Carbothermal Reduction Demonstration: Laser Driven Reaction in a Thermal-Vacuum Environment and Project Status. A. J. Paz[1], D.O'Connor [1], B.C. White[2], A Colozza[3], N Azim[4], [1]NASA Johnson Space Center, 2101 NASA Parkway, Houston TX 77058, [2] Sierra Space ,1212 Fourier Drive, Madison WI 53717, [3]NASA Glenn Research Center, 21000 Brookpark Rd, Cleveland OH 44135, [4]NASA Kennedy Space Center, 1st St SE, Merritt Island FL 32953. (Contact: aaron.paz-1@nasa.gov)

Introduction: Lunar regolith is approximately 45% oxygen by mass. The majority of the oxygen is bound in silicate minerals. The carbothermal reduction process has been proven to be effective at removing oxygen from lunar regolith simulants [1]. The Carbothermal Reduction Demonstration (CaRD) project aims to increase the Technology Readiness Level (TRL) of a combined solar concentrator and carbothermal reduction system in order to demonstrate this technology on the lunar surface. The CaRD project is divided into two design cycles, a brassboard and prototype. The status of both design cycles will be discussed, as well as concepts for how this technology can be applied to the Artemis program in the future.

Brassboard Vacuum Test: For the brassboard demonstration, a 2 kW Nd-YAG laser was used to heat lunar regolith simulant within a carbothermal reactor developed by Sierra Space. The reactor was placed inside of a 15ft thermal vacuum chamber at the Johnson Space Center. The resulting reaction products were analyzed using both a gas chromotograph and mass spectrometer provided by Kennedy Space Center.Thermal data was also collected.

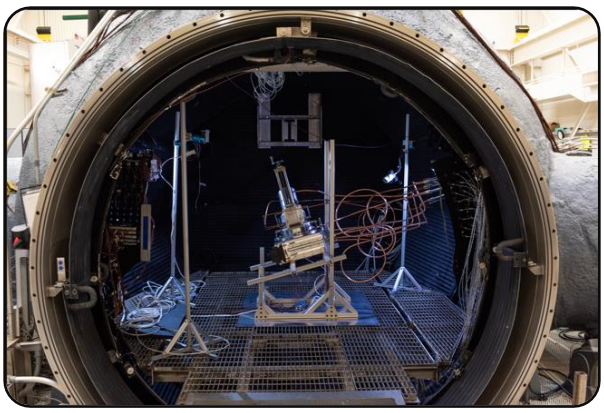

Figure 1: Carbothermal Reactor Developed by Sierra Space Inside 15ft Dirty Thermal Vacuum Chamber at JSC

Prototype Design: For the prototype, the CaRD team will perform another thermal vacuum test at JSC using the same interfaces and assets developed for the brassboard, but will test a new carbothermal reactor design that Sierra Space is developing through the Carbothermal Oxygen Production Reactor (COPR) Tipping Point project that will include a means to autonomously move regolith in and out of the reactor. In addition, a deployable solar concentrator is being developed by Glenn Research Center using mirrors produced by Carbon Mirror Applications. The solar concentrator will be used to deliver solar energy into a carbothermal reactor to melt regolith and extract oxygen. Avionics and software for the concentrator are being developed by Kennedy Space Center.

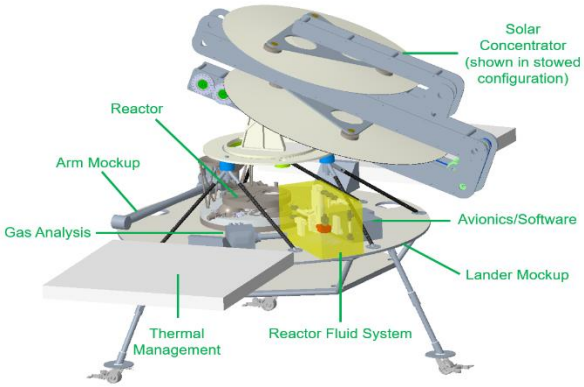

Figure 2: CaRD Prototype

Future Concepts: An ongoing task within the CaRD project is to update models that can be used to determine the mass, power, and size of In-Situ Resource Utilization concepts at various scales. These models can now be used to analyze alternatives for future applications based on the latest available data.

References:

[1] Gustafson, R., White, B., & Fidler, M. (2011). 2010 field demonstration of the solar carbothermal regolith reduction process to produce oxygen. In *49th AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition* (p. 434).