Astronaut-deployable Geophysical and Environmental Monitoring Stations

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Future astronauts exploring Mars, the Moon, and asteroids will deploy surface geophysical experiments to gain high-value science, while also enhancing astronaut safety. We present a concept for Astronaut-deployable Geophysical and Environmental Monitoring Stations (GEMS, Figure 1).

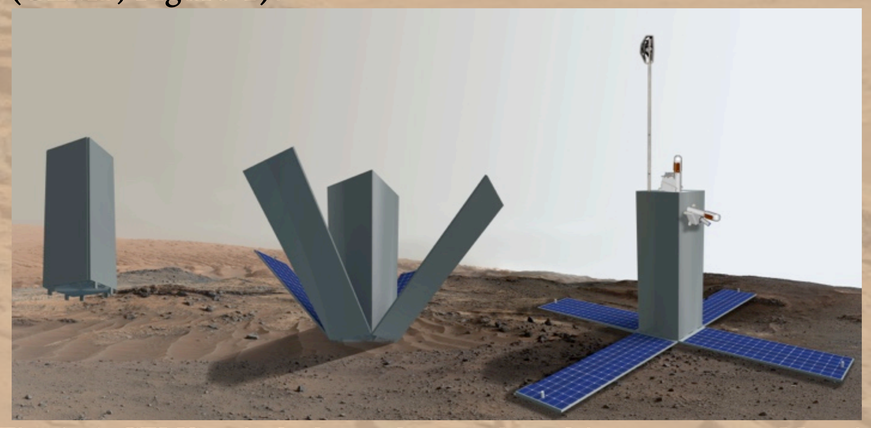


Fig. 1: A GEMS unit deploys solar panels and instruments on Mars in this concept image.

History: Apollo astronauts deployed the Apollo Lunar Science Experiments Package (ALSEP) at several locations on the Moon. The instruments consisted of seismometers, magnetometers, and instruments to measure the solar wind and charged particles. ALSEPs were powered by radioisotope thermoelectric generators.

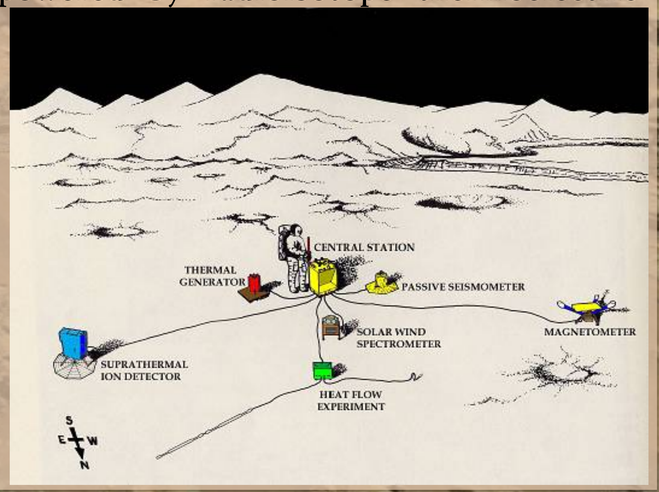


Fig. 2: A cartoon of ALSEP deployment at the Apollo 15 landing site.

https://www.hq.nasa.gov/alsj/hskap15alsepdiag_sm.jpg

GEMS Concept Goals:

1. Produce high-value geophysical science
2. Enhance astronaut safety
3. Simple deployment
4. Low cost through mass production
5. Tailorable instrument suites

Network Science: The Planetary Science Decadal Survey [*Visions and Voyages for Planetary Science in the Decade 2013-2022*, NRC, 2013] has rated geophysical network science as high priority for Mars and the Moon. Over the duration of a surface mission, astronauts (or robotic precursors) could deploy a broad and dense *network* of GEMS units (Figure 3). Such a network would:

- Produce high-value science
- Serve as an "early warning" network for crew safety
- Be robust against loss of individual units
- Operate autonomously

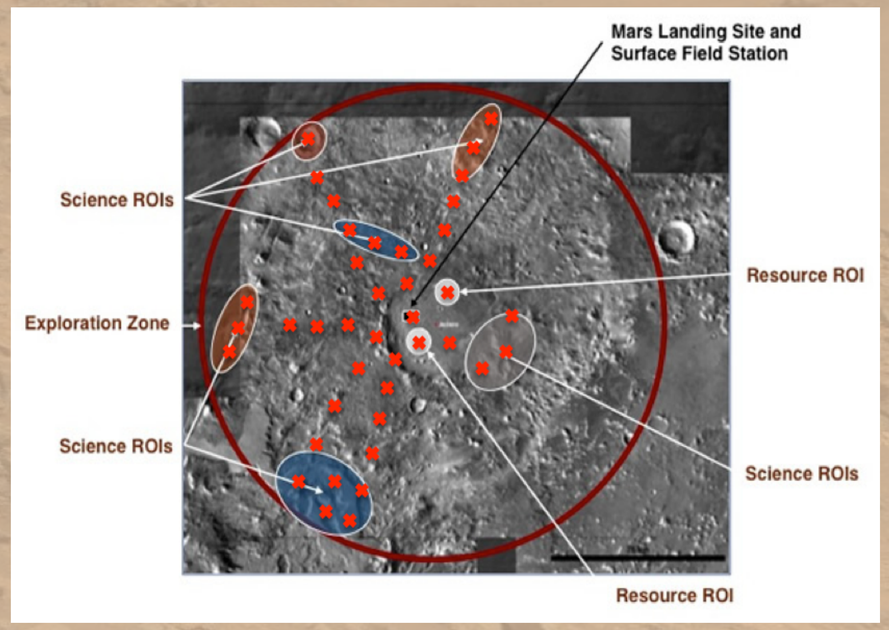
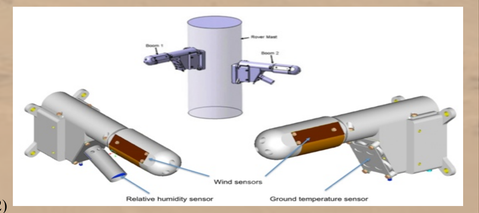


Fig. 3: GEMS units (red X's) are deployed along astronaut traverse routes to scientific regions of interest (ROIs) and create a wide network in this concept image of a Mars exploration zone (NASA First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars, 2015).

Instrumentation: GEMS unit instrumentation would be tailorable to the destination. On Mars, GEMS units would be equipped with meteorological sensors (e.g., Figure 4), whereas charged particle experiments would be well-suited to the Moon and asteroids. Candidate instrumentation includes:

- Seismometers
- Heat flow probes
- Magnetometers
- Meteorological sensors
- Charged particle detectors
- Cameras/imagers

Fig. 4: The REMS booms from the Mars Science Laboratory.



Gómez-Elvira, J. et al. (2012)

Deployment and Operation: Ease of deployment and operation would foster a broader GEMS network, hence improving both scientific and safety goals.

We envision GEMS units being packed into a "magazine", which are then deployed individually by a (crewed or a robotic) rover's manipulator arm along a traverse route. Hence, the crew is not required to perform an EVA. After a systems and communications check, the rover would depart the GEMS unit.

Following deployment, GEMS units would operate autonomously using pre-programmed duty cycling. Data would be transmitted to the crew habitat or orbiting assets either directly, or via "hopping" the data packets to neighboring GEMS units until within range of the habitat or a surface base station (i.e., a wireless sensor network architecture).