STRUCTURAL AND THERMAL COMPOSITES FOR PLANETARY ROVERS

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ABSTRACT

Structural and thermal composite materials solve a fundamental space robotics problem. Lightweight, stiff structures have a cascading effect reducing actuator loads, power loads and increasing payload ratio. This effect is compounded further when multi-axis manipulators or mobility are considered. Integrating tailored composites early in the development of robotic platforms achieves game-changing mass reductions. Composites play a key role in thermal systems of lunar rovers, which are exposed to temperature extremes ranging between -180°C and 120°C. Thermally conductive composites are used for lightweight thermal management of sensitive components. This paper describes the design and development of structural and thermal composites for planetary rovers.

1. INTRODUCTION

Spacecraft structures routinely push materials and structural technologies to their limits due to ultra-light mass budgets and demanding structural and thermal environments. Historically, cutting edge materials and structures proved to be mission enablers. This paper describes the composite design and prototyping of a lunar rover under development at Carnegie Mellon University's Field Robotics Center and Advanced Composites Lab. The rover is the centerpiece of Astrobotic Technology's maiden mission to the moon to win the Google Lunar X Prize and to usher in an era of near-term regular lunar access. The 70 kg rover will land on the moon carrying 20 kg of third-party payload on board. The rover has been developed over the course of a two year design and prototype phase. The intent of this paper is to inform the composites community about development toward composite components for planetary rovers.

1.1 Historic Planetary Rover Structures

Any treatment of planetary rovers must start with the Soviet Union's Lunokhods in the early 1970s. These rovers were technological marvels of their time. Lunokhod operated from lunar dawn to sunset with a three day hiatus at noon to avoid overheating. It hibernated though numerous lunar nights, while relying on a decaying radioisotope to keep warm. White paint was used on external surfaces to reflect and reduce absorption of heat. Electronics were housed in a sealed pressure vessel with circulating gas to eliminate hot spots. Lunokhod was made from a cutting edge aluminum magnesium alloy developed for the Soviet space program [1].

In 1997, Sojourner landed on Mars becoming the first composite structure flown on a planetary rover. Sojourner's chassis was designed to maximize heat retention in the Martian environment