GCM Simulation of Outer Solar System Atmospheres for Flight Simulation. J. R. Beltz [1] and R. P. LeBeau [1], [1]Parks College, Saint Louis University, Saint Louis, MO 63103

The concept of flight on other planets has now been realized by the Ingenuity helicopter on Mars. Similarly, the Dragonfly mission will employ a rotorcraft to fly on Titan. Given the lack of opportunity to directly test designs on other planets, proposed is a toolbox to simulate flight by combined atmospheric and flight simulation to assess the potential effectiveness of missions. Inspired by Dragonfly and prior research by Colletti et al on glider design for various planetary atmospheres [1], this research aims to accomplish its own mission of representing extra-terrestrial flight [2]. While the initial focus is simulating a glider on Titan, this toolbox is intended to be used for any fixed-wing aircraft in any simulated atmosphere.

Initial analysis assumed models that determined temperature and pressure for a given altitude. Those equations were fed into a flight simulator where different designs can be tested against various flight profiles. Models that are derived from data collected by a single probe (such as Huygens [3]), exist at only a singular path through the atmosphere over a short time span. To generate an atmosphere of data, current research aims to create higher fidelity data to use in flight simulation by utilizing a General Circulation Model (GCM). The EPIC GCM [4] was chosen due to prior group experience to simulate outer planet atmospheres including the Berg cloud feature of Uranus [5] and the Great Dark Spot of Neptune [6]. Simulated atmospheric data can be fed into the flight simulator, providing the more varied conditions that might be experienced by the glider as it traverses from a high altitude after entry until it finds its landing location. Utilizing GCM data expands upon the simple column pressure and temperature models, incorporating other various weather conditions such as changing winds, clouds, and storms.

The version of EPIC employed uses a hybrid vertical coordinate, ζ, that transitions continuously from potential temperature, θ, to a function of the pressure coordinate, σ, based on the approach of Konor and Arakawa [7]. This hybrid coordinate system allows increased vertical resolution where θ is near constant such as in the deeper troposphere. A significant challenge of this approach is defining a sufficiently robust hybrid profile (Fig.1) to support sufficient resolution in the model for flight. Improving model refinement along with the initial conditions for the atmospheric models will enhance the environment created for the flight simulation.

While the initial choice of soaring missions allows for a relatively simpler flight simulation process, the interface between the simulation platforms should be applicable to powered flight as well. As the simulations advance in detail, increasingly complex missions will be able to be represented through this approach.

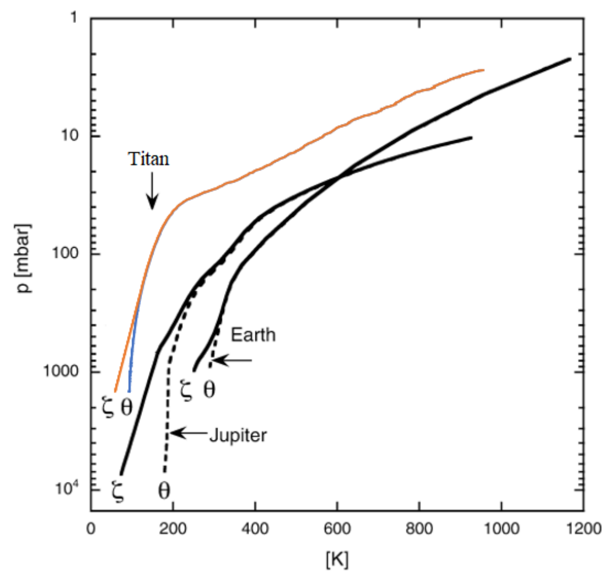

Figure 1. Hybrid vertical coordinate, ζ, and potential temperature, θ, versus pressure, p, for typical EPIC models of Earth, Jupiter, and Titan (profiles from [4,8]).

Acknowledgments: Huygens data from the Planetary Data System (PDS) data [3].

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