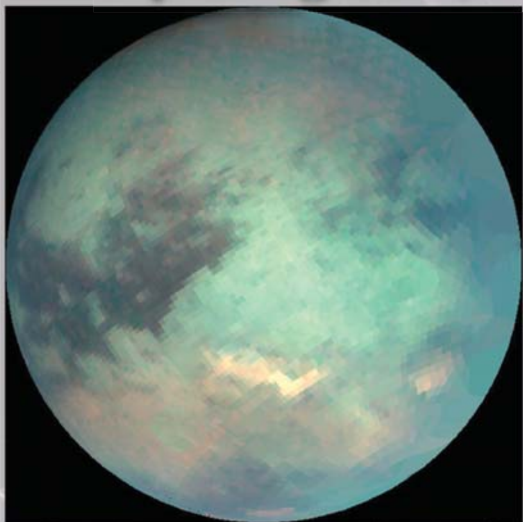
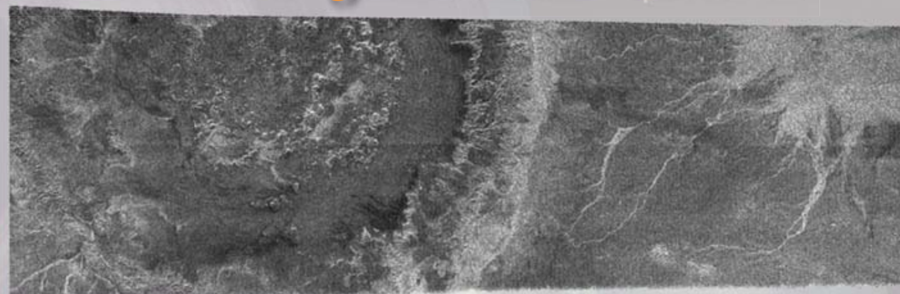
TITAN EXPLORER

Exploring Titan, an Earthlike Organic-Rich World …

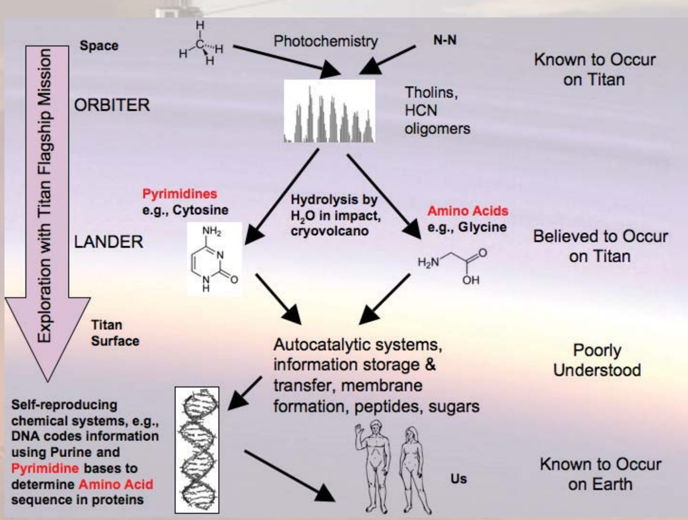


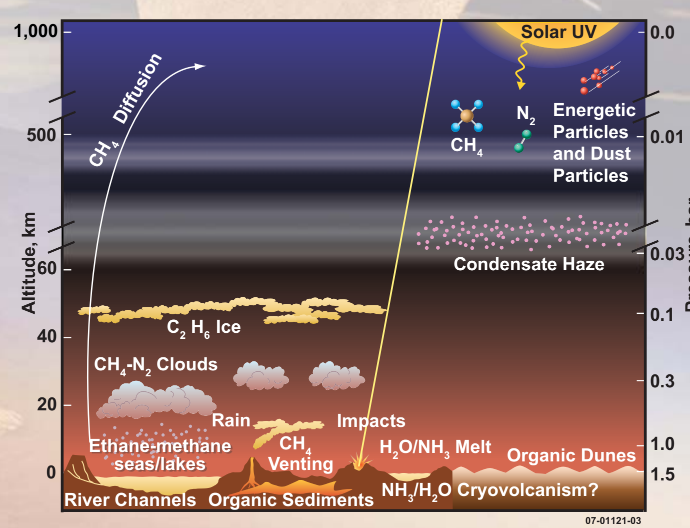


Titan System Science – The rich interactions at Titan among the surrounding space environment, the atmosphere, the surface, and the interior mirror processes on Earth. Titan is a dynamic world: clouds and rainfall change on hourly timescales. On ~16-day timescales, tides rise and fall in lakes of liquid hydrocarbons, drive winds in the atmosphere, and raise stresses deep in the interior. Year-to-year, seasonal changes are observed in atmospheric composition, aerosols, temperatures, and wind patterns. On geological timescales, atmospheric evolution occurs via escape, photochemical reactions, and cryovolcanism. Many analogs to Earth have been found. Titan's surface has been eroded by rivers, the precipitation may be torrential enough to cause flash floods, and the atmosphere exhibits a greenhouse effect and stratospheric anomalies analogous to Earth's ozone hole.

Titan and the Origins of Life – The inventory of complex organic material on Titan is remarkably rich. Synthesis of organics begins in the active ionosphere; it results in the thick haze lower in Titan's atmosphere, the surface accumulations of organic liquids and particles that form lakes in polar regions, and the vast expanses of dunes near the equator. Further processing by exposure for thousands of years to liquid water at sites of impacts and cryovolcanism should yield building blocks of life, such as pyrimidines and amino acids. Given such timescales and conditions, Titan holds possibilities for fundamentally new organic chemistry that cannot be reproduced in the laboratory on Earth.

Synergistic Science – Owing to its unique atmosphere, Titan engages a more extensive range of scientific disciplines than other icy satellites. It is an outstanding target for comparative planetology, both with other satellites and with the terrestrial planets. Titan's environment also enables uniquely affordable deployment of a wide array of instrumentation at the surface, in the atmosphere, and in orbit. Thus, the powerful complement of scientific tools necessary to understand such a complex system can actually be brought to bear. For example, in situ investigations such as seismic sensors and detailed chemical analyses support and inform an orbital survey of this diverse target. Combinations of techniques provide more robust constraints on mysteries such as Titan's interior structure and atmospheric circulation.





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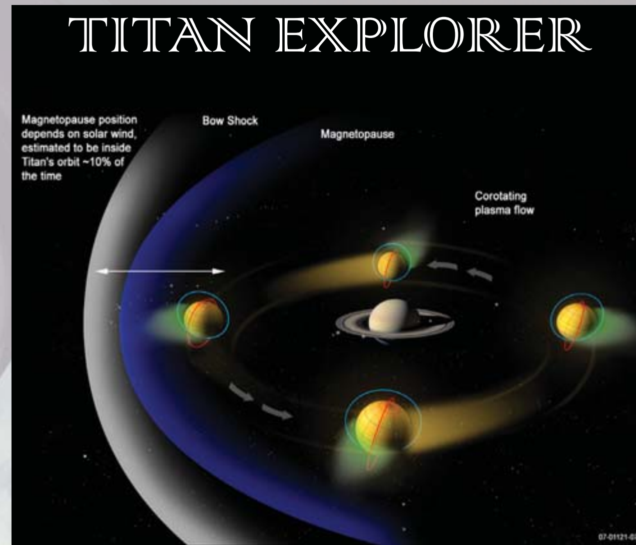
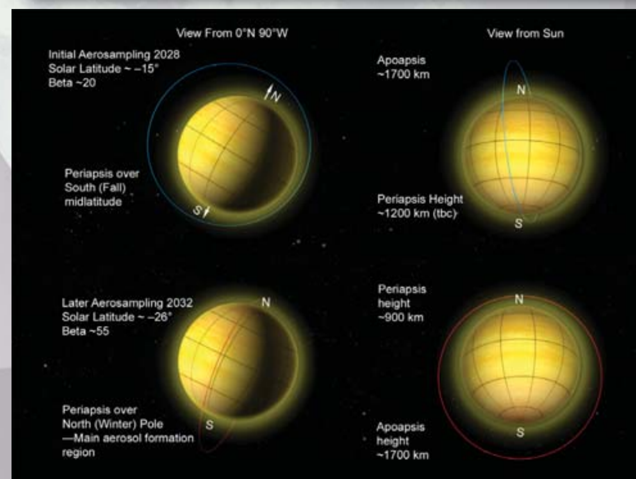
Mission Overview

An Orbiter, Lander, and Balloon designed to provide synergistic science at multiple, complementary scales, arrive at Titan in 2028. The 4-year orbital mission returns orders of magnitude more data about Titan than Cassini – this mission will spend more time at Titan in its first 3 days in orbit than the nominal and extended Cassini missions – and at a complementary season. The 1-year in situ Lander and Aerial Vehicle (Balloon) mission elements are tremendously enhanced by data relay from the Orbiter. They provide invaluable scientific context for remote sensing measurements.



Mission Implementation

The three elements, Orbiter, Lander, and Balloon, are housed in individual aeroshells and are carried by a cruise stage launched by the Atlas V 551 in 2018 through two Venus and two Earth flybys until separation begins ~1 month before Titan arrival in 2028. Four years of operation are planned for the Orbiter, including relaying communications for the two in situ elements in the first year and two "aerosampling" phases where the Orbiter passes through the upper atmosphere to perform scientific analyses.



The Orbiter, carrying 12 instruments and supporting radio science investigations, provides global mapping, remote sensing observations, and in situ upper atmospheric measurements, allowing over half of the science objectives to be partially addressed; the objectives are addressed in full when Orbiter measurements are augmented by those from the in situ elements. The Orbiter design utilizes aerocapture in Titan's atmosphere to save ~4 km/s of propulsive ΔV.

A direct-entry Lander, leveraging experience from Huygens and Mars missions, carries eight instruments and addresses more of the science objectives, in particular allowing seismic measurements and direct analysis of surface composition.

An Aerial Vehicle, a Montgolfiere hot-air balloon, achieves the remaining science objectives by passively circumnavigating Titan using zonal winds and taking measurements with five instruments. The Balloon inflates during atmospheric entry and remains near an altitude of 10 km to bridge the science gap between the Orbiter and the Lander scales, notably providing widespread meter-scale imaging of the surface. Technology developments for aerocapture, balloon technologies, cryogenic applications, and landing systems are funded and scheduled for completion by the mission Preliminary Design Review.

	Mass* (kg)	Power* (W)	ΔV (m/s)	Science Data Volume**
Orbiter	1810	638	408	3.4 Tbits
Lander	897	255	0	5.5 Gbits
Aerial Vehicle	588	128	0	4.6 Gbits
Cruise Stage	1419	0	341	0

*Mass and power are allocations. Mass margin is 19.9%; contingency is 17.5%. Power margins are ≥26% for all modes.
**Science data volumes are current best estimates. Margin on downlink rate is 30%; margin on downlink time is ≥18% above shown volumes.

Schedule and Cost

6.5-year schedule (with 5.5 months of funded reserve in the 4.5-year Phase C/D)

$4B Orbiter, Lander & Balloon Mission can be reduced to $2B Orbiter-only science floor mission