Preparing for future human exploration: Measuring the radiation environment on Mars

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NASA will launch the Mars Science Laboratory on Nov. 26, 2011, to assess the past and present habitability of the Red Planet's surface. The mission will land Curiosity, a rover equipped with 10 instruments designed to search for evidence of elements needed to support life – namely, water and carbon-based materials – and to characterize life-limiting factors, such as the planet's radiation environment.

Southwest Research Institute (SwRI) led the development of the Radiation Assessment Detector, which will measure, for the first time, the radiation environment on the surface of Mars, measuring all the relevant energetic particle species originating from galactic cosmic rays, the Sun and other sources. Positioned in the left front corner of the rover, RAD is about the size of a coffee can and weighs about three pounds, but has capabilities of an Earth-bound instrument nearly 10 times its size. Its wide-angle telescope detects charged particles arriving from space, and the instrument also measures neutrons and gamma rays coming from Mars' atmosphere above, or the surface material below, the rover.

"RAD is a bridge between the science and exploration sides of NASA," says physicist Don Hassler, RAD principal investigator and science program director at SwRI's Planetary Science Office in Boulder, Colo. "The two objectives are equally exciting. RAD's measurements will help the MSL science team assess whether the site has conditions favorable

for life or preserving evidence of life, as well as how deep below the surface we must drill to find potential evidence of life.

"The other primary objective of RAD is to help NASA plan for future human missions to Mars by helping to determine the amount of radiation shielding required to keep astronauts safe on the surface of the planet, as well as during the long journey to get there and back," continued Hassler. "To achieve these objectives, RAD will also characterize the radiation environment during the trip from Earth to Mars, in addition to Mars' surface throughout the rover mission. Understanding radiation levels in interplanetary space is also important to the design of future human missions to Mars, so RAD will be one of the first instruments on Curiosity to send scientific data back to Earth."

The Earth's magnetic field and atmosphere shield our planet from most hazardous galactic cosmic rays and "solar particle events." Mars has an extremely thin atmosphere – about one percent of Earth's – and lacks a global magnetic field, allowing more radiation to reach its surface and pose a hazard to life.

RAD will monitor galactic cosmic rays, streams of charged particles coming from supernova remnants and other sources outside our solar system. The instrument will also characterize the electrons, protons and heavier ions sporadically released by solar particle events such as solar flares and coronal mass ejections on the Sun.

While NASA's Mars Odyssey orbiter evaluated the radiation above Mars' atmosphere, the radiation environment on its surface has never been characterized. Current estimates of surface radiation rely on modeling of how the Mars' atmosphere probably affects energetic particles, but these models are unproven. For example, a single energetic particle hitting the top of the atmosphere can break up into a cascade of lower-energy particles that might be more damaging than the single high-

energy particle itself.

Radiation levels probably make the surface of modern Mars inhospitable for microbial life and would contribute to the breakdown of any near-surface organic compounds. RAD measurements will help determine the depth a possible future robot on a life-detection mission might need to dig or drill to reach a microbial safe zone. Researchers will combine RAD's measurements with estimates of how the activity of the Sun and the atmosphere of Mars have changed in the past several billion years to provide insight into whether the surface may have been habitable in the past.

Because radiation levels in interplanetary space vary on many time scales, from much longer than a year to shorter than an hour, RAD will record measurements for 15 minutes of every hour throughout the prime mission, on steady watch to catch any rare but vitally important solar particle events. Because the first science data from the mission will be collected by RAD on the journey from Earth to Mars, scientists will correlate these en-route measurements with other spacecraft that monitor solar particle events and galactic cosmic rays in the Earth's neighborhood to ultimately yield data about the radiation environment farther from Earth.

Curiosity will arrive at Mars about nine months after launch and collect data for one Mars year, or two Earth years; the mission could be extended to collect data for an entire solar cycle.

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