SPLAT: The Sample Probe for Landing And Testing.

K. Gonyea[1], T. Dendinger[2], J. Fernandez[3], A. Jaunzemis[4]. [1]Georgia Institute of Technology keir@gatech.edu, [2]tdendinger3@gatech.edu, [3]jfernandez3@gatech.edu, [4]Georgia Institute of Technology adjaunzemis@gatech.edu.

Introduction: This paper presents the analysis for the entry, descent and landing of biological samples flown in space. This study considers sample return following free flying operations or after being attached externally to the International Space Station (ISS). Biological samples of the types compatible with the EXPOSE facility were considered as the primary payload.

The reentry system geometry is based on dynamic stability considerations for a passive ballistic vehicle and the temperature constraints for the payload. Specifically, a 45° sphere-cone was selected due to aerodynamic stability and the desire to have a center of mass location that would positively influence the robustness of the vehicle to perturbations. While the target center of gravity location of 0.346 base-diameters was not achieved, it was determined that sufficient spin would maintain a passive vehicle. Further, a drogue chute in the transonic regime would provide increased stability. On-orbit maintenance was determined to be the responsibility of a service module to minimize the mass requirements of the reentry vehicle.

A nominal entry condition was selected through propellant and aerothermal sensitivity analyses, as well as comparisons to heritage missions. The nominal entry velocity was 7.8 km/s and nominal entry flight path angle was -4 degrees. In order to accommodate the widest range of biological samples, a maximum g load of 16 g's for 20 seconds and 20 g's shock load were established. Due to the ballistic nature of the entry vehicle, the trajectory was simulated as 3 degree-of-freedom planar motion. This simulation was then used to analyze landing dispersions through a Monte Carlo simulation. The 99% confidence interval landing ellipse measured 106 x 46 km.

A two-stage parachute system was developed which would sufficiently decelerate the vehicle and allow for the operation of the airbag without exceeding the shock load limits during parachute inflation. For the parachute system, a 0.5m2 pilot ringslot would be mortar deployed supersonically (M = 1.5) to provide initial deceleration at stability through the transonic regime. Afterward, the ringslot would pilot deploy a 9m2 ringsail parachute to limit the final velocity. The peak inflation loads were calculated to be 14 g's and a terminal velocity of 7.8 m/s was attained. Further investigation will be taken to qualify the pilot ringslot for deployment at M = 1.5 and ensure that the correct inflation loads and terminal velocity are met.

During re-entry, the capsule experiences a maximum stagnation point heat rate of 357 W/cm2 and backshell heating of approximately 11 W/cm2. Simulation of the temperature profile within the heatshield during the trajectory lead to the use of 3cm of Silicone Impregnated Reusable Ceramic Ablator (SIRCA) for the forebody TPS material on top of 3cm Delrin insulator and 2.4cm of Li-900 for the backshell TPS material. This TPS design achieved a bondline temperature of less than 150 °C and payload temperature less than 25 °C. For future work, SIRCA will be tested at the high heat rates to ensure that it will perform during the mission.

In order to facilitate a rapid recovery of exposed samples, the Utah Test and Training Range (UTTR) was chosen for the landing site. A hemispherical, vented airbag is employed to bring the capsule to rest without exceeding the design g loading requirements. Following touchdown, the capsule and sample are recovered via helicopter.