Comet and Asteroid Sample Acquisition, Containerization, and Transfer for Sample Return

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Abstract

The authors have been instrumental in the development of three key sample return technologies. This was accomplished through their work at Honeybee Robotics supporting the Champollion-Deep Space 4 (figure 1) mission when that mission was baselined as sample return. Additionally they have provided support for the Mars Sample Return Mission 2001. Both missions were cancelled but not before an autonomous spacecraft rendezvous and docking interface, a hermetically sealable sample return canister, and a subsurface sample acquisition system were developed.

When NASA decided that the Champollion Deep Space 4 Mission would return surface and subsurface samples from a comet, Honeybee Robotics was contracted to supply the Sample Acquisition and Transfer Mechanism (SATM) (figure 2), a WEB (figure 3) docking interface, and a hermetically sealable sample return canister (SRC) (figure 4). The Champollion-DS4 mission in its sample

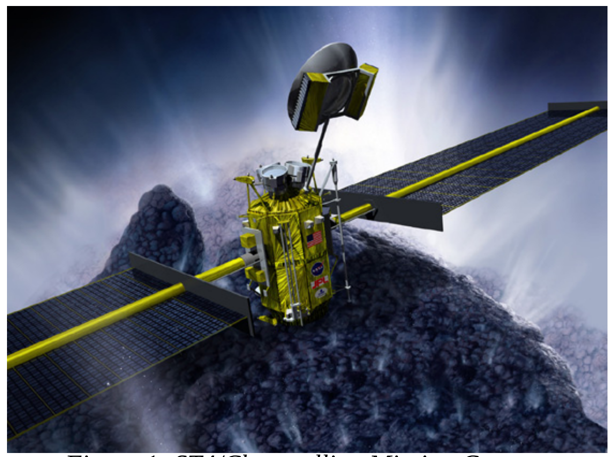

Figure 1: ST4/Champollion Mission Concept
Image courtesy of NASA/JPL

Figure 3: WEB docking system breadboard hardware. Lander (left) near capture with return spacecraft

Figure 2: Sample Acquisition and Transfer Mechanism drilling sequence

Figure 4: Overhead view of 6 sample storage locations

return configuration featured a surface lander that separated from a spacecraft that orbited the comet. The SATM robotically drilled down to 1 meter below the surface and acquired samples in the drill tip. The samples were transferred through mechanisms inside the SATM to the SRC. Dust mitigating seals developed by Honeybee allowed hermetic sealing to take place in a dusty environment. These seals were utilized by autonomously preloading the canister onto the comet surface to maintain the seal for the return cruise. After the samples were collected and the canister was sealed, a portion of the lander with the SRC lifted off from the comet surface to rendezvous and dock with the orbiting spacecraft. The SRC was mechanistically transferred to the orbiting spacecraft for the return cruise. The enabling feature of the WEB docking interface is the net like or spider web type capture element. This feature was unlike any known docking interface and like a spider, it provided for a wide field of capture. Using titanium barbs on the target spacecraft and a vectran web on the chase spacecraft, the target spacecraft was captured when any barb passed the web plane. The flexible web is then retracted pulling the target spacecraft toward each other down a misalignment correcting cone. The WEB docking interface compensated and corrected for extremely wide misalignments in x, y, z, pitch, and yaw and the web acted as a soft interface providing for significant dynamic misalignment as well.

The WEB docking interface is a cost reducing simple way to safely insure precision autonomous docking between two spacecraft. A sample return canister capable of preserving the sample during cruise and designed to be easy to transfer from the small body surface could be enabling to a sample return mission. The same is true for the SATM which not only can service a sample return mission but can also provide for the precision transfer of samples to instruments on board an in-situ characterization mission.