ANTAEUS II: PLANETARY QUARANTINE FACILITY AT THE DEEP SPACE GATEWAY. M. M. Cohen marc@space.coop,[1] S. Bianco[1,2], Tanner Avery[1]. [1]Space Cooperative, [2]University of Houston.

Introduction: In 1981 NASA published The Antaeus Report: Orbiting Quarantine Facility (NASA SP-454). This study proposed to create an Earth orbital space station to quarantining any material returned from Mars:

> ". . .To detect the presence of biologically active agents—either life forms or uncontrolled (replicating) toxins—in the sample and to assess their potential impact on terrestrial systems. Only when the sample could be certified safe or controllable would it be transmitted to laboratories on Earth for physical analysis."[1]

The authors named the mission after Antaeus, a "half-giant" whom Hercules fought as his 11th Labor. The only way Hercules could defeat Antaeus was by lifting him off the Earth, from which he received his power. The analogy they authors applied was that if they could keep Mars samples away from contact with the surface of the Earth, they could control any dangerous microbes, and if necessary, kill them. Figure 1 shows the concept for the Antaeus orbital quarantine space station.

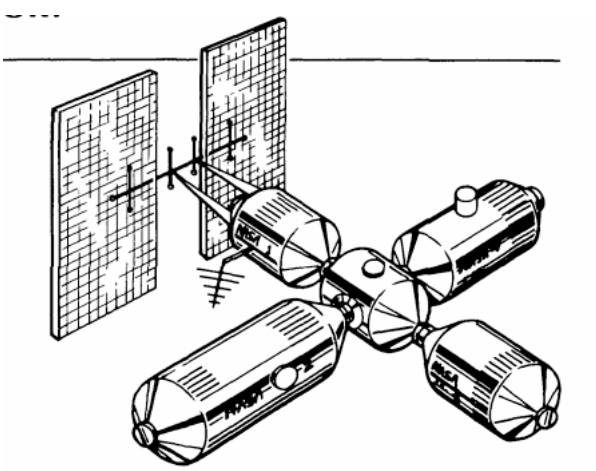

Figure 1. Design Concept for the Antaeus Orbiting Quarantine Facility, (NASA SP–454, 1981).

Adaptation of Bioisolation Technology for Mars Returned Sample Handling (MRSH): During the Mars exploration fanfare of the late 1990s, NASA funded a series of contractor studies to examine the design, mission, and operational problems of collecting samples from Mars and returning them to the Earth without creating or allowing any biological hazards from "back contamination." Much of this discussion assumed the use of Bioisolation technologies at the highest BioSafety Levels (BSLs) as defined and certified by the National Institutes of Health and the Centers for Disease Control. The CDC publishes standards for BSL–1 through BSL–4, the latter being most restrictive set of precautions against the inadvertent release of a pathogen into the environment or allow outside contamination of samples.

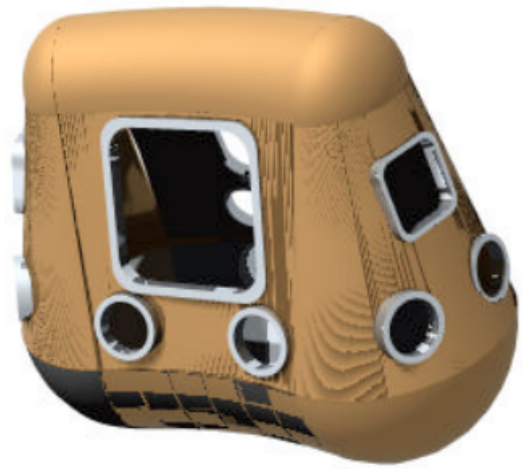

Figure 2. Ergonomically designed, vacuum jacketed "BSL–5" ΔP "glovebox" that mounts mechanical manipulators at the glove ports. [3]

Some study authors began thinking about creating a *BSL–4+ or BSL–5* measure of protection, although these ideas never made their way back into the CDC system of BSLs. The essence of BSL–5 would be to wrap the sample handling "glove-boxes" with a vacuum jacket that would be continuously evacuated through an autoclave, as shown in Figure 2. That way, if any organism should escape the sample handling enclosure, it would suffer immediate incineration.

Another leading challenge was how to actually handle and manipulate the Mars samples. The astrobiologists in the NASA Ames Center for Mars Exploration (CMEX), distrusted robotic manipulators, and as one said, he wanted to "hold the sample in his own hand." Since bare hands and rubber gloves were emphatically ruled out, the design team proposed to adapt mechanical manipulators from the AX-5 Space Suit Advanced Development Project. Figure 3 shows the Jameson Prehensor as an example of such a manipulator that affords force feedback to the operator, while maintaining a proven pressure seal around the manipulator rods.

Where on Earth? Initially, during the this activity at CMEX, the emphasis on Mars sample handling was for astronauts to do it in a Mars surface science laboratory, based on NASA's 1997 *Mars Design Reference*

Mission 1.0. [5]. Following this period of study and speculation that accompanied the "Follow the Water" philosophy, NASA began looking more seriously at returning Mars samples to Earth under highly controlled and guarded conditions.

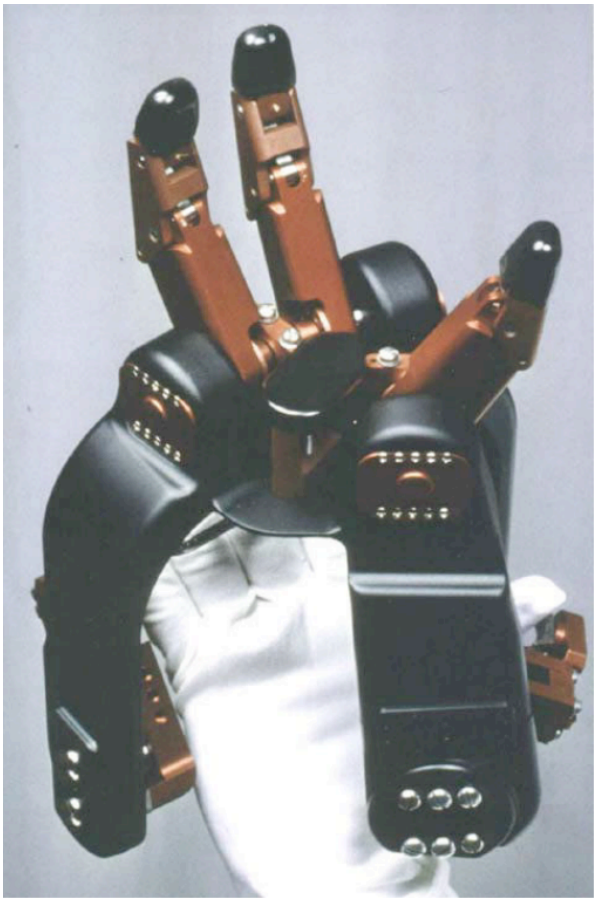

Figure 3. The Jameson Stanford/Ames Direct Linkage Prehensor, show out of its pressure shell.

One of the key realizations to emerge was that the Bioisolation technology and operations might not be the most challenging part of the Mars Sample Return mission. Instead, the most challenging aspect might be "writing the environmental impact statement to locate a MRSH laboratory on Earth."

One participant's not entirely sardonic solution was to return Mars samples to an orbital storage module, until such time as it was possible to complete construction of the BSL–5 Mars sample receiving and handling facility. Estimates for the completion of the Earth-based facility ranged up to three times as long as the entire Mars sample return mission itself, from project start to sample return to an orbiting "short stop."

These studies extended into the early 2000s, and applied both system engineering and urban and regional planning methods to identify the appropriate landing site on Earth and where to transport the samples from there to a permanent curatorial facility. [6,7]. However, the lead author came to the then unpublishable conclusion that the original Antaeus Mission was the best idea and most correct from a system analysis perspective. It would be far more efficient, economical, and safe to process and analyze Mars returned samples in a space-based laboratory.

The Deep Space Gateway would afford the ideal space-time coordinates for the Mars returned sample science receiving lab. It provides the essential Bioisolation from Earth to prevent back contamination. Surgical and industrial robots are now sufficiently advanced to provide all the capabilities a scientist could need to manipulate, slice, dice, and assay a Mars sample. The two-second time latency to Earth from the distant retrograde orbit of the Deep Space Gateway might be slightly annoying, but far less of an obstacle than sending commands to the Mars surface with up to 40 minutes latency. Finally, it would be feasible for astrobiologist scientist-astronauts to work directly on Mars samples at the Deep Space Gateway, in concert with remote "telecommuting" researchers.

The baseline requirements for the Planetary Sample Receiving Laboratory at the Deep Space Gateway include a dedicated module equipped with BSL-4 grade containment systems and telerobotics. A dedicated sample airlock to pass returned samples directly into the PSRL, without need to pass other through pressurized portions of the DSG station, would greatly simplify control of potential back-contamination. The PSRL would attach to the DSG station via a dedicated airlock, with decontamination capability, including showers and evacuation to vacuum. The operational design for the PSRL mission would concentrate on teleoperated or autonomous operation of the analytical capabilities, while being crew tended in terms of sample selection, loading, unloading, and packaging for return of sterile samples to Earth.

References: [1] D. L. DeVincenzi (1981). The Antaeus Report, NASA SP-454. p 1. [2] M. M. Cohen (1999 July). Mars Surface Science Laboratory Accommodations and Operations (SAE 1999-01-2142). [3] M. M. Cohen (2000 July). Design Development Strategy for the Mars Surface Astrobiology Laboratory (SAE 2000-01-2344). [4] J. W. Jameson (1991). Mechanical Prehensor, US Patent 4,984,951. [5] S. J. Hoffman, D. L. Kaplan, (Eds.) (1997 July). Human Exploration of Mars: The Reference Mission of the NASA Mars Exploration Study Team (NASA SP-6107). [6] M. M. Cohen (2002 July). Mission Architecture Considerations for Mars Returned Sample Handling Facilities (SAE 2002-01-2469) [7] (2003 July). Global Overview: Returned Astrobiology Sample Mission Architectures (SAE 2003-01-2675).