

TiME: Titan Mare Explorer

Oded Aharonson

Talk from:

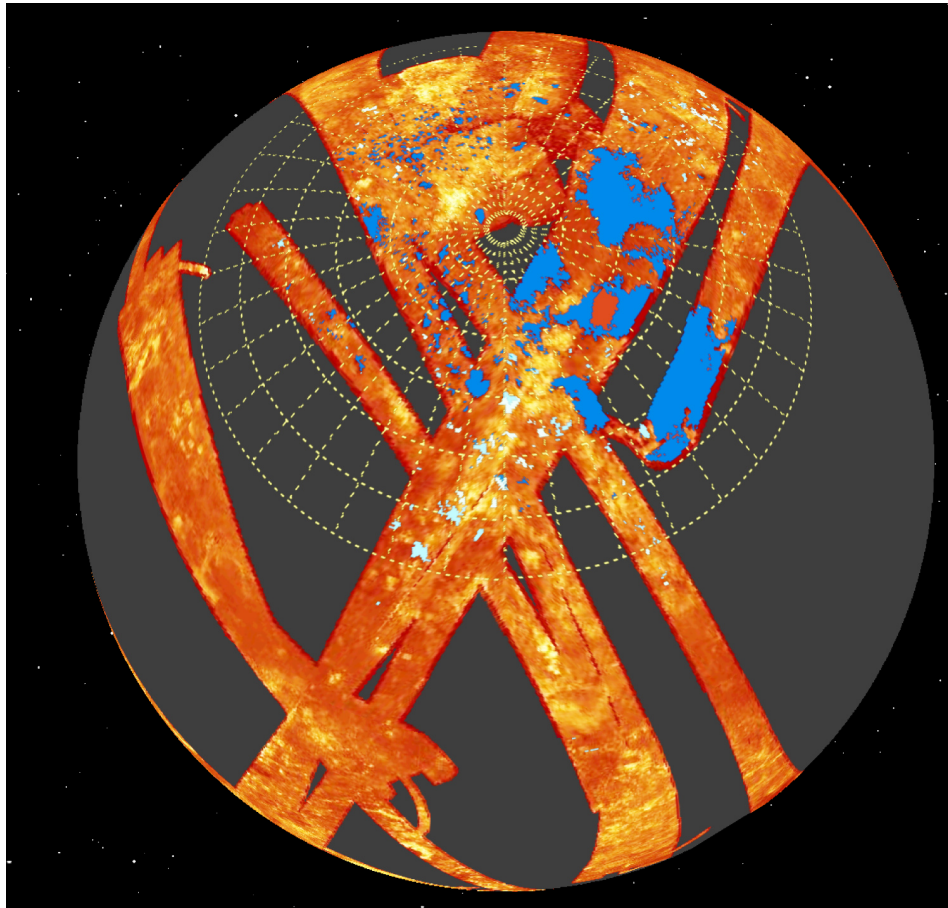
Ellen Stofan, R. Lorenz, J. Lunine, E. Bierhaus, B. Clark, O. Aharonson, C. Griffith, A.-M. Harri, E. Karkoschka, R. Kirk, P. Mahaffy, C. Newman, M. Ravine, M. Trainer, H Waite, J. Zarnecki

Titan through Time Workshop

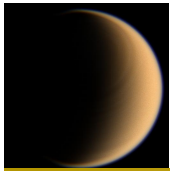




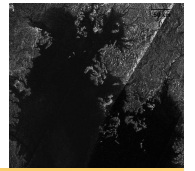
Overview



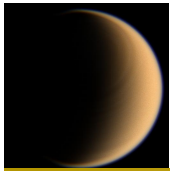
- Discovery of lakes and seas in Titan's northern hemisphere confirmed the expectation that liquid hydrocarbons exist on the surface
- Detection of ethane in Ontario Lacus near the South Pole (Brown et al., 2008)
- Lake basin origin- impact, cryovolcanic, dissolution?
- *Titan is the only known body,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



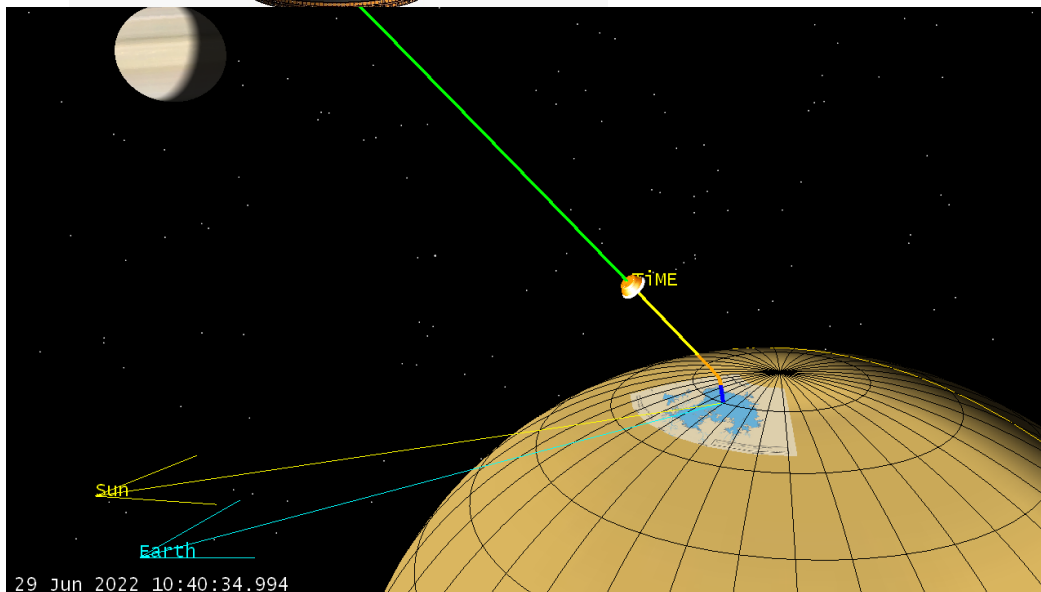
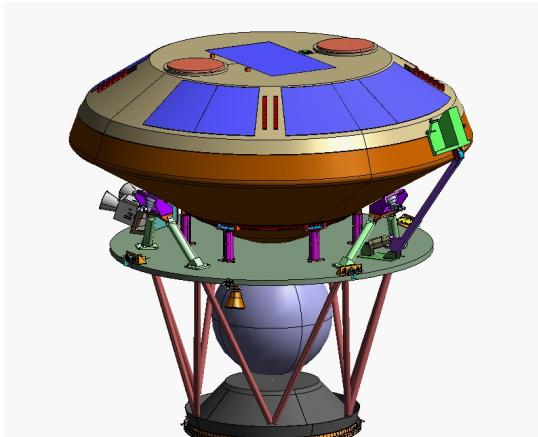
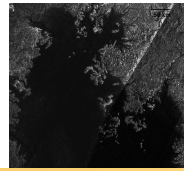
Titan Lake Studies



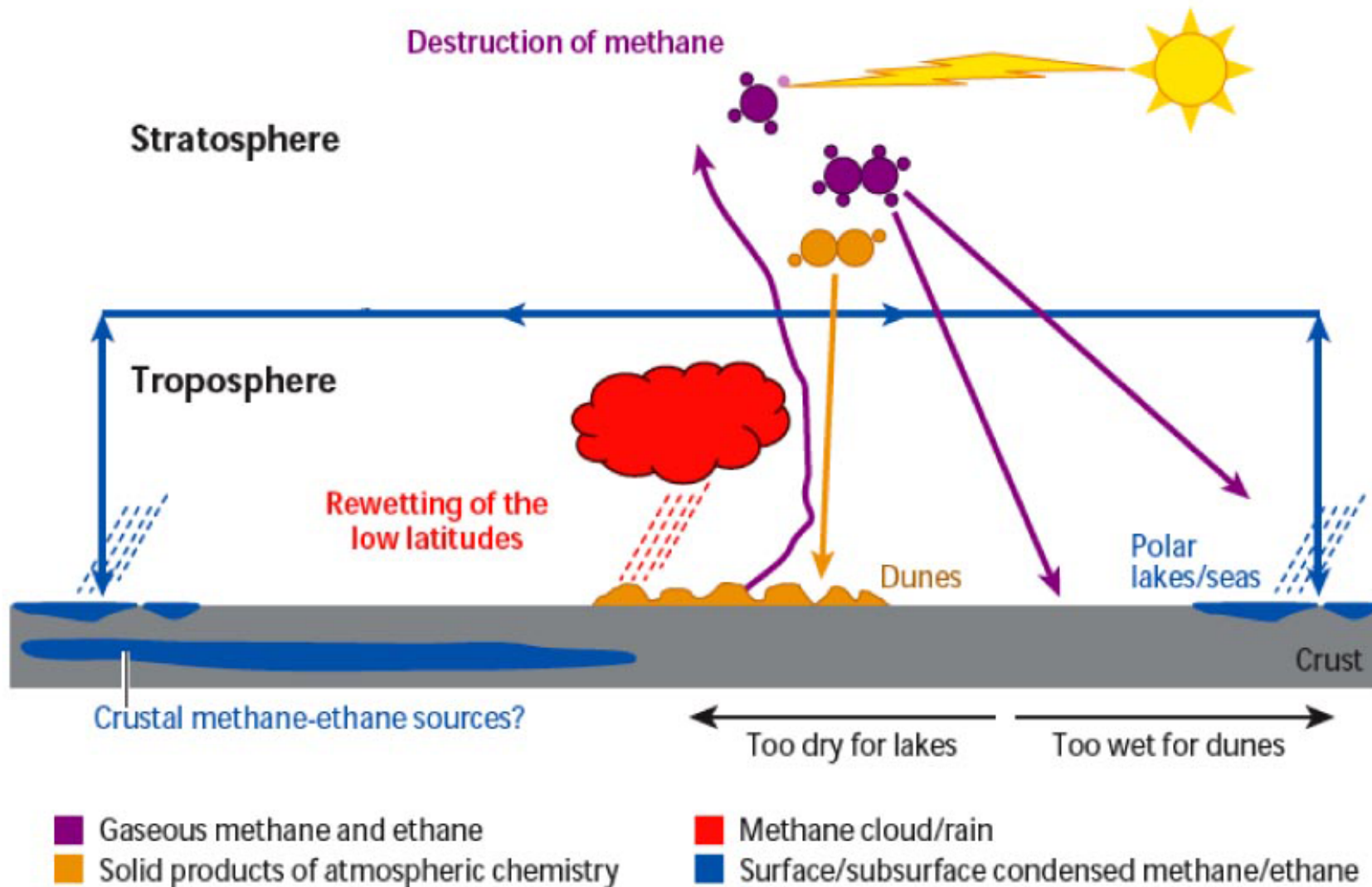
- Titan lake/sea composition is unknown. At best Cassini might constrain C₂H₆ fraction to ~30% accuracy via RADAR/VIMS/RSS.
- Remote sensing data may indicate surface slope distribution (assumed shape/distribution gives wave height) but associated wind-speeds will be unknown.
- Depth of large seas is 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

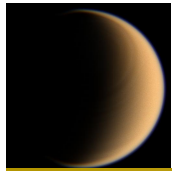


TiME

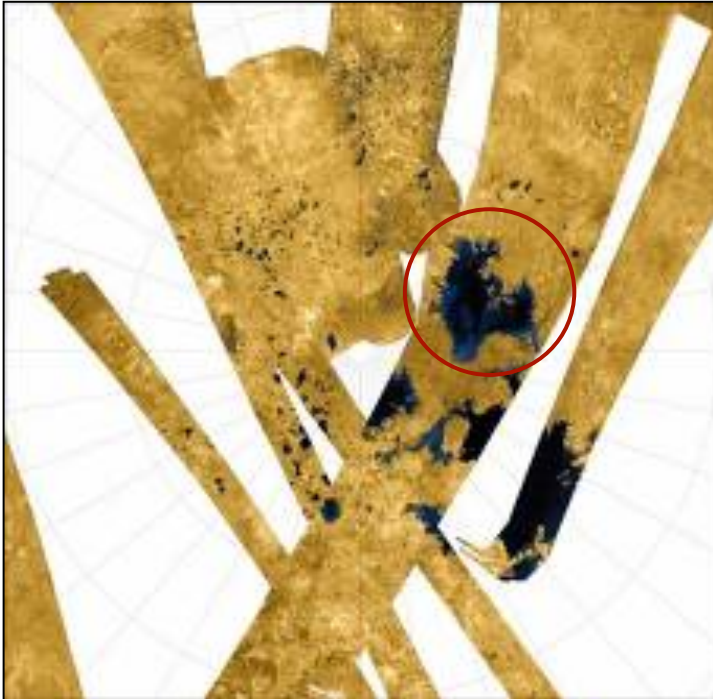
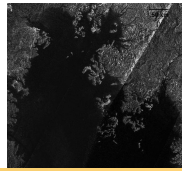


- Titan Mare Explorer (TiME) is a Discovery concept being developed by LM and APL
- ASRG-powered lake lander
- Will address fundamental questions about sea chemistry and Titan's methane cycle

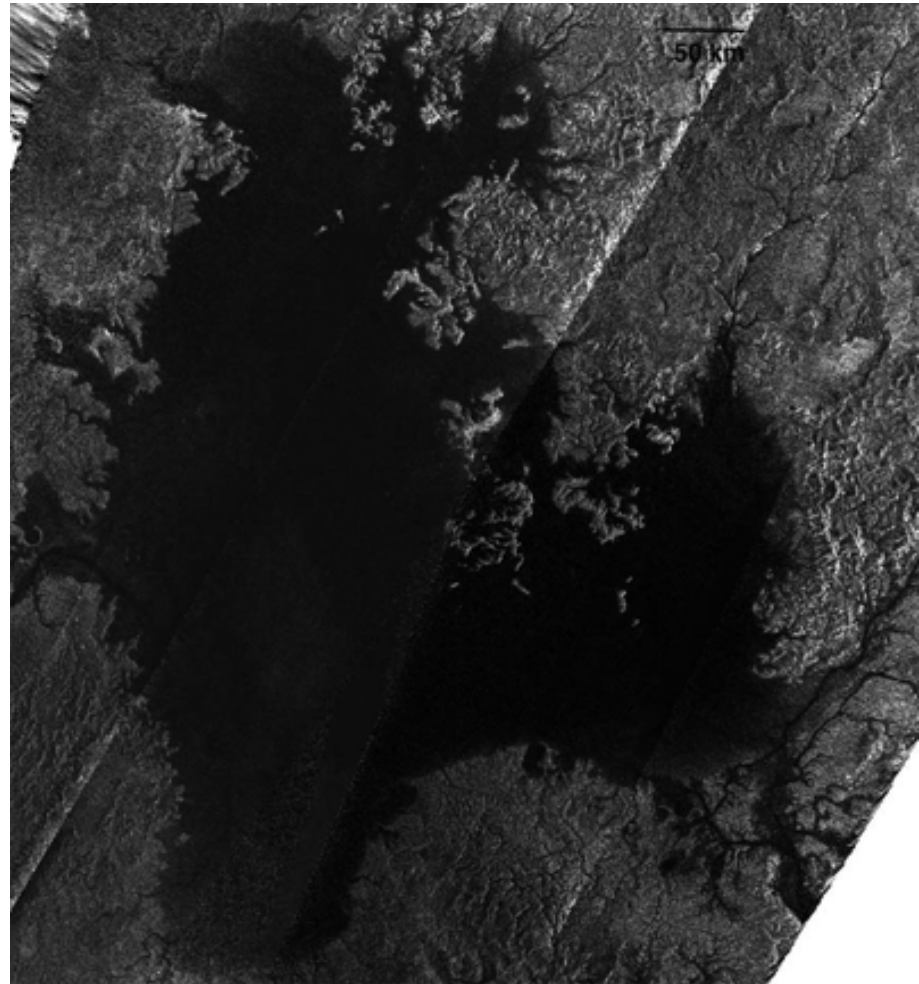


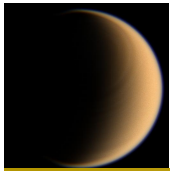


TiME Science Target

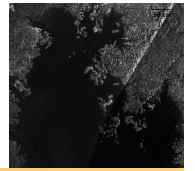


- Target: Ligeia Mare (78°N , 250°W)
 - One of the largest lakes identified to date on Titan, surface area $\sim 100,000 \text{ km}^2$
 - Backup target- Kraken Mare





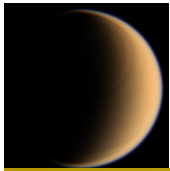
TiME Mission Objectives



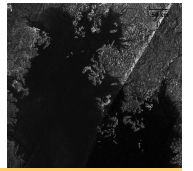
- Mission Goals:
 - Understand Titan's carbon cycle through study of a Titan sea
 - Investigate a Titan sea to explore the limits to life
 - Investigate the origin of Titan

- 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
 - **Decadal Survey – Processes: How Planetary Systems Work**
 - 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.



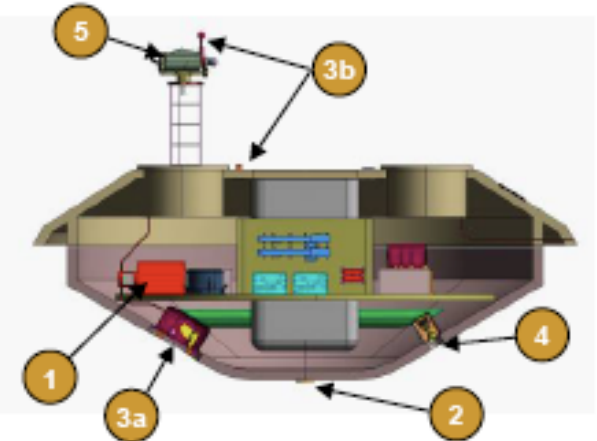
TiME Science Team

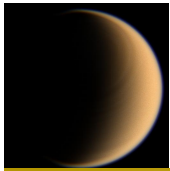


- **PI:** Ellen Stofan
- **Co-Is:**
 - Jonathan Lunine* – Deputy PI
 - Ralph Lorenz* – Project Scientist
 - Oded Aharonson
 - Beau Bierhaus
 - Ben Clark*
 - Caitlin Griffith
 - Ari-Matti Harri*
 - Erich Karkoschka*
 - Randy Kirk
 - Paul Mahaffy
 - Claire Newman
 - Mike Ravine
 - Melissa Trainer
 - Hunter Waite
 - John Zarnecki*

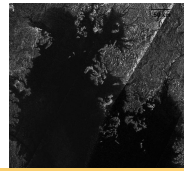
TiME Science Objectives

- **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.





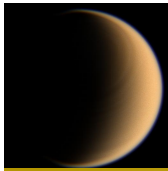
Mission Implementation Overview



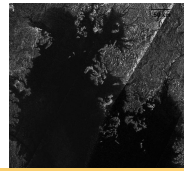
- **TiME**

- Launch Vehicle: Atlas 401
- 21 day launch window opens 17 January 2016

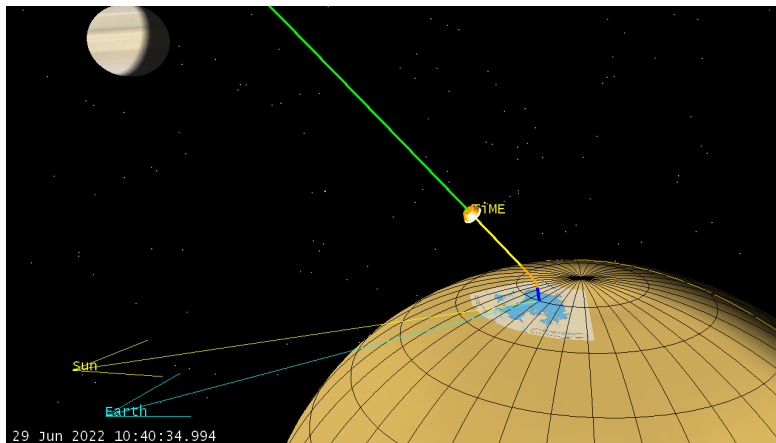
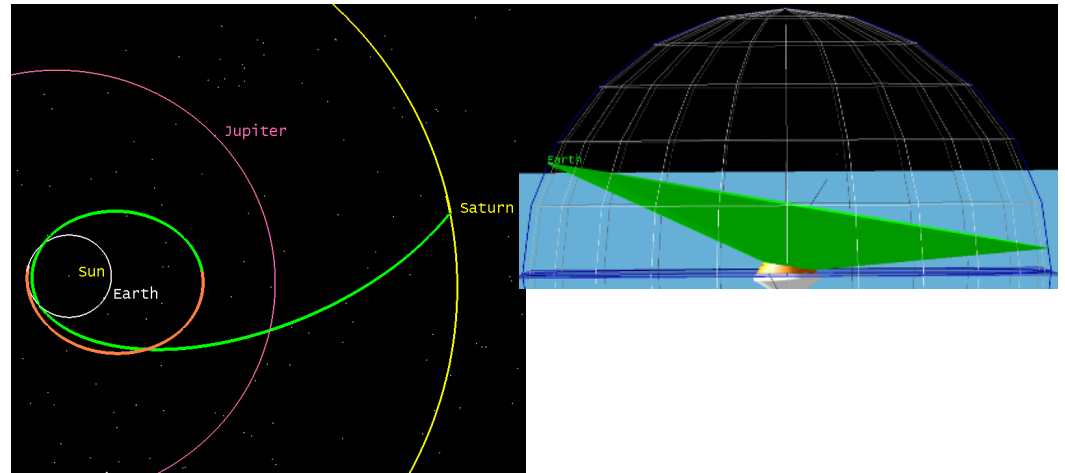




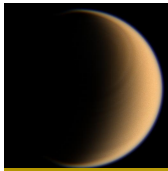
Lander: Overview



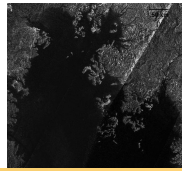
- Cruise: One DSM, one Earth and one Jupiter flyby en route to Saturn.
- Titan Entry: Cruise stage separates from lander shortly before Titan entry on 29 June 2023.



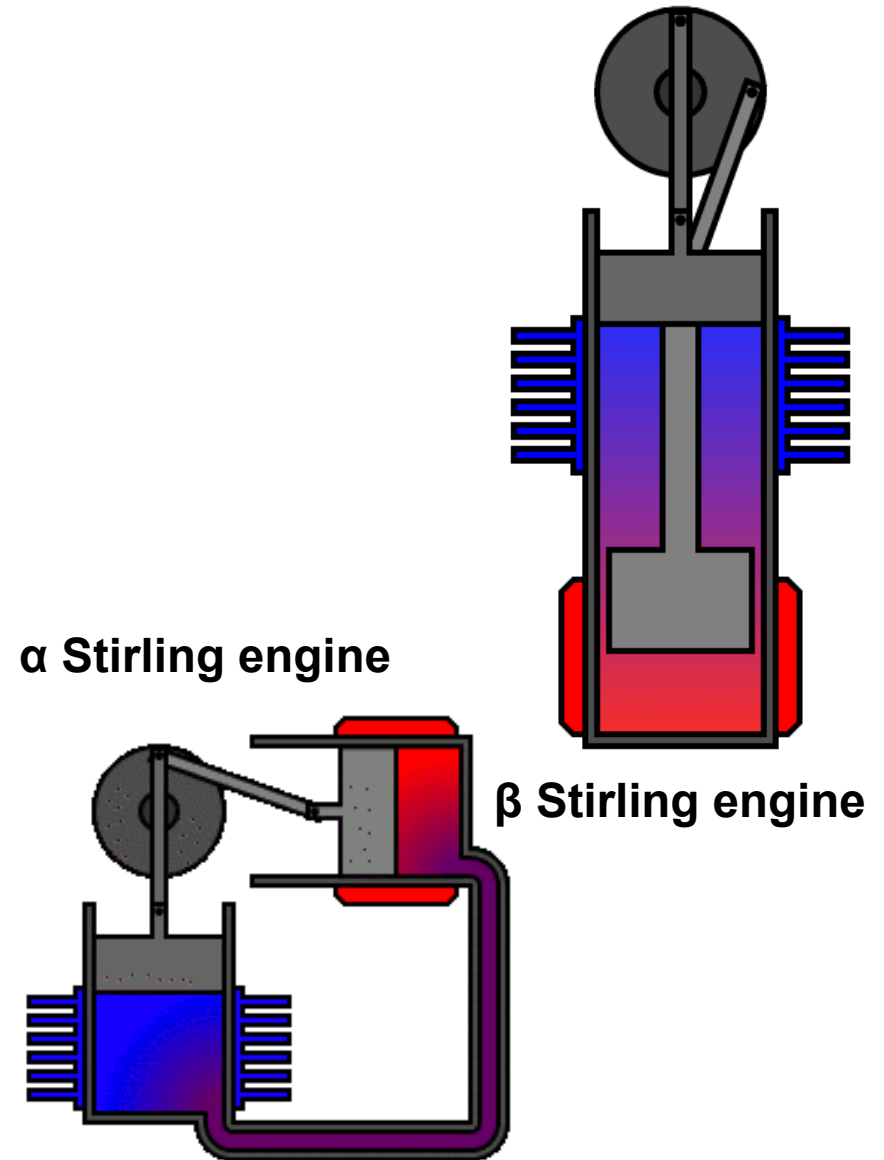
Earth & the Sun are above the horizon for the 5 Titan day mission lifetime, during which TiME collects and transmits data on the sea and atmosphere.

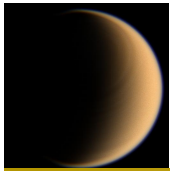


ASRG Overview

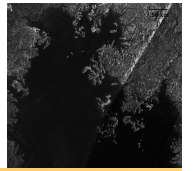


- ASRG = Advanced Stirling Radioisotope Generator
- Each ASRG expected to generate >100 W of electrical power
 - 4x more efficient than previous RTG
- Mass is 28 kg
- Nominal lifetime of 14 years
- TiME provides test of ASRGs in two environments, with extended (7 yr) test during cruise

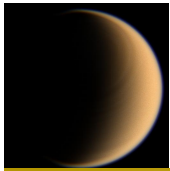




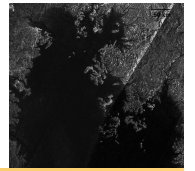
TiME for Discovery



- 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