Oceanus: A New Frontiers orbiter concept to study Titan's potential habitability

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Cassini has demonstrated that Titan is an organic world of two oceans: surface hydrocarbon seas [1,2] that cover part of the north polar region and a deep water ocean [3] that decouples the outer ice crust from an inner core likely composed of hydrated silicates [4]. The Cassini mission also demonstrated that Titan's reduced nitrogen-rich atmosphere operates as an organic factory [5] where heavy organic molecules are produced by a series of reactions starting by the photolysis of methane [6,7]. Oceanus is a proposed orbiter concept that would follow up on Cassini's amazing discoveries and assess Titan's habitability. By following the organics and the water, this Titan orbiter carries a straightforward payload and will (i) Determine the chemical processes producing the heavy organic molecules in Titan's upper atmosphere, (ii) Follow the transport of organics at the surface as climate has evolved, (iii) Determine if organics and water have mixed in the crust, and (iv) Determine whether geological processes have allowed for the transport of organics into Titan's subsurface ocean.
The New Frontiers 4 AO includes the theme "Ocean Worlds (Titan and/or Enceladus)" focused on the search for signs of extant life and/or characterizing the potential habitability of Titan and/or Enceladus. The Titan's science objectives are (i) Understand the organic and methanogenic cycle on Titan, especially as it relates to prebiotic chemistry; and (ii) Investigate the subsurface ocean and/or liquid reservoirs, particularly their evolution and possible interaction with the surface. Oceanus would not only address these two science objectives but would also be responsive to a large number of the important science questions defined by the 2011 Decadal Survey.
Oceanus would provide the data that can shed light on the organic chemistry that operated on Earth when life emerged 4 billion years ago [8]. At that time Earth was a 'pale orange dot' that eventually became the living planet we know today. That "pale orange dot" version of Earth had plenty of liquid water in its oceans and energy in the form of sunlight. However, we do not know the roles that carbon chemistry played to enable the development of an Earth's biology. Given how active tectonics has erased the geologic record of Early Earth, information about how those processes has been lost. Oceanus would provide that information.
Oceanus would address these questions with three high-heritage instruments that address the potential habitability of Titan: an infrared camera that would acquire 25 m pixel size images of Titan's surface at 1500 km altitude, a radar altimeter that would provide a global topography and measurements of the time-dependent deformation of Titan's surface, and a mass spectrometer capable of characterizing the processes that build the heavy molecules fabricated in Titan's upper atmosphere as well as determining

their building blocks. In addition, information on the gravity field would be obtained from the Doppler shift of the microwave carrier used in the radio link to the ground.

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