ROTARY WING DECELERATOR USE ON TITAN

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The ongoing Cassini mission to Saturn is considered one of the most successful international collaborations in the history of space exploration. The mission included the Huygens probe, which landed on the surface of Saturn's largest moon Titan in 2005, generating a huge amount of scientific interest in further exploration of Titan. Huygens brought its power source with it in the form of batteries, which limited its operational lifetime to about six hours, nearly half of which was spent in atmospheric descent.

Huygens' success, combined with other recent findings, provide justification for a return mission to study Titan's atmosphere and surface. A vehicle for such a return mission would greatly benefit from a descent system that can provide landing site selection, low-velocity touchdown, and power generation capabilities, while providing a platform for atmospheric research. A comparison of various atmospheric deceleration technologies based on their potentials for providing heading control, a soft landing, and power generation during descent, shows rotary wing decelerators (RWDs) to be of significant merit for applications on Titan.

RWD systems use autorotating wings to slow down a vehicle in atmospheric descent. During the majority of the descent, the rotary wing spins freely at high rpm to store up energy. When the vehicle approaches the surface, the RWD system performs a "cyclic flare" maneuver, using the stored energy to generate the lift necessary for a soft landing. Similar systems are implemented on terrestrial helicopters as a safety mechanism. Vehicle heading control is achieved by adding fully articulated blades to the system, such as are used on most modern helicopters, rather than only the collective pitch control required for landing.

Titan's dense and highly extended atmosphere make it an ideal location for RWD applications. Because the entry vehicle will spend several hours transiting hundreds of kilometers during descent, a generator attached to the autorotating wing could generate significant power while also keeping the rotation speed within a safe operating range. Preliminary calculations show that for average descent velocities of 4 to 8 m/s and probe masses of 300 to 800 kg, power generation levels of 1 to 4 kW may be feasible. Achieving similar power levels using radioisotope thermoelectric generators (RTGs), which are most commonly proposed for missions to Titan, would involve power system masses on the order of 500 kg or more.

We propose a preliminary design for a rotary wing decelerator system for landing on Titan. Initial blade sizes, material selections, and power systems are presented. Additionally, we provide analysis of aerodynamic performance, landing speeds, allowable probe masses, and predicted power output. We also discuss the feasibility of extending such a system for applications on Earth, Venus, and Mars.