Project Summary

Radiation-cooled, bipropellant thrust chambers are being considered for the Ascent Module (AM) engine of the Altair Lunar Lander. Currently, iridium-lined rhenium combustion chambers are the state-of-the-art for radiatively cooled thrusters. To increase the performance of radiation-cooled engines, improved chamber materials are being developed that will allow higher operating conditions (pressure and temperature), better resistance to oxidation, and reduce mass. In an effort to increase performance, hafnium oxide thermal barrier coatings and improved iridium liners have been developed, and hot-fire tests of rhenium chambers with these improvements have shown higher operating temperatures are possible. To reduce engine mass, recent efforts have focused on the development of carbon-carbon (C-C) composites with iridium liners. Preliminary results from tests of iridium lined C-C chambers have shown considerable promise. During this effort, an innovative composite thrust chamber was developed that incorporates advanced hafnium oxide and iridium liner techniques as well as replacing the expensive, high density rhenium with a low mass C-C structural wall.

As a result of the different materials and multilayered architecture, no single fabrication technique was suitable for producing the advanced composite thrust chamber for the AM main engine. For example, Vacuum Plasma Spray (VPS) forming techniques were preferred for producing the hafnium oxide thermal barrier coating. To produce the dense, iridium oxidation protection layer, electrochemical forming (EL-Form®) methods were desired. For the carbon-carbon structural layer, innovative carbon fiber braiding and chemical vapor infiltration techniques were used. Although the three techniques have been used in the past to produce thrust chambers and other hot gas components, this investigation was the first where all three fabrication techniques were to be used on a single thrust chamber. Therefore, the focus of this effort was to develop the techniques necessary to integrate the three fabrication methods to produce the Phase II composite thrust chamber. As a result of this effort, the ability to produce a large scale, composite chamber comprised of a thermal barrier coating, oxidation protection layer, and a light-weight C-C jacket was demonstrated.