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**(Statement A)**

# Development of GOX/Hydrocarbon Multi-element Swirl Coaxial Injector Technology

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## ABSTRACT

In developing the advanced liquid rocket engine, injector design is critical to obtaining the dual goals of long engine life as well as providing high-energy release efficiency in the main combustion chamber. Introducing a swirl component in the injector flow can enhance the propellant mixing and thus improve engine performance. Therefore, swirl coaxial injectors, which swirl liquid fuel around a gaseous oxygen core, show promise for the next generation of high performance staged combustion rocket engines utilizing hydrocarbon fuels. Understanding the mixing and combustion characteristics of the swirl coaxial flow provides the insight of optimizing the injector design. A joint effort of Sierra Engineering (Sierra) and the Propulsion Directorate of the Air Force Research Lab (AFRL) was conducted to develop a design methodology, utilizing both high-pressure cold-flow testing and uni-element hot-fire testing, to create a high performing, long life swirl coaxial injector for multi-element combustor use. Several swirl coax injector configurations designed and fabricated by Sierra have been tested at AFRL. The cold-flow tests and numerical simulations have been conducted. The cold flow result provided valuable information of flow characteristics of swirl coaxial injectors. However, there are two important flow features of liquid rocket engines missed from the cold flow test: 1) the effect of combustion on the propellant mixing, and 2) the interaction of multiple injectors. The present work studies the hot flow environment specifically the multiple element swirl coaxial injector. Numerical simulations were performed with a pressure-based computational fluid dynamics (CFD) code, FDNS. CFD results produced loading environments for an ANSYS finite element thermal/structural model. Since the fuels are injected at temperature below its critical temperature, the effect of phase change and chemical reactions needs to be accounted for in the CFD model. A homogeneous spray approach with a real-fluid property model was employed in the FDNS code to simulate the spray combustion phenomena over a wide range of operating conditions. Numerical results will be reported in the full-length paper. Future work, which will not be presented in this paper, will compare these numerical results to planned hot fire test results.