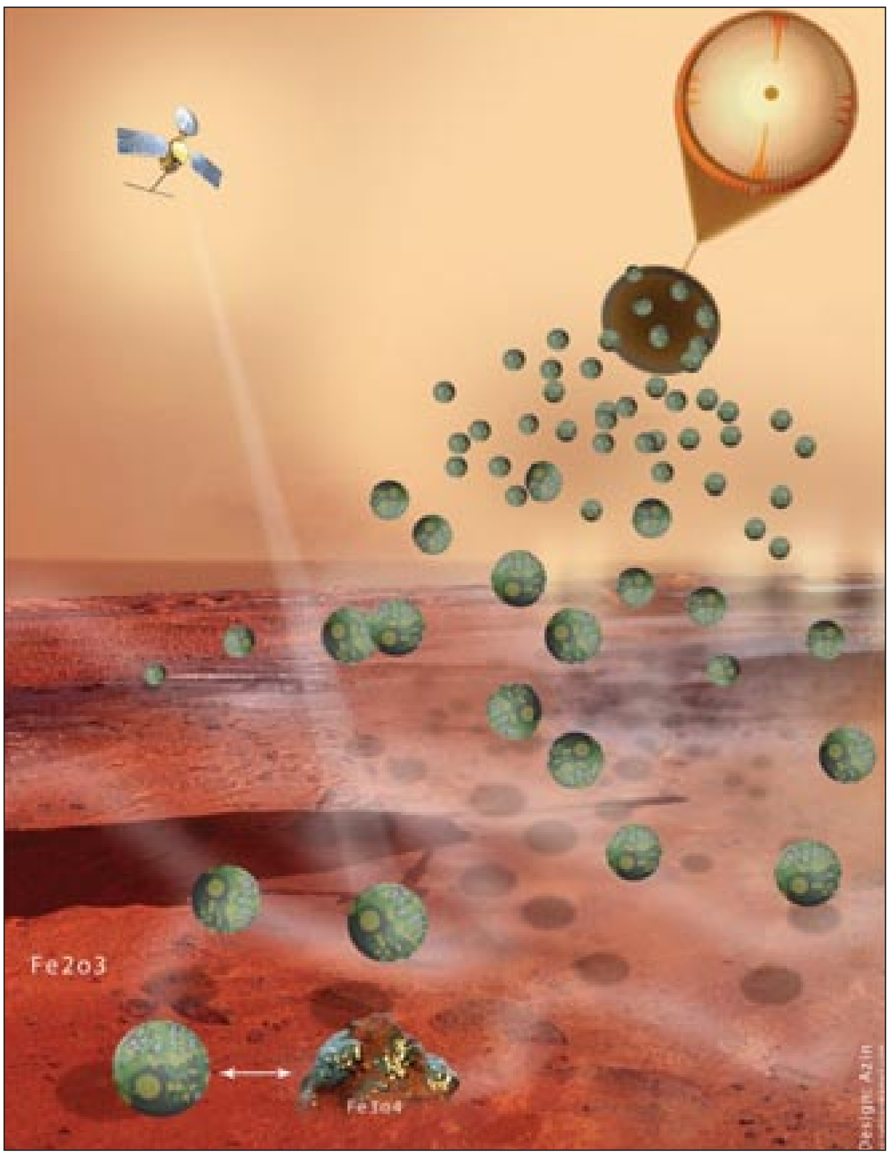
Physical Sciences

Wind-Driven Wireless Networked System of Mobile Sensors for Mars Exploration

GOne with the Wind ON-Mars (GOWON-Mars): A mobile sensor network that could be used on any windy solar system body, such as Mars or Titan.

NASA's Jet Propulsion Laboratory, Pasadena, California

A revolutionary way is proposed of studying the surface of Mars using a wind-driven network of mobile sensors: GOWON. GOWON would be a scalable, self-powered and autonomous distributed system that could allow *in situ* mapping of a wide range of environmental phenomena in a much larger portion of the surface of Mars compared to earlier missions. It could improve the possibility of finding rare phenomena such as "blueberries" or bio-signatures and mapping their occurrence, through random wind-driven search. It would explore difficult terrains that were beyond the reach of previous missions, such as regions with very steep slopes and cluttered surfaces. GOWON has a potentially long life span, as individual elements can be added to the array periodically. It could potentially provide a cost-effective solution for mapping wide areas of Martian terrain, enabling leaving a long-lasting sensing and searching infrastructure on the surface of Mars.



A depiction of **Moballs** being released on Mars.

Thanks to earlier exploration missions, there is a much better understanding of the natural characteristics of Mars; in particular, average wind speeds of 15 to 20 m/s and much higher maximum speeds have been characterized. There are communication satellite systems in place that orbit Mars and that can monitor its surface. Future Mars missions can leverage these characteristics and capabilities, and may do so by exploiting, for example, recent advances in power scavenging techniques, micro-devices using MEMS technologies, miniature instruments, low-power wireless devices, mesh networking technologies, low-power data management strategies, and novel system architectures. The system proposed here addresses this opportunity using such technology advances in a distributed system of wind-driven sensors, referred to as Moballs.

The Moballs could communicate with each other and Earth through a satellite system orbiting Mars. Moballs would also use peer-to-peer communication to create a network of sharing data, computing, and sensing tasks. The Moballs would negotiate with each other locally and share tasks intelligently in order to optimize the entire system's resources (energy, memory, and communication bandwidth).

Moballs would exploit local resources for locomotion and power: they would be wind-driven, and so do not need energy for locomotion. The energy required for sensing, data processing, and communication could be generated from sunlight. In addition, the Moballs could harvest energy from their motion and vibrations, thermoelectricity, and other energy scavenging techniques, when they are in shadow. Together this allows each Moball to have a low mass, enabling a large number of Moballs to be deployed by a single mission.

The effectiveness of sensor networks, as opposed to a single sophisticated sensor, is now well understood in a terrestrial setting. Mobile sensor networks are also gaining traction. There exist several proposals, for example, to exploit the accelerometers that exist in handheld cellphones to characterize earthquakes. Here it is the mobility of the cellphone users, the fact that they move about randomly and unpredictably, and that they are in constant contact with base stations that allow this. One can think of GOWON as such a mobile sensor network, making a wide range of measurements distributed across the Martian terrain, and leveraging natural resources and facilities currently in place on Mars, such as existing satellite systems.

GOWON would be a system complementary to current Mars missions, making measurements over a much larger geographic expanse than current *in situ* experiments, providing ground-truth for orbiting experiments, and helping identify promising locations for future manned and unmanned missions.

This work was done by Faranak Davoodi and Neil Murphy of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

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In Situ Solid Particle Generator

This system enables filter testing, and fluid and gas dynamic research, in closed-system, non-standard, or extreme environments.

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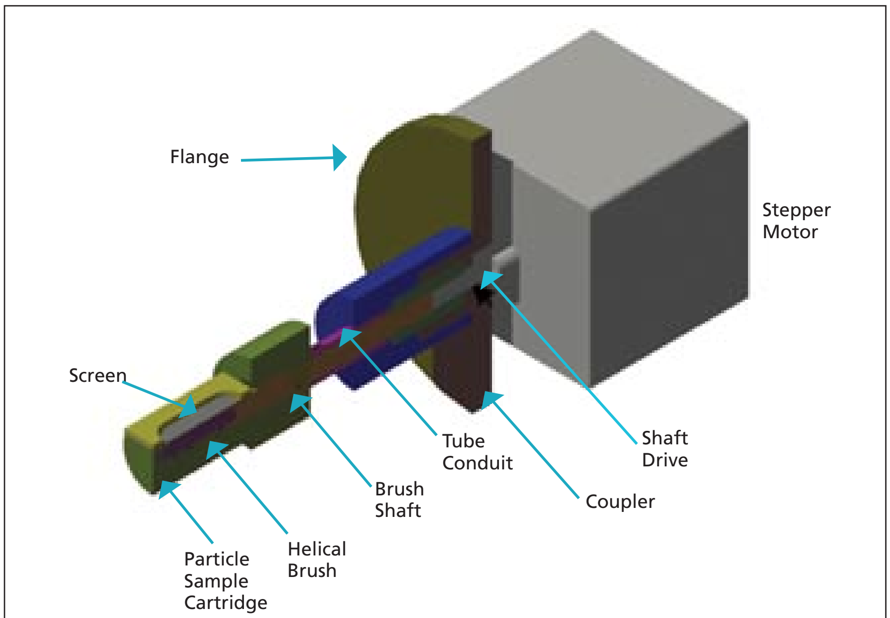
Particle seeding is a key diagnostic component of filter testing and flow imaging techniques. Typical particle generators rely on pressurized air or gas sources to propel the particles into the flow field. Other techniques involve liquid droplet atomizers. These conventional techniques have drawbacks that include challenging access to the flow field, flow and pressure disturbances to the investigated flow, and they are prohibitive in high-temperature, non-standard, extreme, and closed-system flow conditions and environments.

In this concept, the particles are supplied directly within a flow environment. A particle sample cartridge containing the particles is positioned somewhere inside the flow field. The particles are ejected into the flow by mechanical brush/wiper feeding and sieving that takes place within the cartridge chamber. Some aspects of this concept are based on established material handling techniques, but they have not been used previously in the current configuration, in combination with flow seeding concepts, and in the current operational mode. Unlike other particle generation methods, this concept has control over the particle size range ejected, breaks up agglomerates, and is gravity-independent. This makes this device useful for testing in microgravity environments.



The ***In Situ* Solid Particle Generator** supplies particles directly within a flow environment.

Before any particles can be generated in the flow, the cartridge chamber is filled with the solid particles of choice. A programmable mechanical motor providing a range of rotational motion is used to drive a helical brush (or wiper) inside the chamber. Due to the action of the brush, the particles are dragged across the length of the internal chamber, particularly along the surface of the fine mesh screen, causing the particles to pass through the screen. The flow around the cylindrical body of the cartridge then entrains the ejected particles into the flow stream. System components consist of: a motor, flange supports for mounting and sealing the internal chamber volume, a drive shaft and tube conduit, a particle sample cartridge, a helical wire brush or wiper, a fine mesh screen, and screws (see figure). An optional aerodynamic leading edge can be used to streamline or stabilize the flow around the cartridge body, and to decrease flow effects as the particles are entrained in the flow. Alternately, a turbulence gener-