Phase I Project Summary

Research Objective:
A robust, lower cost alternative material is desired for the Attitude Control Motor (ACM) valve assembly. Rhenium with its high melting temperature, excellent elevated temperature properties, and lack of a ductile to brittle transition temperature (DBTT) make it ideally suited for the hot gas components of the ACM and other high temperature applications. However, the high cost of rhenium makes fabricating these components using conventional fabrication techniques prohibitive. Therefore, near-net-shape forming techniques are being investigated for producing cost-effective rhenium and rhenium alloy components for the ACM and other propulsion applications.

Research Performed:
During this investigation, innovative electrochemical forming (EL-Form™) techniques are being evaluated for producing the hot gas components for the ACM and other high temperature applications. The Phase I investigation focused on demonstrating that EL-Form™ processing techniques could be used to produce the ACM flow distributor.

Research Results:

- Modified EL-Form™ processing techniques were developed for producing a simulated flow distributor and material properties specimens were harvested from this deposit.
- Mechanical and physical properties tests showed the rhenium produced with the modified EL-Form™ processing techniques was equivalent to rhenium produced with standard EL-Form™ processing.
- Analysis of EL-Form™ rhenium coated graphite and carbon-carbon samples showed the importance of matching the CTEs of the substrate and rhenium deposit to produce lightweight rhenium coated composite components for high temperature and propulsion applications.
- Two graphite materials were shown to be compatible with EL-Form™ rhenium for producing lightweight rhenium coated composite components.
- For higher strength applications, a C-C composite material with a CTE similar to rhenium may be needed.

Phase II Justification:
The Phase I results have demonstrated the ability of EL-Form™ processing techniques to produce rhenium ACM hot-gas components such as the flow distributor. During Phase II, rhenium, rhenium alloys, and rhenium coated composite materials will be developed for use as ACM hot gas components and for other high temperature propulsion components such as radiatively cooled thrust chambers. After an initial screening study, one of the materials will be selected for detailed properties testing. The goal of this detailed testing will be to produce a material properties database that can be used for modeling and design of high temperature components. Based on these results, high temperature components such as an ACM valve assembly or a radiatively cooled thrust chamber will be produced and delivered to NASA-MSFC for hot-fire testing.