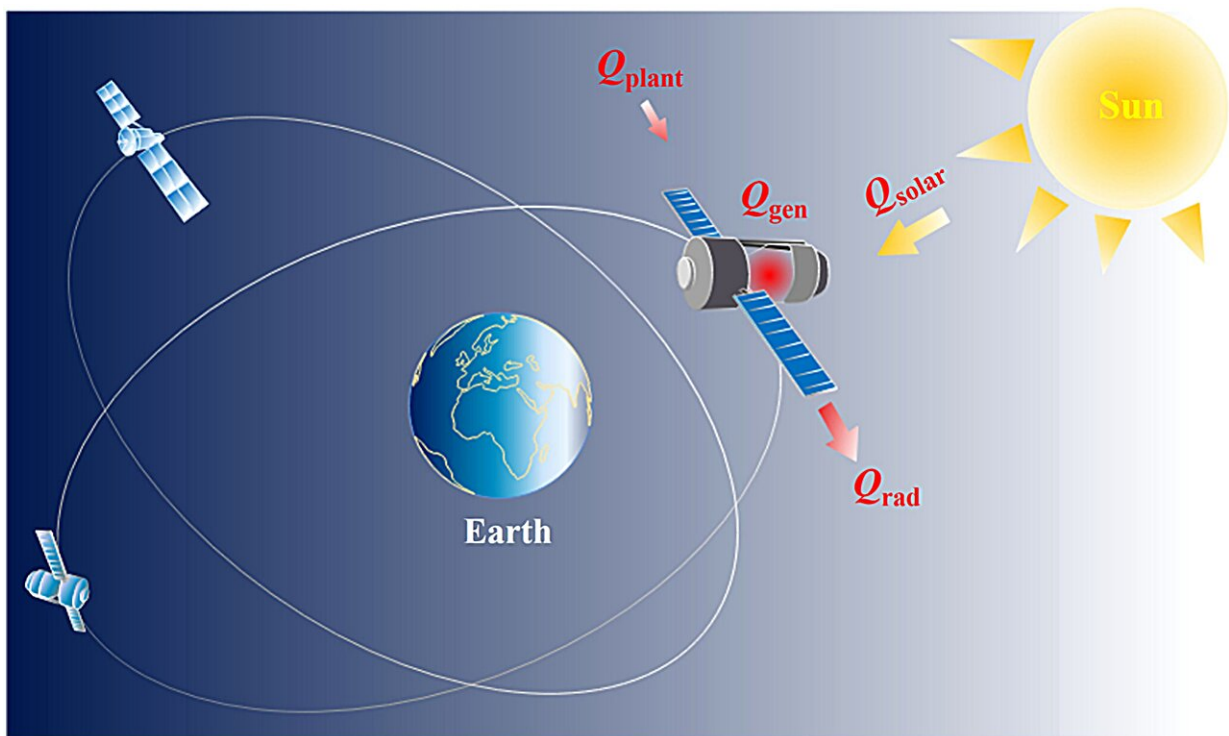


Space race heats up: Advanced electronics cooling systems for spacecraft

June 4 2024



Schematic of the thermal environment for electronics in spacecraft. Credit: *Energy Storage and Saving* (2024). DOI: 10.1016/j.enss.2024.03.001

Spacecraft electronics operate under extreme conditions, facing issues like microgravity, thermal cycling, and space radiation. These factors necessitate robust thermal management solutions to maintain the functionality and longevity of onboard equipment.

Traditional thermal control methods often fall short in addressing these challenges. Based on these challenges, there is a need to conduct in-depth research on advanced thermal management technologies to ensure the stability and efficiency of space missions.

A [comprehensive review](#) by researchers from Xi'an Jiaotong University and the Xi'an Institute of Space Radio Technology, published in *Energy Storage and Saving* on March 28, 2024, delves into advanced thermal management technologies for spacecraft electronics. The study categorizes these technologies based on heat transfer processes, including heat acquisition, transport, and rejection.

The review evaluates thermal management technologies (TMTs) for spacecraft electronics, focusing on heat acquisition, transport, and rejection. It explores high thermal conductance materials such as carbon-based composites and annealed pyrolytic graphite (APG) and discusses novel packaging structures using micro-/nano-electromechanical system (MEMS/NEMS) technologies.

Heat transport solutions, including various heat pipes and mechanically pumped fluid loops (MPFLs), are examined, with heat pipes categorized into unseparated and separated types. Advanced microfluidic cooling techniques for efficient heat removal are also highlighted.

For heat rejection, the review focuses on deployable radiators, variable emissivity radiators, and phase change materials (PCMs), addressing the fluctuating thermal environment in space to ensure effective heat dissipation.

Dr. Wen-Xiao Chu, the corresponding author of the study, states, "Our review highlights the critical advancements in thermal management technologies that are essential for the success of future space missions. By addressing the unique thermal challenges in the spacecraft

environment, these technologies ensure the reliability and performance of onboard electronics, paving the way for more ambitious space exploration and satellite missions."

Advancements in thermal management technologies have significant implications for the space industry. By ensuring efficient heat control, these technologies enhance the reliability and lifespan of [spacecraft electronics](#), crucial for long missions.

Lightweight and high-performance TMTs improve overall efficiency and cost-effectiveness. As demand for high-power and miniaturized space systems grows, implementing these advanced thermal solutions is vital for the future of space exploration and satellite technology.

More information: Yi-Gao Lv et al, Review on Thermal Management Technologies for Electronics in Spacecraft Environment, *Energy Storage and Saving* (2024). [DOI: 10.1016/j.enss.2024.03.001](https://doi.org/10.1016/j.enss.2024.03.001)

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