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Titan Orbiter Aerorover Mission with Enceladus Science (TOAMES)

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Cassini and Huygens have made exciting discoveries at Titan and Enceladus, and at the same time made us aware of how little we understand about these bodies. For example, the source, and/or recycling mechanism, of methane in Titan's atmosphere is still puzzling. Indeed, river beds (mostly dry) and lakes have been spotted, and occasional clouds have been seen, but the physics to explain the observations is still mostly lacking, since our "image" of Titan is still sketchy and quite incomplete. Enceladus, only $\sim$500 km in extent, is even more puzzling, with its fiery plumes of vapor, dust and ice emanating from its south polar region, "feeding" Saturn's E ring. Long term variability of magnetospheric plasma, neutral gas, E-ring ice grain density, radio emissions, and corotation of Saturn's planetary magnetic field in response to Enceladus plume activity are of great interest for Saturn system science. Both Titan and Enceladus are bodies of considerable astrobiological interest in view of high organic abundances at Titan and potential subsurface liquid water at Enceladus.

We propose to develop a new mission to Titan and Enceladus, the Titan Orbiter Aerorover Mission with Enceladus Science (TOAMES), to address these questions using novel new technologies. TOAMES is a multi-faceted mission that starts with orbit insertion around Saturn using aerobraking with Titan's extended atmosphere. We then have an orbital tour around Saturn (for 1-2 years) and close encounters with Enceladus, before it goes into orbit around Titan (via aerocapture). During the early reconnaissance phase around Titan, perhaps 6 months long, the orbiter will use altimetry, radio

science and remote sensing instruments to measure Titan's global topography, subsurface structure and atmospheric winds. This information will be used to determine where and when to release the Aerorover, so that it can 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 probably use a "hot air" Montgolfier balloon concept using the waste heat from the MMRTG $\sim$ 1-2 kwatts. 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 Aerorover will have all the instruments needed to sample Titan's atmosphere and surface with possible methane lakes-rivers. It will e.g., use multi-spectral imagers and for last 6 months of mission, balloon payload will land on surface at predetermined site to take core samples of the surface and use seismometers to help probe the interior. All remote (and active) sensors on the orbiter will share a $\sim$ 1 meter telescope, called MIDAS (Multiple Instrument Distributed Aperture Sensor). MIDAS observations in stable orbit at Titan can provide full global maps of Titan's surface and could additionally provide long term observations of the Saturn system including Enceladus for extended mission phases over many years, potentially for decades. Experience from the Hubble Space Telescope has shown strong public interest and commitment to exciting generational missions.