Phase I Project Summary

Research Objective:
Currently, iridium-lined rhenium combustion chambers are the state-of-the-art for in-space engines. NASA's Advanced Materials Bipropellant Rocket (AMBR) engine, a 150-lbf iridium-rhenium chamber recently set a hydrazine specific impulse record of 333.5 seconds. To withstand the high loads during terrestrial launch, rhenium chambers with improved mechanical properties are needed. Recent electrochemical forming (EL-Form™) work has shown considerable promise for improving the mechanical properties of rhenium by producing a multi-layered deposit comprised of a tailored microstructure, i.e., Engineered Re. In addition, the multi-component processing ability of the EL-Form™ process has the potential to significantly reduce the cost of producing advanced iridium-rhenium thrust chambers.

Research Performed:
- Evaluated the mechanical properties of Engineered Re produced in a configuration similar to an AMBR size chamber.
- Performed high temperature post-deposition heat treatments to simulate the effect of hot-fire testing on the mechanical properties of Engineered Re.
- Characterized the samples through microstructural analysis.
- Performed room and elevated temperature tensile tests.
- Evaluated the feasibility of producing Engineered Re deposits during multi-component processing.

Research Results:
- Engineered Re deposits were produced on an AMBR size chamber.
- Microstructural analysis confirmed the Engineered Re was produced in both the barrel and throat regions.
- Examination of Engineered Re deposits after heat treating at 1600, 1800, and 2000°C showed the pinning layer was successful at preventing grain growth.
- Tensile results showed the modified deposition process can produced Engineered Re material with the desired yield strength, i.e., 40ksi.
- Deposition of the Engineered Re material on three mandrels demonstrated multi-component manufacturing capability.
- Preliminary work on compositional effects demonstrated the ability to produce an Engineered Re deposit using two component electrolytes.

Phase II Justification:
The Phase I results have demonstrated the ability of the EL-Form™ process to produce Engineered Re structures on an AMBR size chamber. Tensile testing showed the target yield strength of 40ksi can be achieved. In addition, the ability to produce the Engineered Re structure during multi-component processing was demonstrated. Multi-components processing has the potential to significantly reduce the fabrication cost of an AMBR chamber, i.e., 30% cost reduction. During Phase II, the Engineered Re and multi-component fabrication techniques will be optimized. The most promising techniques will be selected and used to produce Engineered Re chambers. At the conclusion of the Phase II effort, an AMBR size engine will be delivered to NASA for hot-fire testing.