EXPLORATION OF TITAN USING VERTICAL LIFT AERIAL VECHICLES. L.A. Young, Army/NASA Rotorcraft Division, M/S T12-B, Ames Research Center, Moffett Field, CA 94035 (layoung@mail.arc.nasa.gov).

Introduction: Autonomous vertical lift aerial vehicles (such as rotorcraft or powered-lift vehicles) hold considerable potential for supporting planetary science and exploration missions. Vertical lift aerial vehicles would have the following advantages/attributes for planetary exploration: low-speed and low-altitude detailed aerial surveys; remote-site sample return to lander platforms; precision placement of scientific probes; soft landing capability for vehicle reuse (multiple flights) and remote-site monitoring; greater range, speed, and access to hazardous terrain than a surface rover; greater resolution of surface details than an orbiter or balloons. Exploration of Titan presents an excellent opportunity for the development and usage of such vehicles.

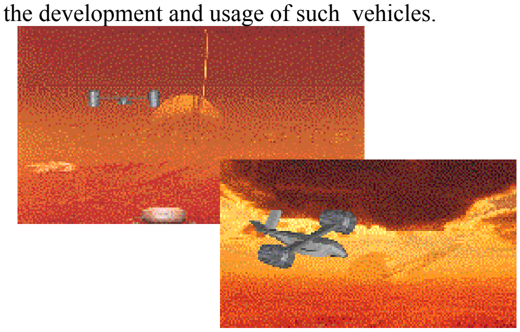

Fig.1-Titan Vertical Lift Aerial Vehicle

Current Work: Titan, Saturn's largest moon, is unique in the solar system in that it is the only moon that has a substantial atmosphere. Titan's atmosphere may even have properties similar to Earth's early atmosphere, before life began. The use of vertical lift aerial vehicles to explore Titan would be a tremendous enabler of scientific investigations of one of the solar system's more mysterious planetary bodies. References 2-3 provide some preliminary discussion of the potential for vertical lift aerial exploration of Titan.

Several types of rotorcraft (such as helicopters and tiltrotor aircraft) or powered lift vehicles could be developed for aerial exploration of Titan. Such vehicles by necessity will be highly autonomous and will likely have electric propulsion for their rotors or fans. In particular, ducted fan configurations such as tilt-nacelle aircraft are perhaps ideally suited for Titan (fig.1). Ducted fan aerial vehicles would inherently be more robust taking off or landing in an unknown, potentially hazardous, environment than conventional rotors. Nonetheless, detailed design studies will be required to identify the optimal design configuration for a specified planetary mission.

Initial mission concepts being studied at NASA Ames would employ a lander-based architecture where small ducted fan tilt-nacelle vertical take-off and landing (VTOL) aircraft could use the lander as a primary base site. The lander would service and support the vertical lift aerial vehicles, including: recharging their power supplies with radioisotope thermoelectric generators; download and transmit data acquired in-flight and at remote landing sites; act as a storage depot for science packages, drop probes, and other payload for the aerial vehicle; store spare aircraft; provide/erect temporary shelter for the aerial vehicles to protect them from severe weather conditions.

Figure 2 shows estimates of hover total shaft power for a notional Titan tilt-nacelle VTOL vehicle having two ducted fans that can pivot at the wing tips. A Titan VTOL's ducted fans will be very small and consume very little power as a result of the high atmospheric density near Titan's surface and it's low gravity field.

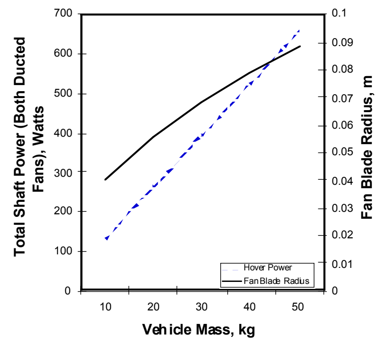

Fig.2-Ducted Fan Hover Performance

Figure 3 shows range estimates for a 50kg Titan twin tilt-nacelle/ducted-fan VTOL vehicle, assuming power matching between the hover and cruise design points.

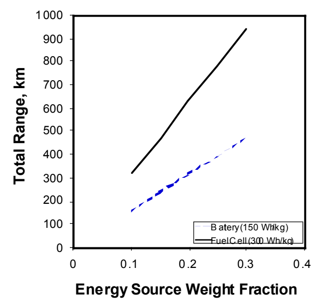

Fig.3-Vehicle Range

As can be seen from figures 2-3, a small aerial vehicle acting in concert with a lander (which would recharge and service the vehicle) could enable mapping and scientific investigations of an area of several thousand square-kilometers.

Future Work: Work continues at NASA Ames on design studies of vertical lift planetary aerial vehicles. The feasibility of NASA sponsoring a student design competition for Minority Universities and HBCUs for Titan vertical lift aerial vehicles is being explored. This would complement the American Helicopter Society Student Design Competition on Martian autonomous rotocraft [4,5].

References: [1] Young, L.A. et al. (Jan. 2000) *AHS Vertical Lift Aircraft Design Conference, San Francisco, CA*. [2] Young, L.A., (Oct.30-Nov.1, 2000) *AHS/AIAA/SAE/RaeS International Powered Lift Conference, Arlington, VA*. [3] Lorenz, R.D. (Vol. 53, pg. 218-234, 2000) *JBIS*. [4] University of Maryland Design Proposal (http://www.enae.umd.edu/AGRC/Design00/MARV.html).

[5] Georgia Institute of Technology Design Proposal (http://www.ae.gatech.edu/research/controls/projects/mars/reports/index.html).