TiME: Titan Mare Explorer

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Talk from:

Titan through Time Workshop
Overview

- Discovery of lakes and seas in Titan’s northern hemisphere confirmed the expectation that liquid hydrocarbons exist on the surface
- Detection of ethane in Ontario Lacus near the South Pole (Brown et al., 2008)
- Lake basin origin- impact, cryovolcanic, dissolution?
- *Titan is the only known body, other than Earth, with seas and lakes, and an active liquid-based cycle*
Titan Lake Studies

- Titan lake/sea composition is unknown. At best Cassini might constrain C2H6 fraction to ~30% accuracy via RADAR/VIMS/RSS.
- Remote sensing data may indicate surface slope distribution (assumed shape/distribution gives wave height) but associated wind-speeds will be unknown.
- Depth of large seas is indicated only by analogy – no direct measurement of lakes deeper than ~10m.
- Dissolved minor constituents will remain unknown (but Ontario ‘bathtub ring’ suggests they are present.
- Models show Titan seas, depending on C2H6 amount, can be strong influence on local climate, enhancing winds.
- Models suggest thermal stratification of seas may occur in summer, but effect of wind stress on forcing overturn has not been studied.
- Astrobiological implications of seas will remain unknown
- TiME offers key in-situ measurements to enable Cassini data interpretation and model developments
Titan Mare Explorer (TiME) is a Discovery concept being developed by LM and APL.

- ASRG-powered lake lander
- Will address fundamental questions about sea chemistry and Titan’s methane cycle
TiME Science Target

• Target: Ligeia Mare (78°N, 250°W)
  – One of the largest lakes identified to date on Titan, surface area ~100,000 km²
  – Backup target- Kraken Mare
TiME Mission Objectives

- Mission Goals:
  - Understand Titan’s carbon cycle through study of a Titan sea
  - Investigate a Titan sea to explore the limits to life
  - Investigate the origin of Titan

- Relevance and Importance to NASA Planetary Objectives and the Decadal Survey:
  - Decadal Survey – Volatiles and Organics, The Stuff of Life
    - Directly measure the organic constituents on another planetary object
    - First active measurement of liquid cycle beyond Earth

- Air-Sea exchange processes are vital – but often uncertain - factors in our climate (i.e., hurricanes on Earth). Through TiME, Titan provides us with a laboratory in which to explore these familiar processes under radically different conditions.
TiME Science Team

- **PI:** Ellen Stofan
- **Co-Is:**
  - Jonathan Lunine* – Deputy PI
  - Ralph Lorenz* – Project Scientist
  - Oded Aharonson
  - Beau Bierhaus
  - Ben Clark*
  - Caitlin Griffith
  - Ari-Matti Harri*
  - Erich Karkoschka*
  - Randy Kirk
  - Paul Mahaffy
  - Claire Newman
  - Mike Ravine
  - Melissa Trainer
  - Hunter Waite
  - John Zarnecki*
• **Science Objective 1.** Determine the chemistry of a Titan sea. **Instruments:** Mass Spectrometer (MS), Meteorology and Physical Properties Package (MP3).

• **Science Objective 2.** Determine the depth of a Titan sea. **Instrument:** Meteorology and Physical Properties Package (Sonar) (MP3).

• **Science Objective 3.** Constrain marine processes on Titan. **Instrument:** Meteorology and Physical Properties Package (MP3), Descent and Surface cameras.

• **Science Objective 4.** Determine how the local meteorology over the sea varies on diurnal timescales. **Instrument:** Meteorology and Physical Properties Package (MP3), Cameras.

• **Science Objective 5.** Characterize the atmosphere above the sea. **Instrument:** Meteorology and Physical Properties Package (MP3), Cameras.
Mission Implementation Overview

- TiME
  - Launch Vehicle: Atlas 401
  - 21 day launch window opens 17 January 2016
• **Cruise:** One DSM, one Earth and one Jupiter flyby en route to Saturn.
• **Titan Entry:** Cruise stage separates from lander shortly before Titan entry on 29 June 2023.

Earth & the Sun are above the horizon for the 5 Titan day mission lifetime, during which TiME collects and transmits data on the sea and atmosphere.
ASRG Overview

• ASRG = Advanced Stirling Radioisotope Generator
• Each ASRG expected to generate >100 W of electrical power
  – 4x more efficient than previous RTG
• Mass is 28 kg
• Nominal lifetime of 14 years
• TiME provides test of ASRGs in two environments, with extended (7 yr) test during cruise
TiME for Discovery

- TiME is a Discovery Class mission
  - Focused science objectives
  - High heritage instruments
  - ASRGs, launcher are GFE
  - Simple cruise- no flyby science
  - Direct to Earth comm
  - Entry conditions at Titan similar to Huygens, one of most benign places to land in the solar system
  - Simple surface operations
TiME for Titan

• First nautical exploration of an extraterrestrial sea
• Constrain the role of lakes and seas in Titan’s active carbon cycle and search for signs of self-organizing organic chemistry
• Unique and wide-ranging EPO opportunity
• Low-cost approach
• ASRG validation in two environments
• Science from Titan by 2023 BEFORE it gets dark