Detailed exploration of Titan with a Montgolfiere aerobot

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The International Cassini/Huygens (CH) mission has verified the expectation that Saturn's moon Titan offers many opportunities for studying high-priority planetary and astrobiology science objectives. CH results to date show that this world, though entirely alien in its frigid environment, presents an Earth-like and diverse appearance due to the relative balance of competing forces such as geology/tectonics, meteorology, aeronomy, and cosmic impacts. But with the limitations of a single Huygens probe, and a finite number of Cassini flybys limited in proximity and remote sensing resolution by Titan's thick atmosphere and hazes, there is much science to be done there after the CH mission has ended.

Detailed exploration of Titan's surface and lower atmosphere, especially for astrobiological objectives, is best addressed by in situ investigations. The atmosphere and its hazes severely restrict orbital remote sensing: Titan cannot be mapped from orbit in the same manner as Mars, at (essentially) arbitrarily high resolution, and limited infrared (IR) windows allow only gross compositional interpretations. After CH indeed there will be further orbital investigations to be carried out, notably completion of the global mapping by Synthetic Aperture Radar and IR mapping spectrometry begun by CH, at the best resolutions practical from orbit. But to fully understand Titan as an evolving, planetary-scale body and an abode of preserved protobiological chemistry will require a platform that has access to, and mobility at, the surface and the lowest few kilometers of the atmosphere.

The TiPEx study team weighed the options for Titan in situ exploration, and finds that a mission based on a Montgolfiere (a type of hot-air balloon) aerobot is the best candidate for post-CH exploration. Ground-based platforms of the type used to date on Mars are far too limited in range to sample the diversity of Titan, and do not adequately investigate the lower atmosphere. Titan's cold, dense atmosphere is ideal for aerial vehicles, requiring orders of magnitude less power for sustained flight than equivalent vehicles at Earth. Its winds provide mobility unequaled by any ground-based platform, and even controllability by the same techniques used by hot-air balloonists on Earth. The study team also found that the Montgolfiere approach is most effective when it is supported by a Titan orbiter that provides data relay as well as its own science observations.

Operationally, the Montgolfiere is seen as an evolutionary step from the Huygens probe, adding controlled buoyancy to the long list of Huygens demonstrations, thus enabling greatly expanded longevity (at least months) and greater data return by 3 to 4 orders of magnitude. It is amenable to long periods of autonomous control, necessary due to the three-hour communication round-trip time to Earth and longer periods out of Earth and orbiter visibility. Tests at Earth show that deployment and inflation under a parachute present no unsolved problems, and that altitude control is simple and accurate, as demonstrated by precision "touch and go" landings, so surface sampling of a limited number of sites at Titan is practical.

This presentation will summarize the study team's concept of science objectives, mission architecture, and operations of a Montgolfiere mission to Titan.