



Design for the Structure and the Mechanics of Moballs

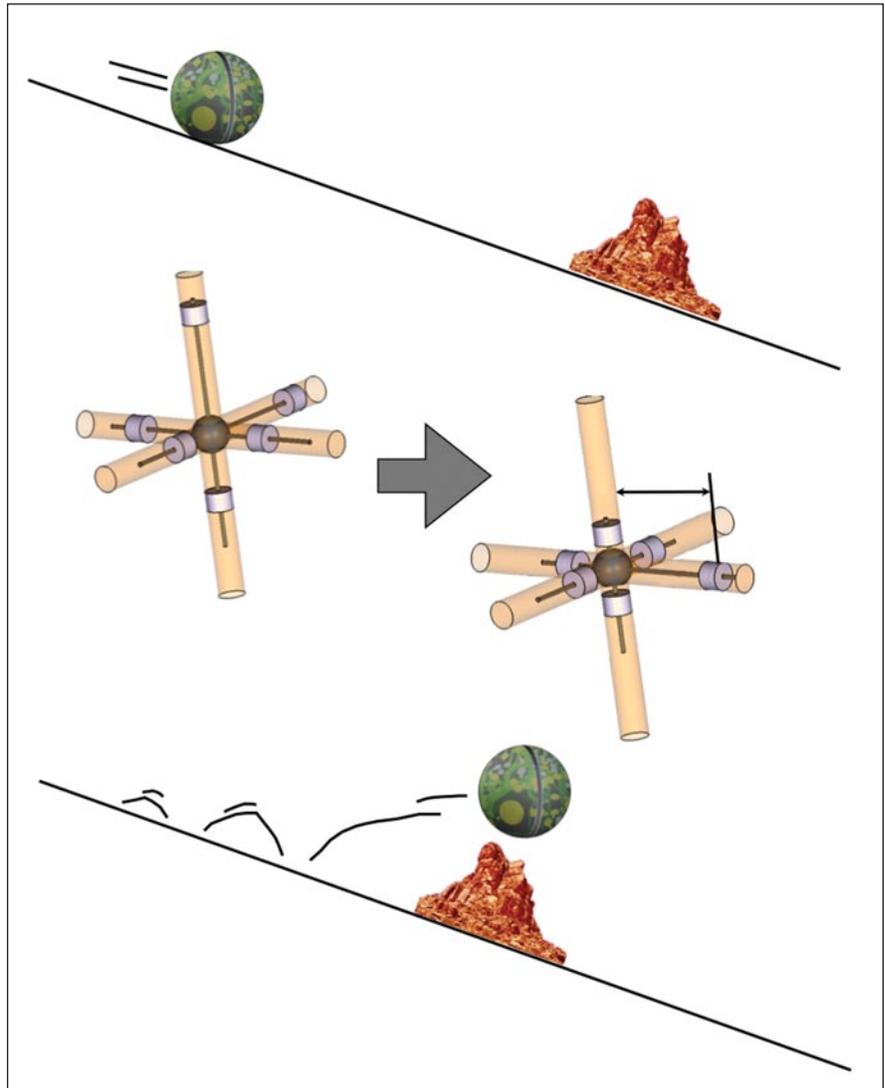
Moballs could be used to explore Mars and other windy bodies of the solar system such as Titan.

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The moball is envisioned to be a round, self-powered, and wind-driven multifunctioning sensor used in the Gone with the Wind ON-Mars (GOWON)

[<http://www.lpi.usra.edu/meetings/marsconcepts2012/pdf/4238.pdf>]: A Wind-Driven Networked System of Mobile sensors on Mars. The moballs would have sensing, processing, and communication capabilities. The moballs would perform in situ detection of key environmental elements such as vaporized water, trace gases, wind, dust, clouds, light and UV exposure, temperature, as well as minerals of interest, possible bio-signatures, surface magnetic and electric fields, etc. The embedded various low-power micro instruments could include a Multispectral Microscopic Imager (to detect various minerals), a compact curved focal plane array camera (UV/Vis/NIR) with a large field of view, a compact UV/Visible spectrometer, a micro-weather station, etc. The moballs could communicate with each other and an orbiter. Their wind- or gravity-driven rolling movement could be used to harvest and store electric energy. They could also generate and store energy using the sunlight, when available, and the diurnal temperature variations on Mars. The moballs would be self-aware of their (and their neighbors') positions, energy storage, and memory availability; they would have processing power and could intelligently cooperate with neighboring moballs by distributing tasks, sharing data, and fusing information. The major advantages of using the wind-driven and spherical moball network over rovers or other fixed sensor webs to explore Mars would be: (1) moballs could explore a much larger expanse of Mars in a much faster fashion, (2) they could explore the difficult terrains such as steep slopes and sand dunes, and (3) they would be self-energy-generating and could work together and move around autonomously.

The challenge in designing the structure and the mechanics of the moball would be that it should be sturdy



Moballs are able to recognize sharp objects as well as their speed and direction. Based on algorithms already provided in the controller, they can decide when and how to change weights in order to avoid obstacles or jump over them.

enough to withstand the impact of its initial fall, as well as other impacts from obstacles in its way. A mechanism would be needed that could enable hundreds of moballs to be carried while they would be deflated and compact, then would inflate them just after deploying them to their drop site. Furthermore, the moballs should also be light enough to allow them to move easily over obsta-

cles by force of the wind. They also should have some kind of maneuvering mechanism in place to help them avoid very hazardous sharp objects or events, and to enable them to get closer to the objects of interest.

The structure of the moballs was designed so that they would have different layers. The outer layer should comprise a sturdy, yet light, polymer that could

withstand both the impact of the initial drop, as well as the impact of the different obstacles it would encounter while traversing the surface of Mars. This polymer should not deteriorate with the 100 K daily temperature swings on Mars. The inner layer should consist of a very light gas such as nitrogen or helium. In terms of maneuvering, six very light weights placed at strategic locations would give moballs the ability to turn, or even hop, over hazardous (e.g., sharp) obstacles, or even initiate a movement (before getting more help from the wind to be carried around) when stuck. Maneuvering would be necessary in order to get closer to objects of interest. If the weights would be allowed to move freely, they could also be used to generate energy.

To deploy the moballs, NASA Standard Initiators (NSIs) would carry a light gas in the middle, and a few NSIs in the outer layer would carry the liquid form of a selected polymer. As soon as the moballs would get released by the deployer, the inner capsule would be exploded and the gas would fill out the inner layer of the moball, making it round. The NSI capsules containing the special polymer would then be broken, releasing the polymer that fills out the outer layer. In this manner, hundreds or

even thousands of deflated moballs could be compacted inside the deployer and inflated just after the deployment and before their initial drop.

For the inner sphere of the moball, three principal (*XYZ*) axes with movable weights inside them would be constructed. The movable weights could be used to balance the motion of the moball. In this manner, the trajectory of the sphere could be corrected with a motorized controller that sits in the center of the sphere and that would control the distance of each weight from the center. This system of weights could be used to deflect the trajectory of the moball. If the weights would be magnet, they could generate power while tumbling around too.

The design described here (in terms of the inner and outer layer, and the three principal axes with controllable weights) would be novel. No pump would be required to deflate or inflate the moballs, saving power, and also reducing the risk of failure. However, it is emphasized that the novelty in this design would make the “hopping” movement of the moball much easier than earlier methods. Previous techniques for making a spherically-shaped robot hop over an object on Mars have assumed that the initial condition of the robot

was stationary, i.e., the robot would hop from a position of complete stillness. This would be difficult to do on Mars, since the gravity is around 1/3 of the gravity of Earth, making the reaction force much less than what one would expect. However, since the moballs proposed here would be in a wind-driven (or downward rolling) movement already, they would have an “initial velocity,” which would make hopping all the more easy. This is believed to be the most possible way of hopping over a hazardous object on Mars.

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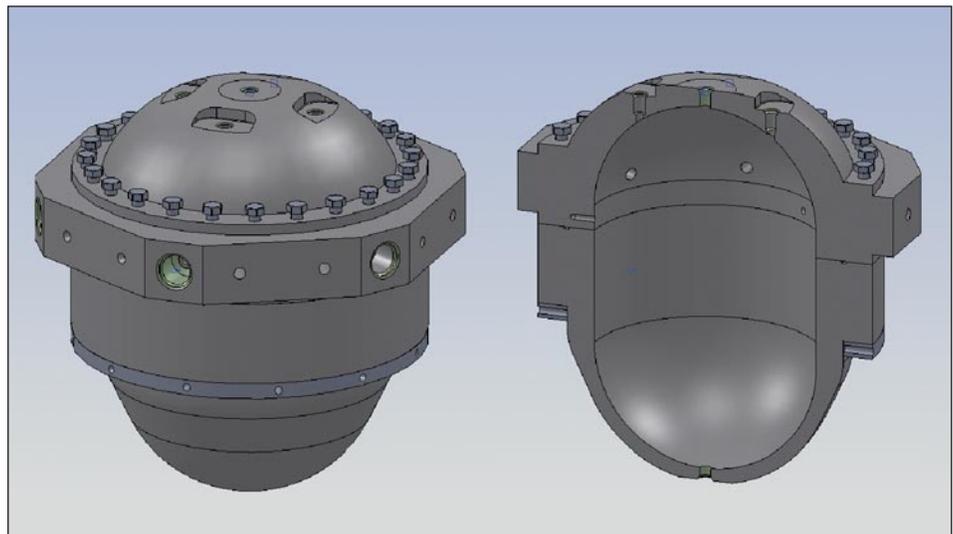
Refer to NPO-48643, volume and number of this NASA Tech Briefs issue, and the page number.

❁ Pressure Dome for High-Pressure Electrolyzer

External gas pressure permits higher pressure and more versatile electrolyzer.

John H. Glenn Research Center, Cleveland, Ohio

A high-strength, low-weight pressure vessel dome was designed specifically to house a high-pressure [2,000 psi (≈ 13.8 MPa)] electrolyzer. In operation, the dome is filled with an inert gas pressurized to roughly 100 psi (≈ 690 kPa) above the high, balanced pressure product oxygen and hydrogen gas streams. The inert gas acts to reduce the clamping load on electrolyzer stack tie bolts since the dome pressure acting axially inward helps offset the outward axial forces from the stack gas pressure. Likewise, radial and circumferential stresses on electrolyzer frames are minimized. Because the dome is operated at a higher pressure than the electrolyzer product gas, any external electrolyzer leak prevents oxygen or hydrogen from



The **Pressure Dome** consists of two machined segments. An O-ring is placed in a groove in the flange of the bottom segment and is trapped by the flange on the top dome segment when these components are bolted together with high-strength bolts.