IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies to Enable Space Systems (3)

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LOW TEMPERATURE TECHNOLOGIES AND ARCHITECTURE FOR EXTREME ENVIRONMENTS

Abstract

Many types of science missions are aiming at targets in the solar system that have harsh thermal environments, such as Mars, the Moon, asteroids, comets, and other bodies at the fringes of the solar system. Traditional spacecraft avionics rely on the storage of electrical energy in electrochemical systems (typically secondary batteries) for covering peak energy demands and periods where no electrical energy is generated (Lunar/Martian/cometary night, etc.).

At present, most military specifications of electronic equipment call for operability down to -55C. Equipment capable of operating at lower temperatures and in ad-hoc architectures conceived for low temperature environments can reduce the electrical power consumption needed to maintain operational temperatures. This approach has the potential to extend mission operations, among other possible advantages. The European Space Agency has commissioned the present study which has identified the constraints of the target environments and, based on these, a variety of components and technologies which have been demonstrated to be operable over a substantial portion of a relevant target temperature range. This has resulted in the production of an inventory of technologies that for the first time provides a comprehensive overview of existing technologies for harsh thermal (mainly low temperature) environments that are available in Europe.

In order to assess the impact of these technologies (which have a variety of TRLs) and architectures on future missions, the team has used the architecture of the Lunar Volatiles Mobile Instrumentation (LUVMI) rover as a benchmark. LUVMI is an on-going EU-funded project, consisting of a low-mass,

low-footprint rover designed to prospect resources in the Permanently Shadowed Regions of the Moon. LUVMI plans to use a baseline architecture involving batteries and heaters.

For the purpose of this ESA study, the baseline architecture of LUVMI is replaced with a low-temperature architecture using some of the key components and subsystems identified in the inventory. The system concept is outlined, simulated, and evaluated in terms of mass, cost, system size, complexity, mission lifetime, operational flexibility, development time and AIT aspects. The expected performance operating inside a Permanently Shadowed Region is assessed, as well as the expected accomplishment of scientific objectives within the rovers' estimated lifetime and available resources.