Phase II Project Summary

PSI-6211

Firm: Physical Sciences Inc.
Contract Number: NNX10RA22C
Project Title: Long Duration Space Shelter Shielding

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)
Physical Sciences Inc. (PSI) demonstrated fiber reinforced boron carbide composite shielding materials for long duration manned space vehicles and habitats that will provide at least 20% more effective for shielding galactic cosmic radiation (GCR) and solar particle emission (SPE) than aluminum. Fiber reinforced boron carbide matrix composites are a new ceramic composite system pioneered by PSI during the Phase I program that have applications in nuclear waste management in addition to space systems. B_4C composites will enable lunar habitats that keep the equivalent dose received by an astronaut below the 150 mSv limit set in NASA STD 3000 Vol. 1 for a 90 day lunar mission. During Phase II we developed materials and construction techniques using PSI's ceramic composite manufacturing facility to demonstrate that the boron carbide composite system can be produced with consistent mechanical, electrical and thermal properties suitable for structural and shielding applications for long duration manned space systems.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)
The PSI team will demonstrate manufacturing processes for carbon fiber reinforced boron carbide composites that will produce material with a variation in mechanical properties by less than 10% and predictable thermal and electrical properties. PSI will demonstrate that the carbon fiber reinforced boron carbide composites will retain their mechanical properties after exposure to doses of up to 5 Gy/cm^2 of simulated SPE. In addition, we will design and fabricate a prototype wall segment of a long duration manned space habitat that could be used to limit astronaut exposure to less than 150 mSv. The prototype wall segment will employ carbon fiber reinforced boron carbide composite materials and joining procedures that can be used to construct a lunar habitat.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)
Carbon fiber reinforced boron carbide composite materials were successfully fabricated and shown to have strengths exceeding 280 MPa. Both ceramic and polymer composite systems retain strength after exposure to proton radiation doses greater than would be anticipated on the lunar surface for five years. Joining methods using threaded fasteners were developed to enable the assembly of large composite structures. The OLTARIS system was used to model the shielding effectiveness of boron carbide composite materials and a preliminary design for a multifunctional lunar shelter wall was developed. Using the design parameters a prototype section of the lunar shelter wall was constructed.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)
Ceramic composites developed under this program will be used in long duration space habitats for lunar and Martian exploration as well as crew transport vehicles to these mission sites. Ceramic composites are ideal for this application because they can be used as structural elements in vehicles/habitats while enabling other functions such as thermal management. Advantages of ceramic composites include lighter weight and higher shielding efficiency against GCR, SPE and albedo neutrons compared to aluminum.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)
Commercial applications for ceramic composites include detector shielding enclosures for high energy physics and space experiments, radiation source containers, light weight nuclear waste transport containers and shielding enclosures for working near nuclear reactors. All of these applications will benefit from the high strength, low weight and neutron shielding capabilities of these materials.

Name and Address of Principal Investigator: (Name, Organization, Street, City, State, Zip)
Dr. John Steinbeck, Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810

Name and Address of Offeror: (Firm, Street, City, State, Zip)
Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810