Using the Mars Ascent Vehicle as a Stand-Alone Sample Return System A. S. Lo[1], M. Trinidad[1], T. Guilmette[1], and T. Segura[1], [1]Northrop Grumman Aerospace Systems, One Space Park, Redondo Beach, CA. 90501

In support of a Mars Sample Return mission, the NASA In-Space Propulsion program has initiated a three phase Mars Ascent Vehicle (MAV) propulsion technology development program to retire risks associated with MAV propulsion stages. Phase I of the program focused on MAV system definition. Northrop Grumman Aerospace Systems (NGAS) and two other contractors were awarded a Phase I study.

During this study, we developed a MAV that uses a two-stage liquid propulsion system comprised of coaxial tanks, solid propellant gas generators, main engines, thrust vector control engines and attitude control system (ACS) thrusters. Some of the primary benefits include: 1) light mass MAV system, 2) trajectory optimization capability, 3) performance that is relatively insensitive to off-axis launch angles, 4) minimized power requirements for storage, 5) favorable launch windows during any season, 6) structurally robust system capable of handling entry and shock loads. Figure 1 shows the MAV and its major components.

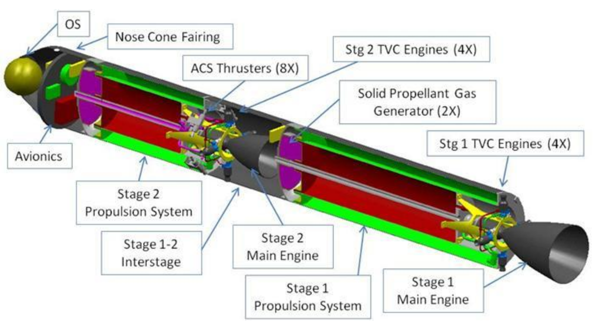

Figure 1: The NGAS design for a Mars Ascent Vehicle.

As part of internal research and development, we took the existing MAV design and performed a feasibility study to see if the MAV can be used as a stand alone sample return vehicle for other planetary surfaces such as the Moon. We were mostly interested in propulsion and navigation control.

We performed analysis of sample return capabilities from two regions on the lunar surface: one from the lunar south pole, and one from the center of the South Pole-Aiken basin. The south pole is of interest to robotic and future human exploration, and in particular, in-situ resource utilization processes will require details of the materials in the lunar regolith. The South Pole-Aiken basin has long been a scientific site of interest, as this basin is one of the largest and oldest craters in the solar system.

We made the following assumptions during our analysis:

- Assume MAV will take off from a lander platform with optimal 90 degree pointing
- Assume MAV will travel directly to Earth with no lunar orbiter rendezvous
- Assume a Stardust style sample return architecture.

Our preliminary analysis shows that from both locations, the NGAS MAV design is capable of bringing ~5 kg of sample back, using a Stardust style sample return mechanism totaling 40 kg. The trajectory is shown in Figure 2. We use the same starting sequence for the MAV on the lunar surface as would be used for the Mars sample return. The Earth reentry sequence is the same as for the Stardust sample return. We target the sample to drop in the NASA White Sands test facility, with the MAV splashdown in the Pacific, well off the coast of central America.

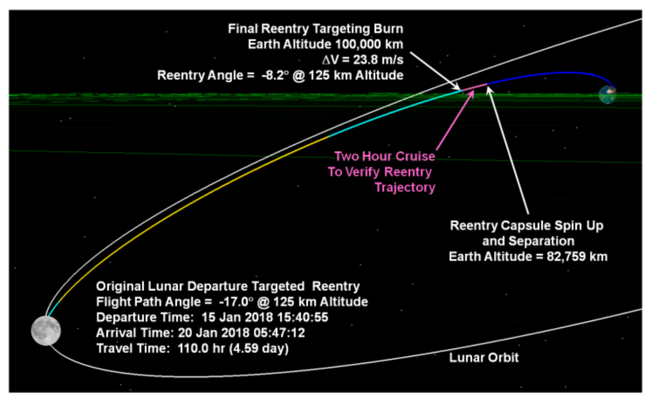

Figure 2: MAV return trajectory from the South Pole Aiken Basin.

We have identified the following issues as the major drivers for following on work.

- **Guidance and Navigation**: current MAV may not have sufficiently small impulse bit for fine control needed.
- **Power**: current MAV design does not have sufficient battery power for the 4.5 day return trip to Earth.

However, we feel that there is sufficient mass that can be traded on the current MAV design. For example, the nose cone fairing structure is designed for Martian atmosphere traverse, and would not be needed for the airless Moon. We are very interested in community input and welcome collaborations.