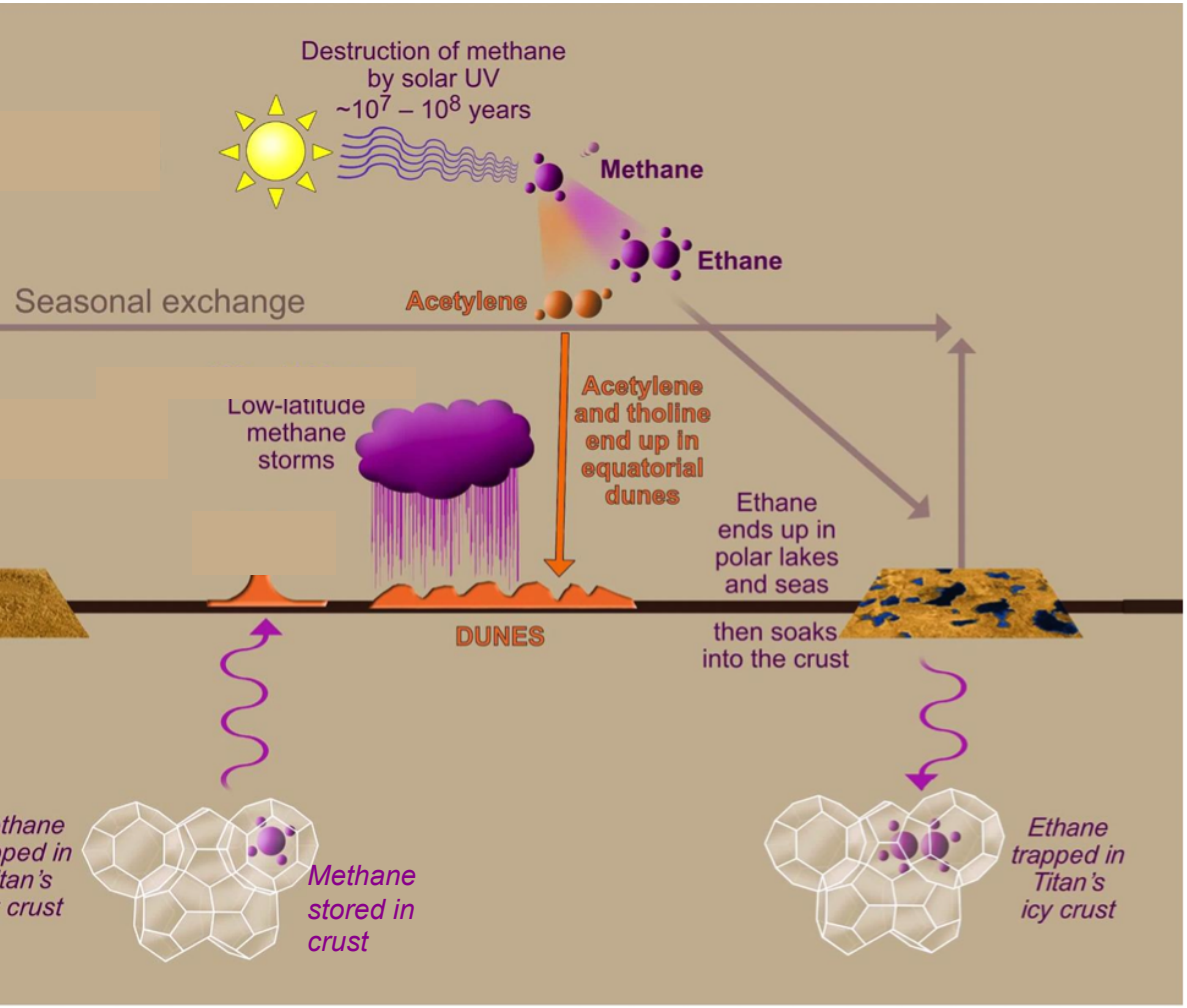
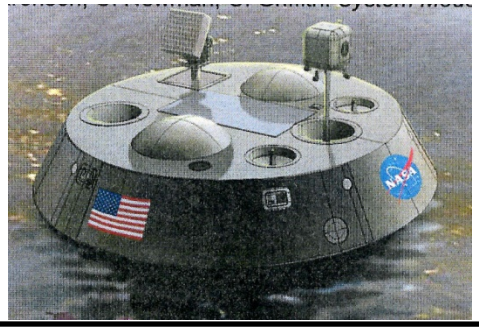
Titan Mare Explorer: TiME for Titan



- Titan Mare Explorer (TiME) will:
  - Conduct the first exploration of an extraterrestrial sea
  - Directly sample and measure the organic constituents on another planetary object
  - Provide the first extended in situ studies of a liquid volatile cycle beyond Earth

TiME Mission: Quad Chart



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Spacecraft: LM
Ops: LM, JPL (nav)
Payload: APL, GSFC, MSSS

Mission:
Lander to Titan's *Ligeia Mare* methane-ethane polar sea, 96 days on surface

Goals:
- Understand Titan's methane cycle through study of a Titan sea.
- Investigate Titan's history & explore the limits of life

Instruments:
- Meteorology & physical properties (MP3)
- Mass Spec for Lake Chemistry (NMS),
- Descent and Surface Imaging Cameras

Efficient Trajectory
Launch 2016
Cruise 7.5 years (EGA, JGA)
Entry 2023

Mission Features
Focused science objectives
High heritage instruments
Simple cruise, no flyby science
Simple surface operations
ASRGs, LV are gov't furnished

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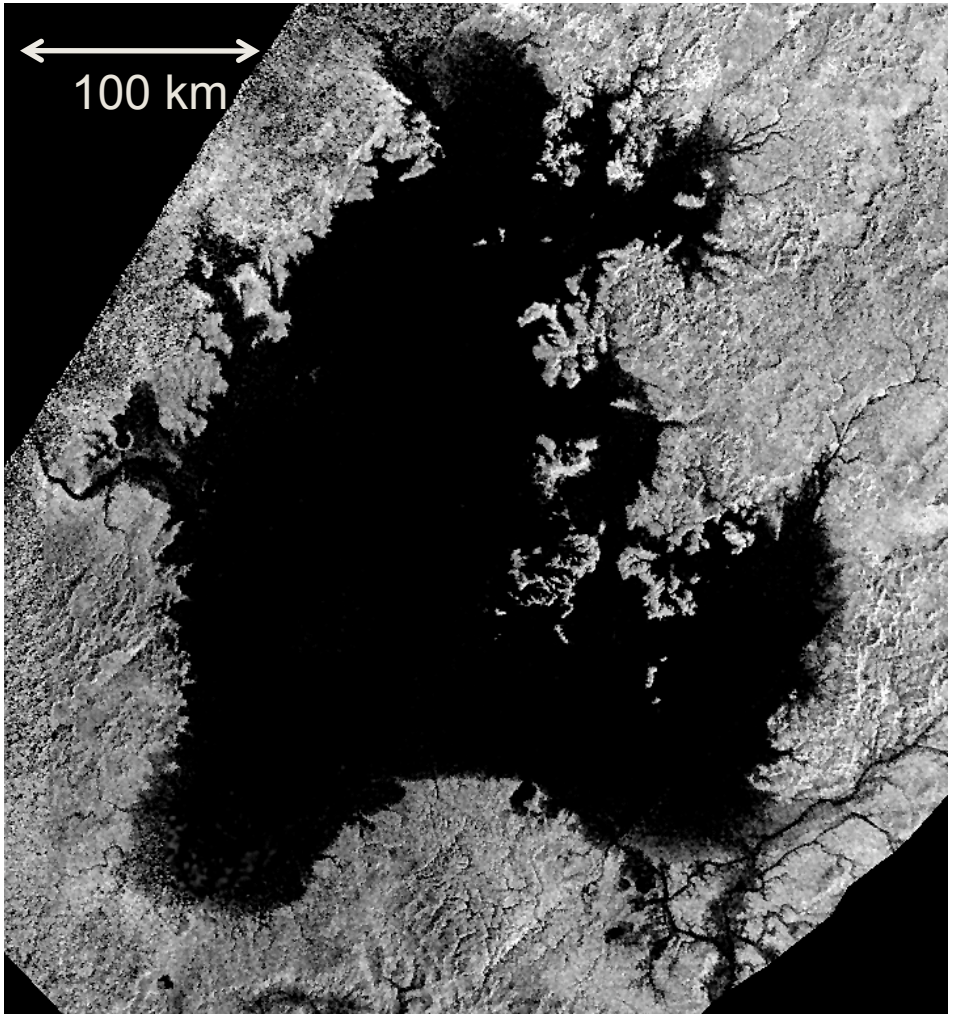
TiME-line for Titan Mare Explorer

- 2004: Cassini's first Titan flyby; images Ontario Lacus
- 2005: Huygens lands at Titan's equator; methane in soil
- 2006: Cassini discovers hundreds of small lakes in north
- 2007: Cassini radar discovers large seas in north
  - Tandem/TSSM Flagship studies begin
  - "Titan splasher" idea; *TiME* team formed for DSMCE
- 2008: NASA selects nine DSMCE missions; including TiME
- 2009: NASA prioritizes Titan Flagship (TSSM) second.
- 2010: NASA Discovery call for ASRG-powered missions
- 2011: TiME among three selected for Discovery phase-A.
  - 2012: Phase B downselect July to one mission for flight

TiME's target: Ligeia Mare

- Best mapped by radar of Titan's seas
- Radar penetration of ≥10m in liquids confirms safe splashdown.
- Expect Cassini Radar and near-IR observations in coming years
- Interesting, complex shorelines
- Relatively benign autumn conditions



Liquid methane/ethane are familiar materials (transport properties are well-understood)

Algerian LNG ~87% methane, ~8% ethane

US LNG ~96% methane, ~2% ethane

Cordier et al model for Titan Seas ~10% methane, ~75% ethane.

Raulin model ~31% methane, 65% ethane

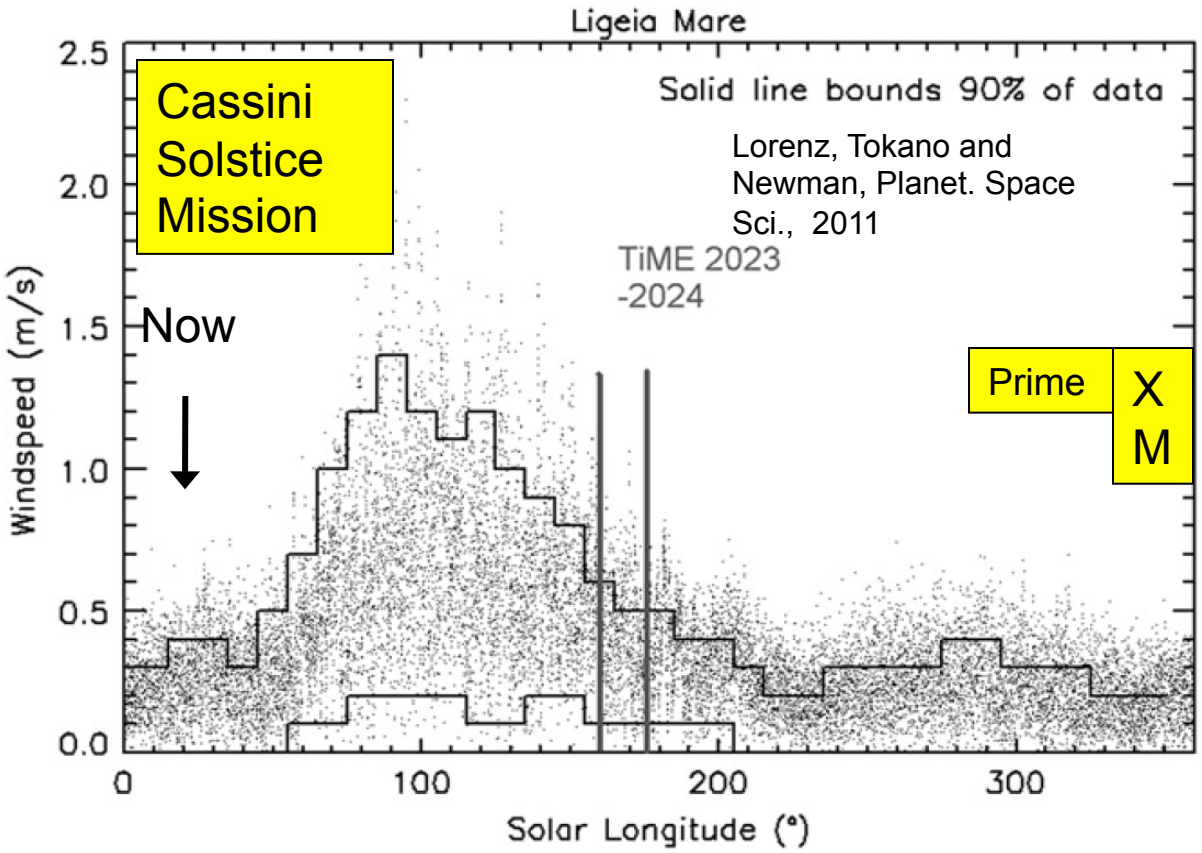
~300 LNG carriers worldwide. Typical modern capacity ~120,000 m^3, held at 110 K

Need ~ 10^9 such carriers to bring Ligeia home.

The season of TiME

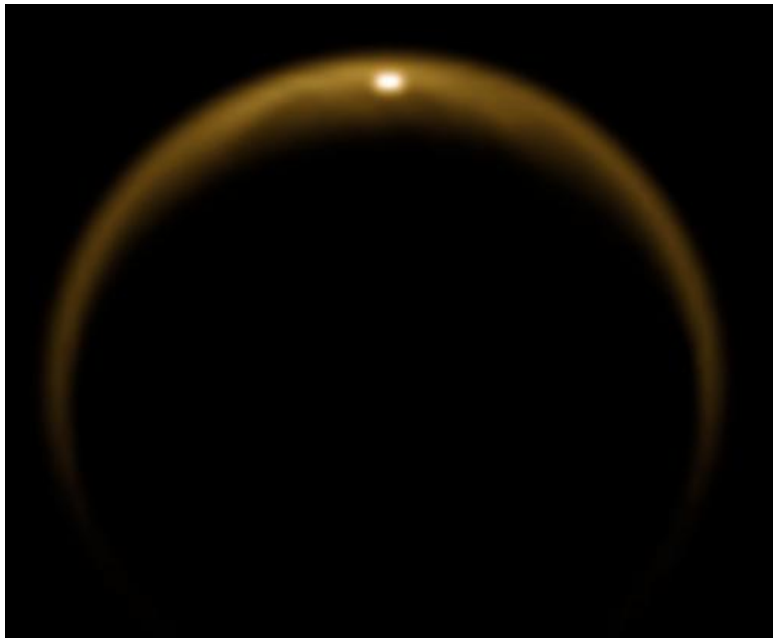
Sea surface

- Winds on Titan have formed dunes in many regions, apparent wave-modified beach at Ontario
- FLAT surfaces observed to date at Titan lakes
- GCM predictions are consistent with non-detection of waves so far, but expect to observe waves ~2015-2017.
- Tokano GCM predicts modest winds during summer/fall TiME season.



TiME for Titan science

- Titan's seas are the major surface component of Titan's methane cycle, and are a chemical repository that can constrain Titan's history, as well as the limits to life in natural multi-phase systems
- TiME will address critical Titan science:
  - Constrain methane cycle: sea composition and volume, air:sea exchange processes, atmospheric conditions at the sea surface
  - Titan prebiotic chemistry: sea composition including complex organics
  - Titan history: Measure noble gases and carbon isotope ratios



TiME Science Objectives

- **Constrain sea composition**
  - Determine the chemistry of seas to constrain Titan's methane cycle, look for patterns in the abundance of constituents in the liquids and analyze noble gases. ***Instruments:*** Mass Spectrometer (NMS), Meteorology and Physical Properties Package (MP3).
- **Constrain sea depth**
  - Determine the depth of the Titan sea to determine sea volumes, and thus, organic inventory. ***Instrument:*** MP3 (Sonar).
- **Measure sea surface properties**
  - Characterize physical properties of sea liquids and how they vary with depth and position. ***Instrument:*** MP3, NMS.
  - Determine how the local meteorology over the seas ties to the global cycling of methane on seasonal and longer timescales. ***Instrument:*** MP3
  - Analyze the nature of the sea surface (waves, foams, scums) and the state of the atmosphere above the sea. ***Instrument:*** Descent and Surface Imagers.

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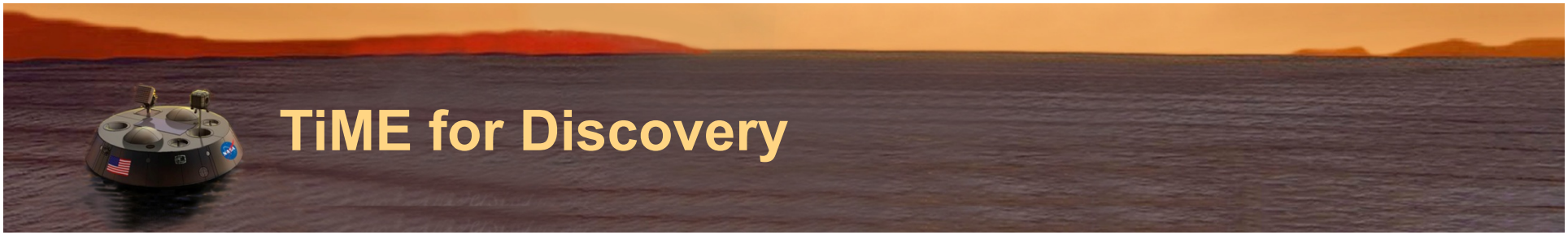

TiME for Discovery

- Simple complement of instruments with high heritage
- No cruise science
- Simple surface operations
- Benign (and well understood) EDS environment
- Direct to Earth communication
- Opportunity is transient: Earth-set in 2025; Earth-rise 2040. Thus 2023-2024 is the last chance in this generation for a Discovery-class, low cost approach.

TiME for Titan: the only outer solar system mission in prime phase in the 2020's?

Depiction of the Planetary Program Architecture Recommended in the Survey

Large Missions ("Flagship"-scale)

"Recommended Program" (budget increase new start for JEO)	*"Cost Constrained Program"* (based on FY11 Request)	*"Less favorable" budget picture than assumed* (e.g., outyears in FY12 request)
1) Mars Astrobiology Explorer-Cacher (MAX-C) – descoped	1) Mars Astrobiology Explorer-Cacher (MAX-C) – descoped	**Descope or delay Flagship missions**
2) Jupiter Europa Orbiter (JEO) – descoped	2) Uranus Orbiter & Probe (UOP)	
3) Uranus Orbiter & Probe (UOP)		
4/5) Enceladu Orbiter & Venus Climate Mission		

Discovery

$500M (FY15) cap per mission (exclusive of launch vehicle) and 24 month cadence for selection

New Frontiers

$1B (FY15) cap per mission (exclusive of launch vehicle) with two selections during 2013-22

Research & Analysis (5% above final FY11 amount then ~1.5%/yr)

Technology Development (6-8%)


Voyage Across
an Alien Sea
TiME
TITAN MARE EXPLORER