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Tool for optimizing the scientific operations and performance of the Mars lander

Harri Haukka
Finnish Meteorological Institute, Space Research and Observation Technologies, Helsinki, Finland (harri.haukka@fmi.fi)

For space projects, the availability of energy is a critical factor. The farther we go from the Sun the power of solar irradiance is weaker, at Mars it is 43 percent compared to the Earth. A special feature of Mars is the opacity of the atmosphere, as well as possible dust storms and sand floating in the atmosphere, which affect the solar irradiance received by the lander on the surface.

The most common methods for generating electrical energy in Mars are solar panels and a radioisotope thermoelectric generator (RTG). RGT produces energy all the time, regardless of the prevailing solar irradiance. For smaller landers, a combination of solar panels and batteries is usually sufficient. The possibility of using RTG as part of the energy production system has been considered in this work.

Payload and service electronics set the starting point for the design of the energy and power generation system. In addition to the electrical requirements, the mass and space limitations brought by the lander have to be taken account. The introduced tool was designed in the frame of the MetNet Mission and ESA MiniPINS study and both landers are relatively small and limitations are e.g. with the mass and volume of the batteries and available solar panels as well as the RTG. The optimization tool developed in this work provides virtually limitless possibilities to modify the energy system parameters, but due to the limitations imposed by the landers, in this study we do not simulate unrealistic alternatives for the selected landers.

The introduced optimization tool was developed in two steps. First with MS Excel, which was used to define realistic starting points, e.g. the number of solar panels and batteries and testing the static operating modes at different solar irradiance densities and subsystem efficiencies. Second, we use a Python tool that includes all the features of the Excel tool and we can simulate the operations with variable solar irradiances at any time of the day and season with one minute resolution. The required solar irradiance data is acquired and extrated from the Mars Climate Database covering almost the whole Mars surface. The developed tool is designed to simulate operations more than one Martian year, so with the tool, user can cover and simulate all seasons in any location on the Mars.

Devices on the surface of Mars operate fully autonomously. In this case, the availability of energy and optimized use of it are key factors. The lander service electronics must be able to operate even in non-optimal situations and, if necessary, interrupt scientific operations. These operations

are controlled by the so-called cyclograms, i.e. pre-programmed operation plans, implemented by the lander computer when required. In this work, we simulate cyclograms for different operating conditions using the developed optimization tool.