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Direct Cooled Reactor with Supercritical Brayton Power Conversion

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Program: Reactor Concepts

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ABSTRACT:

This project will design a direct cooled reactor that is integrated with a supercritical Brayton power conversion system. The system will benefit both NASA and national security users. The proposed technology will leverage existing work on both the reactor and power conversion system, but will move the technical readiness of the technology forward through design and optimization as well as complementary work on materials compatibility and bearing technology.

The power system is a critical component in a spacecraft or a space mission. Long duration and/or high power level missions require the use of fission reactors with high efficiency and reliable power systems that are enabled by advanced conversion systems and higher operating temperatures. The Brayton cycle has exceptional potential for use in space power systems. The substantial benefits associated with the supercritical carbon dioxide Brayton cycle have been well-documented resulting in substantial effort on terrestrial applications. In addition to high efficiency, the very high density of the working fluid enables the power conversion system to be extremely compact even at high power levels which is obviously extremely important for space power systems. The Brayton cycle provides continuous flow that leads to flexibility relative to cycle configuration and integration with both the reactor and the heat rejection systems.

This proposal brings together a project team that is uniquely capable of designing a direct cooled reactor with a supercritical power cycle for space power applications. The team covers the technology requirements from the reactor neutronics to the power conversion system to the heat rejection system and the proposed project builds on a substantial body of work that is directly relevant to this effort. One focus of this effort will be on the design of a 40 kW_e system including the heat rejection system, recuperative heat exchangers, turbomachinery, and reactor. This work will explore a range of heat rejection temperatures and fluids in order to understand the trade-off between cycle performance and heat rejection system performance given the unique environment associated with a space power system. In parallel, the project will address some key technical challenges that are associated with this system. The compatibility of the specific materials required by the turbomachinery and other system components with supercritical carbon dioxide will be studied. The most appropriate bearing system for a space power system will include flexure mounted tilt-pad journal bearings and spiral groove thrust bearings in order to achieve low leakage through the seals with the high stiffness and stability required for high rotational speed. The operation of these bearing components under the high Reynolds number, high power dissipation, non-ideal conditions associated with supercritical carbon dioxide cycle will be studied theoretically and demonstrated experimentally.