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The Mars Hopper: an impulse driven, long-range, long-lived mobile platform utilising in-situ martian resources

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The ESA and NASA Mars exploration programmes are based on a joint exploration philosophy leading to a network mission and Mars sample return. The requirements and performance of planetary probes will need to meet the challenges imposed by these missions. In addition there is a goal to provide a greater scientific return on the financial investment in new ambitious enabling technologies and each launch. As a result of increasing cost, the desire to acquire geochemical and geophysical data over large areas and samples from multiple regions, missions that can provide mobile, long range and extended lifetime platforms are becoming more attractive. If an instrumented platform could be placed on the surface of a planet that could repeatedly acquire highly detailed data from the surface and subsurface, travel large distances to multiple sites, extract and store multiple samples and deploy instrumentation, an entire planet could be studied with a higher resolution than orbiting platforms. We propose to design and develop an instrumented platform that can acquire data at hundreds of locations during its lifetime - a Mars Hopper. The platform will be able to "hop" with a degree of flexibility from one location to the next. One design scenario included a $\sim$450 kg vehicle with a 20 kg science payload that can perform a hop every $\sim$7 days with a separation of 1-2 km per hop. With a lifetime goal of 10 years, large sections of Mars can be mapped in detail by a few dozen platforms. Regions inaccessible with wheeled or static landers could be explored with such a vehicle.

The basic concept is to utilise the decay heat from radioactive isotopes to raise a block of material to high temperatures while simultaneously diverting some of the thermal power to run a compressor. The compressed martian atmosphere liquefies at 1.93 MPa. The liquefied carbon dioxide is then transferred to a tank. Once full, the power converter is turned off and the core is allowed to increase in temperature. After the peak temperature is reached, the liquid carbon dioxide is injected into the core, heated, expanded through a nozzle and allowed to produce thrust. Part of the carbon dioxide propellant is consumed during the ascent phase, with the remaining propellant available for a soft landing.

Such a platform would allow a broad range of lithologies (sedimentary, igneous, hydrothermal, etc.) to be sampled. This is beyond the limits of robotic systems and technologies that have been successfully deployed on planetary surfaces. More ambitious technologies must be developed and methods created to increase the science return for each launch, thus increasing the scientific value for the money spent for each mission.