

TITAN ORBITER AEROROVER MISSION (TOAM)

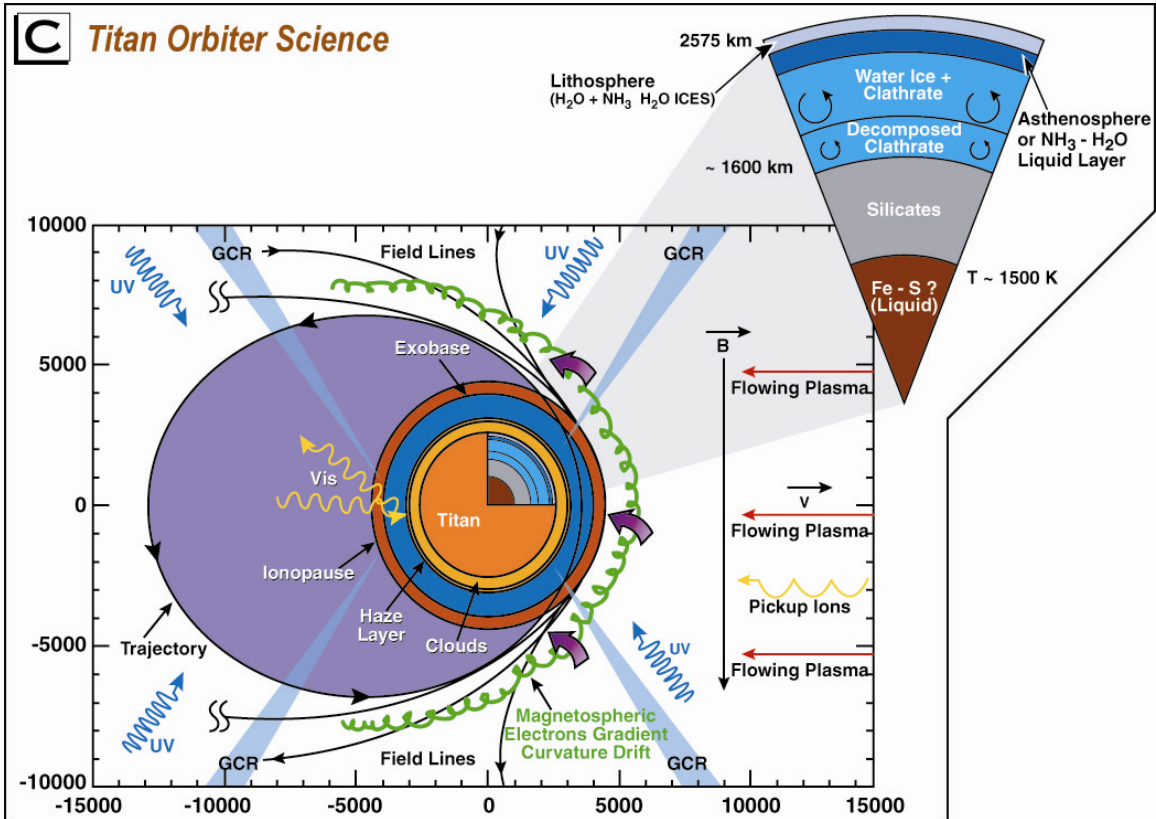
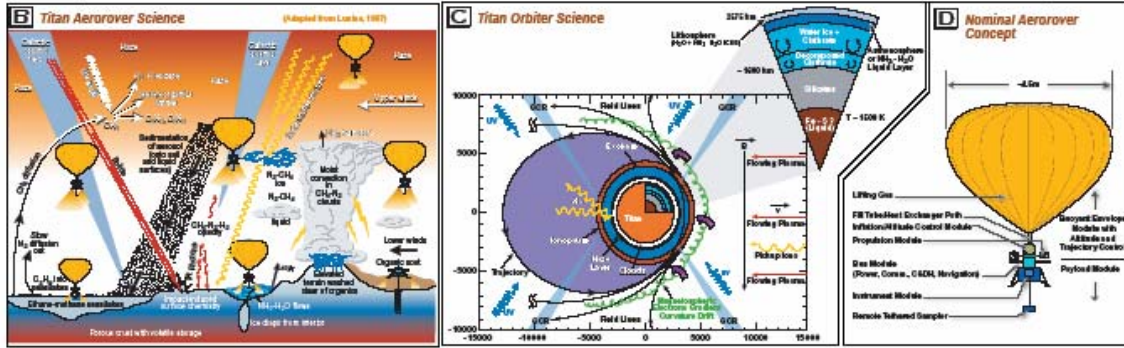
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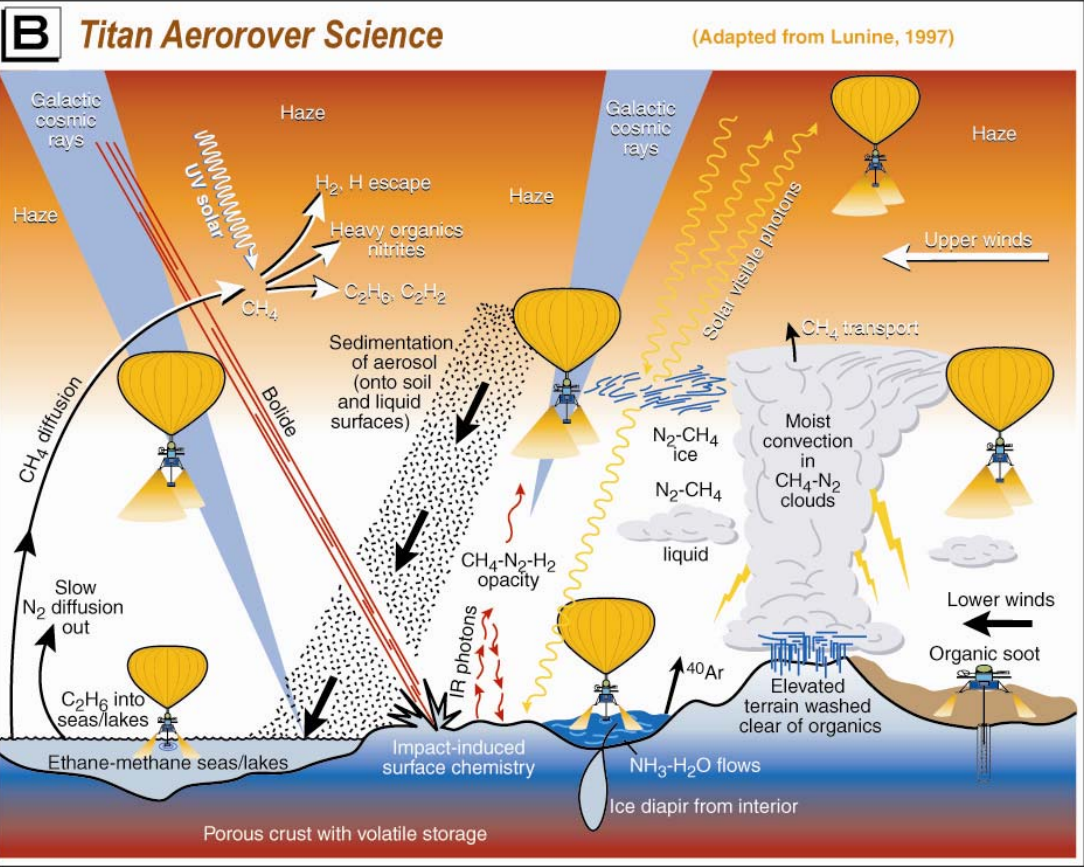
We propose to develop a new mission to Titan called Titan Orbiter Aerorover Mission (TOAM). This mission is motivated by the recent discoveries of Titan, its atmosphere and its surface by the Huygens Probe, and a combination of in situ, remote sensing and radar mapping measurements of Titan by the Cassini orbiter. Titan is a body for which Astrobiology will be the primary science goal of any future missions to it. TOAM is a multi-faceted mission with launch using a Delta IV Heavy for high C3 interplanetary orbit injection, possible Jupiter flyby, Solar Electric Propulsion (SEP), orbit injection via aerobraking at Titan, probe entry with balloon technology (i.e., Aerorover phase) and finally a landing phase. The cruise phase can last between 5-9 years, orbiter reconnaissance phase of ~ 6 months, Aerorover global reconnaissance phase ~ 6 months, Aerorover global surface science phase ~ 6 months and Aerorover landing phase ~ 6 months, with possibility of an extended mission. The orbiter will be powered by 3 MMRTGs and Aerorover by a single MMRTG. The Aerorover will probably use a hot air balloon concept using the waste heat from the MMRTG ~ 500-1000 watts, but other concepts may be considered. Our strategy to use an orbiter is contrary to some studies using just a single probe with balloon. Autonomous operation and navigation of the Aerorover around Titan, which will include descent near to the surface to collect surface samples for analysis, is in itself a very complex process and will require nearly continuous tracking and navigation updates. Only an orbiter can provide this capability as a relay station and GPS role so that the Aerorover will be able to navigate safely within Titan's environment, while maintaining nearly continuous communication with ground stations. Although very complex, our goal is to keep the Aerorover as simple as possible in order to enhance the likelihood of success. Experience has shown that such complex missions will develop unexpected problems, for which a balloon concept allows for it to safe itself by going to high altitudes and thus allow teams on the ground the necessary time needed to work around such problems. New technologies will need to be developed and miniaturization will be required to maintain functionality while controlling mass, power and cost. Duty cycling will be used. The orbiter will combine radar altimetry, radio science and remote sensing instruments to measure the global topography, sub-surface structure and atmospheric winds during its recon phase so that the Aerorover can use this information to navigate safely around Titan and identify prime sites for surface sampling and analysis. In situ instruments will sample the upper atmosphere which may provide the seed population for the complex organic chemistry on the surface. The Aerorover will have all the instruments needed to sample Titan's atmosphere, surface, possible methane lakes-rivers, use multi-spectral imagers for recon phase of surface and take close up surface images and during landing phase take core samples and use seismometers. During the landing phase we may even have a Sojourner class robot that was previously used for Mars.

Titan Orbiter Aerover Mission (TOAM)

A Requirements Flowdown

Research Study Theme	Science Objective	Measurement	Available Orbiter Instruments	Candidate Aerover Instruments
The First 4 Billion Years of Titan's System History	1. What is the origin of Titan's atmosphere? 2. What is the origin of Titan's surface liquids?	<ul style="list-style-type: none"> Provide compositional measurements of Titan's atmosphere Measure D/H ratio and $\delta^{13}C$ in various atmospheric and surface samples Measure Titan's atmospheric density, temperature, and composition from the exosphere to the surface 	<ul style="list-style-type: none"> Ionospheric Mass Spectrometer (IMS) Neutral Mass Spectrometer (NMS) Langmuir Probe (LP) Thomson Scatterometer (TSC) Titan Radio Science (TRS) Titan Submillimeter Link Sounder (TSL) 	<ul style="list-style-type: none"> Aerover Collectible Payload (ACP) Atmospheric Properties (AP) Gas Chromatograph Mass Spectrometer (GCMS)
Water and Organic: The Stuff of Life	3. Are there liquid hydrocarbons on Titan's surface? 4. What is the origin of Titan's surface liquids? 5. What is the origin of Titan's surface organic matter? 6. What is the origin of Titan's surface organic matter?	<ul style="list-style-type: none"> Simple analysis of surface liquids from the atmosphere down to the surface High-resolution spectroscopy of the atmosphere, surface, and subsurface Define the character of emergent particles and clouds in relation to the atmosphere Perform in situ analysis of surface composition and structure, including elemental analysis, particularly of volatile organics and minerals 	<ul style="list-style-type: none"> Hyperspectral Imager for the Titan Science (HTS) Ionospheric Mass Spectrometer (IMS) Neutral Mass Spectrometer (NMS) Radio Science (RS) Thomson Scatterometer (TSC) Titan Submillimeter Link Sounder (TSL) 	<ul style="list-style-type: none"> Aerover Collectible Payload (ACP) Aerover Hyperspectral Imager for Titan Science (AHTS) Gas Chromatograph Mass Spectrometer (GCMS) Langmuir Probe (LP) Thomson Scatterometer (TSC) Titan Submillimeter Link Sounder (TSL)
The Origin and Evolution of Titan's Surface	7. Are there any hydrocarbons on Titan's surface? 8. What is the origin of Titan's surface organic matter? 9. What is the origin of Titan's surface organic matter?	<ul style="list-style-type: none"> Determine Titan's surface composition, including density, density, and subsurface structure Perform detailed surface mapping, including, and composition analysis Detect subsurface oceans 	<ul style="list-style-type: none"> Hyperspectral Imager for the Titan Science (HTS) Titan Radio Science (TRS) Titan Synthetic Aperture Radar and Microwave (SAR/MW) 	<ul style="list-style-type: none"> Aerover Hyperspectral Imager for Titan Science (AHTS) CH₄ Gas Sampling (CGS) Gas Chromatograph Mass Spectrometer (GCMS) Microscopy Probe for Titan (MPT) Surface Sampling (SS) Surface Sampling (SS)
Processes that Reshape Titan	10. What are the energy sources driving the chemical processes on Titan?	<ul style="list-style-type: none"> Perform mapping of topography, surface properties, and subsurface structure Measure atmospheric wind from the surface to the thermosphere Determine Titan's lightning system, including ground flash and space flash Provide temperature and composition mapping of the surface and atmosphere, including CO₂, ethane, CO, and water vapor lines Study Titan's gravity field Measure the atmospheric plasma ionosphere with Titan Measure the energy profile for Titan's ionosphere from space and surface Determine Titan's surface elemental composition, including density, density, and subsurface structure Measure the density, vertical profile, and changing properties of the atmosphere from the surface Measure the density of subsurface oceans and subsurface oceans, the speed of sound, the depth of the oceans, the temperature, porosity, relative viscosity of the fluid, and ocean wave properties Measure orbital impingement, surface albedo, surface, and ground structure 	<ul style="list-style-type: none"> Hyperspectral Imager for the Titan Science (HTS) Langmuir Probe (LP) Radio and Plasma Wave Science (RPWS) Radar (Imaginer of Titan Investigation (ITI)) Titan Synthetic Aperture Radar and Microwave (SAR/MW) Thomson Scatterometer (TSC) Titan Radio Science (TRS) Titan Synthetic Aperture Radar and Microwave (SAR/MW) Titan Submillimeter Link Sounder (TSL) 	<ul style="list-style-type: none"> Aerover Hyperspectral Imager for Titan Science (AHTS) Langmuir Probe (LP) Gas Chromatograph Mass Spectrometer (GCMS) Surface Sampling (SS) Surface Sampling (SS) Surface Sampling (SS) Surface Sampling (SS) Surface Sampling (SS)





D *Nominal Aerover Concept*

~4.5m

