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SOLAR POWER SOLUTIONS FOR SMALL SATELLITES: MARKET ANALYSIS, TRENDS, AND TRADEOFFS

Abstract

This paper presents a comprehensive analysis of solar power solutions for small satellites, focusing on market trends, mission profiles, and a survey of current technologies. The increasing demand for small satellites, including CubeSats and microsatellites, has underscored the need for efficient and reliable power generation systems to meet mission objectives. To address this need, a survey of existing solutions has been done, examining historical missions and identifying power trends to inform future design considerations.

Within small satellite missions, there is a notable trend towards leveraging cutting-edge power systems to enable advanced capabilities. Solar energy acquisition systems have witnessed significant advancements, enabling kilowatt-level power generation through improved photovoltaic and concentrated solar power technologies. Concurrently, enhancements in energy storage systems, including increased battery capacities and optimized small-cell arrangements, have facilitated the storage of high levels of power within small satellite configurations.

The analysis encompasses a survey of existing solutions, including body-mounted and deployable solar panels, origami and roll-out solar arrays technologies. It also makes an assessment of established and emerging types of solar cells. Each solution is evaluated based on its advantages and disadvantages, considering factors such as power generation efficiency, power density, mass and volume constraints, deployment complexity, and scalability.

Body-mounted solar panels provide a simple and compact solution but impose constraints on the satellite design and are limited by the available free satellite walls. Deployable panels offer increased surface area and power generation potential, yet they introduce complexity and are not a fully scalable solution. Origami solutions present innovative approaches to maximizing power generation within limited space constraints, leveraging folding mechanisms to achieve compact stowage and efficient deployment. Roll-out solar arrays offer scalability and flexibility while maintaining a high power density, allowing for tailored power generation capabilities to meet mission-specific requirements.

Gallium-Arsenide solar cells represent traditional yet widely used technologies, offering proven reliability and performance with relatively mild degradation levels (especially for multi-junction cells). However, GaAs cells are expensive and have very long lead times. Silicon cells, in particular self-curing cells, have a lower efficiency but are much more cost-effective than their GaAs equivalents.

Through a preliminary tradeoff analysis, we compare these solar power solutions based on key metrics such as mass efficiency, power generation capability, reliability, and ease of integration. This analysis aims to provide insights into the tradeoffs inherent in selecting the most suitable solar power solution for a given small satellite mission.