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Mars Exploration – Part 2 (3B)

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# BIOLOGICALLY INSPIRED NANOROVERS - SAMPLE RETURN USING LIGHTWEIGHT HYBRID ACTUATION

**Abstract**

This paper describes further progress in the design of an innovative, biologically inspired nanorover suitable for Mars surface exploration and sample return missions. An advanced cliff climbing legged vehicle is presented, incorporating an innovative hybrid actuation system to minimise mass and conserve power.

For maximum agility the legs have been improved with a third degree of freedom - this allows the rover to display an extensive array of gait and pose options. The vehicle incorporates a Shape Memory Alloy (SMA) actuated sample collection tool and can operate autonomously in a self contained sample collection and return capacity. All this is achieved within a mass budget of under 1 kg.

Minimising mass is clearly of critical importance. The rover presented is so small and light that it offers the opportunity for a swarm of rovers to form part of the overall Mars mission. These vehicles would take advantage of their superior agility and ability to traverse difficult landscapes, and work with a larger mother rover based on conventional technology, in a complementary manner – the mother vehicle carries larger scale science and navigation equipments, as well as on board power resources, whereas the smaller vehicle can be despatched to climb through rocky and steep terrain to retrieve samples from the most interesting locations, returning to the mother rover for power and to deposit the sample.

Previous work demonstrated that a very low mass vehicle could be designed using composite materials. Innovations in this new design include hybrid lightweight DC motor / SMA technology for high power / mass ratio whilst minimising power use, integration of a sample gathering tool into the vehicle, and proportional control of SMA actuators, achieved using resistance based feedback. This improves the vehicle's manoeuvrability whilst minimising power consumption. Agility is further improved using 3 DOF legs with increased angular displacement, enabling a wide variety of gait and posture options to be realised. This facilitates attitude control over steep and uneven landscapes and implements biologically- inspired locomotion techniques such as crawling and sideways walking. System control implements high speed / low power consumption COTS embedded systems technology running a standard Linux distribution, and power efficiency and management are improved, enabling the vehicle to carry ample power reserves for meaningful excursion durations. It is envisaged that the nanorover concept presented in this paper will help to advance the state-of-the art of the 'rover mothership' concept.