heat) and cleaning/purging rqrs which will rqr batteries/purge gas components not compatible w. volume constraints of sonde



Harpoon Penetrators delv sample to inst's on aerial platform gondola---this sample acquisition approach allows greater volume for additonal battery power and purge gas elements

Initial Conclusions from System Trade Studies

- More than one delivery architecture is feasible; the question is finding the least expensive
- For an aerobot direct entry package only:
  - With an eight-year flight time we can use VVVGA chemical prop transfer with an Atlas 551
  - A six-year flight time is possible with a SEP transfer on an Atlas 551 or smaller
  - In the 2015-2017 time frame, fast JGA chemical prop transfers are available
- We can add a small orbiter:
  - Using an eight-year VVVGA chemical prop transfer with a Delta IVH and aerocapture
  - Using SEP-VGA with an six-year flight time on an Atlas 551 or smaller and aerocapture
  - In 2015 an eight-year VVEJGA chemical prop transfer is available which allows chemical propulsion to be used for capture
- NEP
  - Would allow significant power in Titan orbit, but has significant challenges to overcome

JIML Science Delivery Package

Team In situ

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In-Situ Science at Europa

Europa's putative subsurface ocean may contain environments suitable for life, and Europa's geological processes may bring evidence of the existence of life to its surface. Europa thus represents a very high-priority target for Outer Solar System Exploration.

JPL is continuing to explore Entry, Descent and Landing (EDL) options for landing safely on the potentially difficult terrains of Europa. Technologies for accessing surface and subsurface materials for astrobiology investigations using compact GCMS instruments have been identified, and these and other surface science capabilities are under continuing development.

Although a powered descent is the most direct approach to landing, surface contamination by propellant by-products is of concern, due to possible impacts on surface science results. We have initiated studies of plume impingement to more completely understand this issue.

Mission Overview

- Mission Concept
  - Develop a surface drop-off probe package that can be flown as an additional payload on JIMO
  - Drop-off probe package must be less than ~375kg and stand-alone system (similar to Huygen's probe).
- Primary Science
  - Surface chemistry (organic and inorganic)
  - Ground truth magnetometry (orbiter will do remote measurement)
  - Seismometry
  - Radiation (full particle flux measurements)
  - Imaging (geology)
  - Physical measurements (hardness, temperature etc.)
- Mission Architecture
  - Trade space examined for hard and soft landers
    - Reconsidered Europa lander airbags/microlander
    - Penetrators (DS2-class and high velocity ballistic)
    - Fully propulsive descent soft landers
    - Hard, rough landers

Assumption was that JIML would be delivered by a JIMO-class orbiter

Europa JIML Reference Instruments (In order of Priority Based on the JIMO Science Definition Team and the Astrobiology Institute's Europa Focus Group)

- GCMS (2; one in each of 2 pods)
- Micro-seismometer (2, one in each of 2 pods)
- Magnetometer (1)
- Imagers: Far field, near field, microscopic (2/pod)
- Raman spectrometer (2, one in each of 2 pods)
- Wet chemistry (2, one suite in each of 2 pods)
- Radiation sensors (8, 2/pod)
- Engineering sensors (Accelerometers, Temperature sensors- since these sensors are part of any probe design, they serve both engineering and science functions and, as such, are not prioritized);