ASTRONAUT-DEPLOYABLE GEOPHYSICAL AND ENVIRONMENTAL MONITORING STATIONS.

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Introduction: When the Apollo astronauts landed on the Moon, they deployed a series of science experiments at their landing sites. Combined, these instruments formed the Apollo Lunar Science Experiments Package (ALSEP), which consisted of seismometers, magnetometers, and various instruments to measure the solar wind and charged particles [1]. We expect future astronauts exploring Mars will deploy similar, but more sophisitcated autonomous instrument packages to study and monitor the environment and geophysical properties of the landing site region. Additionally, the longer expected duration of future human missions, relative to Apollo, present the opportunity for astronauts to build up a large *network* of instruments throughout a wide region, enhancing both the scientific return of the instruments and providing advance notice of potentially hazardous events (e.g., martian dust storms) approaching their location. This abstract presents conceptual ideas for future astronaut-deployable Geophysical and Environmental Monitoring Stations (GEMS).

GEMS Concept: Geophysical network science has been rated as high priority for both the Moon and Mars [2]. On Mars, a meteorological network could better study regional scale phenomena such as dust storms and water transport. Seismological networks on both worlds would help study their interiors and localize seismological sources such as quakes or recent impacts. Thus, network science is a driving element in the GEMS concept. Astronauts would be equipped with a substantial number of GEMS units that could be deployed at will during a traverse. Large-scale production of GEMS units would reduce per-unit cost. Over the lifetime of a landed mission (weeks to possibly 1 Mars year), a dense and broad network of GEMS units could be deployed. Such a network would be robust against loss or failure of individual units. Networked monitoring stations have wide applications terrestrially: monitoring severe weather to protect life and property [3], seismic monitoring [4], and conducting targeted scientific studies [5]. A concept GEMS network is shown in Figure 1.

To simplify deployment, which would both foster a more dense network of GEMS units and be safer and simpler for the astronauts, the GEMS units could be carried on the exterior of the astronaut's rover in a "magazine". At set intervals along a traverse, the rover could briefly stop and deploy a GEMS unit with the rover's manipulator arm. After turning on the unit, radioed commands would deploy the solar panels and instruments and perform a communications check. Then the astronauts could proceed upon their traverse and continue to deploy GEMS units without needing to don their suits and perform an extravehicular activity (EVA).

We present a concept drawing of a GEMS unit on Mars in Figure 2. The GEMS unit is box-shaped, with fold down solar panel "wings", a radio antenna, and possibly masts to extend or deploy instrumentation.

Instrumentation: GEMS instrumentation will be tailored to the world that the astronauts will land upon and the scientific goals of the mission. On Mars, meteorological sensors would be included on each GEMS unit. The Rover Environmental Monitoring Station (REMS) instrument [6] onboard the Mars Science Laboratory (Figure 3) represents a useful initial baseline for such a suite of air pressure, wind, and temperature (both ground and air) sensors and they will be largely reflown for both the InSight mission and Mars2020 rover [7]. Sensors to meaure atmospheric optical depth, as will be included on the Mars2020 Mars Environmental Dynamics Analyzer (MEDA) instrument, would also be valuable for scientific and astronaut-safety purposes by tracking the potential approach of a dust storm and understanding the reduced efficiency of solar power systems during periods of increased atmospheric dust. Geophysical instruments, such as seismometers and subsurface heat-flow, would be scientifically valuable as well.

Conclusion: Human exploration will hopefully reach Mars in the next 20-30 years. To perform their scientific studies, a suite of instruments must be designed, built, and tested long before the first mission is launched. Astronaut-deployable GEMS networks would autonomously collect a wealth of data while also enhancing astronaut safety.

References:

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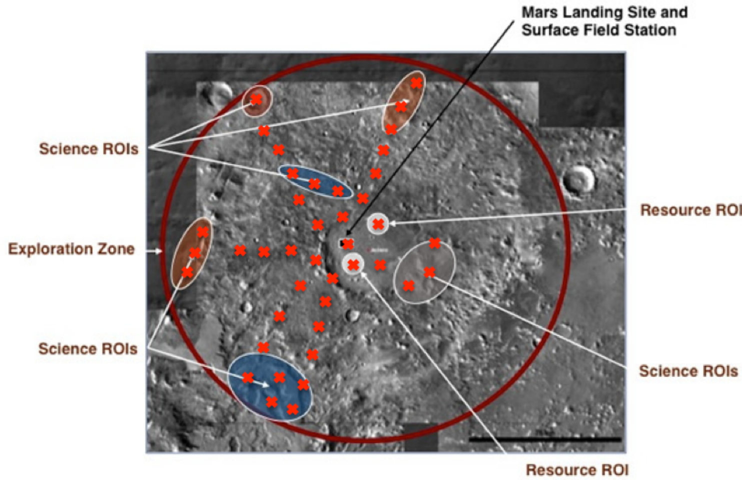
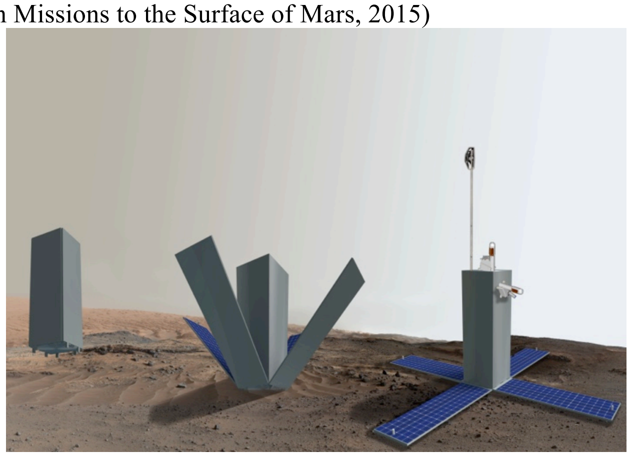
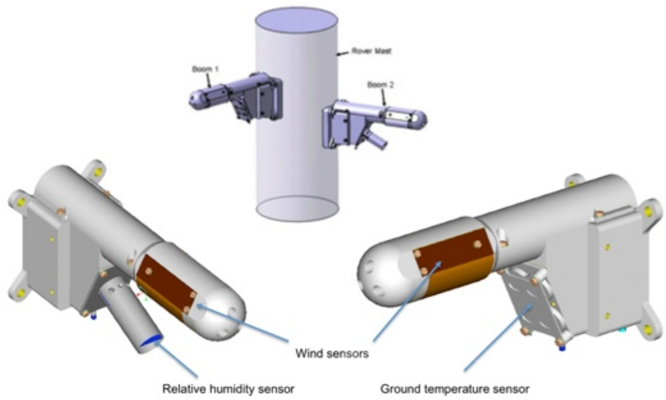


1. GEMS units (red X's) are deployed along astronaut traverse routes to scientific regions of interest (ROIs) and create a wide network in this concept image of a Mars exploration zone (NASA First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, 2015)



2. Concept image of a GEMS unit unfolding and deploying sensors on the martian surface.



3. The REMS sensor booms, containing temperature (air and ground), humidity, and wind sensors, are attached to the mast of the Curiosity rover [6].