AVIATR: Aerial Vehicle for In-situ and Airborne Titan Reconnaissance

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The Aerial Vehicle for In-situ and Airborne Titan Reconnaissance (AVIATR) is a small (120kg), nuclear-powered Titan airplane in the Discovery / New Frontiers class. Given Titan's dense and extended atmosphere, an airplane can acquire higher spatial resolution imagery and spectra than any practical orbiter that must remain above the atmosphere. An airplane can also directly sample the moon's lower atmospheric structure and composition, and can do so at any latitude/longitude as needed. The scientific goals of the mission are to explore Titan's diversity both in terms of surface landforms, processes, and compositions, and in terms of atmospheric circulation, aerosols, and humidity.

Airplane flight is more technically feasible on Titan than anywhere else in the solar system, Earth included. Heavier-than-air flight is over 1000 times easier at Titan than at Mars and more than 20 times easier than on Earth. Given the heritage from the burgeoning field of unmanned aerial vehicles (UAV) on Earth – hundreds of them are flying around Iraq, Afghanistan, and Pakistan as you read this – the technological readiness for a Titan airplane is high.

Both the 2007 Titan Explorer and 2008 Titan Saturn System Mission (TSSM) NASA flagship studies included an airborne in-situ element to study Titan's surface and lower atmosphere. The element in both of these studies was a Mongolfiere, a hot-air balloon kept aloft by exhaust heat from a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). A heavier-than-air airplane cannot work if it is powered by an MMRTG – the power-to-weight ratio is just too low. Hence given the flagship constraints, a hot-air balloon was the only option.

Today, though, the advent of the more-efficient Advanced Stirling Radioisotope Generator (ASRG) is a game-changer. With the ASRG, the energetics of a Titan airplane are fully feasible. An airplane has numerous significant engineering advantages over a balloon while being able to accomplish similar scientific objectives: (1) direct-to-Earth communications capability via a high-gain antenna embedded in the plane's nose, (2) the ability to remain continuously on the dayside by flying west faster than the moon's rotation, (3) a more robust platform capable of withstanding adverse atmospheric conditions, (4) a more reliable deployment mechanism, and most importantly (5) a price and simplicity that allow the mission to be done in the Discovery / New Frontiers programs, independent of a flagship mission. An airplane shares the features of nearly limitless mission durations, in-situ atmospheric sampling capability, a safe and stable platform, and high-resolution surface imaging and spectroscopy with other airborne options (like the balloon).

In addition to engineering, an airplane would also have some scientific advantages over a balloon. First and foremost, the airplane's piloted nature allows a go-to capability to image locations of known interest on Titan at will. This allows directed exploration of Titan's sand dunes, mountains, craters, channels, and lakes, features of primary geologic interest as evidenced by the number of journal articles on the topics over the past several years. Subsequent imaging can search for changes. The airplane can fly predesigned routes in order to build up large context mosaics of areas of interest, and then swoop down to low altitude to acquire high-resolution images at 30-cm spatial sampling similar to that of HiRISE at Mars. The elevation flexibility of the airplane allows us to acquire atmospheric profiles as a function of altitude at any desired location.

Total scientific return from the mission is limited by the downlink bandwidth. In order to maximize the science per bit, we will employ novel data storage and downlink techniques. We will acquire more images, spectra, and atmospheric profiles than could ever be fully downloaded, storing the data in low-mass non-volatile memory. Only thumbnails and metadata will be downlinked for most images – the science team will then make an informed decision about which images, or parts of images, should be downlinked. To maximize flexibility on this account, images can be either lossily or losslessly compressed as the team decides.

AVIATR complements both Titan landers and orbiters, providing linearly independent observations that enhance but do not replace those missions' science. Given the lack of a Titan flagship in the near-term, it makes sense to explore Titan continuously with targeted missions, in the style of the Mars Exploration Program, rather than to wait for one comprehensive flagship mission that may be decades in the future. The AVIATR airplane mission provides an excellent opportunity to pick off flagship-class science with an a Discovery-class cost and schedule.