Curiosity: one year on

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One year ago – on August 6, 2012 – the Mars Science Laboratory (MSL) began the most complex entry, descent and landing (EDL) that NASA had ever attempted. Previous rovers Opportunity and Sojourner were small enough for NASA to enclose in airbags and slam into the Martian surface. But Curiosity, weighing in at nearly a ton, was far too heavy. Engineers opted for an EDL in which a parachute and rockets slowed its descent above Gale Crater, and then a hovering sky crane lowered Curiosity to the Martian surface with a 25-foot tether.

The landing thrilled space enthusiasts around the world. It was particularly pulse-pounding for Sushil Atreya and Nilton Renno, both professors of planetary and space science in the Department of Atmospheric, Oceanic and Space Sciences, and both intimately involved with the Curiosity mission.

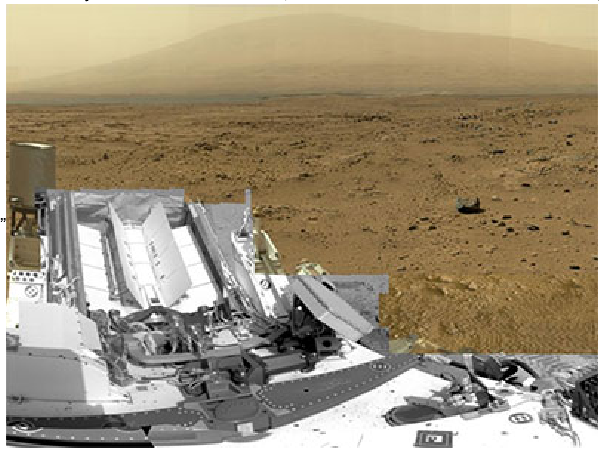
"Curiosity is the most complex, most sophisticated piece of engineering ever to land and operate on another planetary surface," Atreya said. "Science-wise, the rover has performed fabulously – it's been flawless! Outside of the science, there have been some minor hiccups. The only major technical glitch was a temporary failure of one of two rover computers that set the operations back somewhat in February. Following a swap with its redundant, back-up computer, Curiosity resumed full operations, and the former primary computer, which is fully operational now, is used as back-up."

The fabulous science that Atreya mentioned has depended on coordinated sets of observations by the rover's ten investigations, including Curiosity's Sample Analysis at Mars (SAM), a high-precision chemical laboratory that can be rightly viewed as a mission by itself, within the MSL mission: to explore the Gale Crater landing site and the lower layers of Mount Sharp, with particular attention given to the Yellowknife Bay region in the elliptical area around the landing site. Atreya is a co-investigator on the SAM team. Renno, a co-investigator on the MSL's Rover Environmental Monitoring System, pointed out that the main goal of investigating that layered terrain was to "search for evidence of environments that could have been habitable in the past."

Currently, the rover is trekking toward Mt. Sharp at the center of the crater. Atreya said that the exploration of lower layers of Mt. Sharp "is expected to provide valuable insight into the time history of geochemical and climate changes on Mars as these sedimentary layers were laid down over time, something we couldn't do effectively at Yellowknife Bay."

As the rover makes its way to Mt. Sharp, some 8 km (5 miles) away, it will be taking multiple images of rocks and collecting scientific data such as atmospheric pressure and temperature, and surface radiation. "If a target appears to be scientifically appealing – for example, if it might reveal something about ancient water channels that scientists don't already know from existing data – a case could be made to stop and analyze the target briefly," Atreya said. "We'll also have many more opportunities to sniff the Martian air and carry out noble gas isotope measurement with SAM. These data would be extremely important for understanding the evolution of a warmer, wetter Mars, to a cold, arid planet today. I'm excited about these measurements."

Of the many experiments that the MSL and SAM conducted during the past year, Atreya was particularly enthusiastic about some of the firsts – the first hole drilled into a planet other than the Earth, the first high precision atmospheric isotope experiments, and the first searches for methane from the surface of Mars and oxidants in Gale Crater. For Renno, the highlights were "the discovery of fractured terrain with a large quantity of holes; finding evidence of water activity in the past; discovering gray mudstones (clays) below a thin layer of dust at Yellowknife, and water adsorbed in the mudstones; and finding the presence of perchlorate salts in the soil.”



There were also a number of surprises. Atreya pointed out that finding those mudstones so early in the mission was unexpected, as was discovering that methane is either non-existent or present only in extremely small quantities. For Renno, the fractured terrain with lots of holes was a surprise. “It suggests that geological processes are much more active that we imagined. I have to say that I was disappointed by the lack of detection of organics, but this might change when we get to Mt. Sharp.”

About organics, Atreya added, “SAM has actually detected carbon in the gases evolved from heating solid samples but , whether it’s from organics and whether from Earth, Mars or meteorites – requires careful analysis that will take time to sort out. In the end, there is a real possibility that little or no organics are present in Gale Crater, which would not be a complete surprise, considering that oxidation by the same aqueous environment that facilitates indigenous organics can be detrimental to their preservation, as is commonly the case in billion-year-old rocks on Earth. Moreover, the thin atmosphere of Mars allows the Sun’s harsh ultraviolet radiation to impact the surface, and the high energy galactic cosmic rays penetrate globally to several meters beneath the surface. None of this radiation helps with the preservation of organics, either, whether from space or indigenous to Mars. Nonetheless, the search for organics will continue inside the rocks we drill.”

Atreya said that because the thrust of his research is the formation and evolution of planetary atmospheres and planetary habitability, including Mars, all SAM data as well as geological, geochemical and environmental data from other MSL instruments are providing valuable input to my own work.

AOSS and Michigan Engineering partnered with NASA’s Goddard Space Flight Center in developing SAM. “We’ve participated in all of SAM’s experiments,” said Atreya, who is a SAM co-Investigator and science lead for surface–atmosphere interaction investigations. “And those experiments covered a broad range – from analyzing gases in the atmosphere, to gases evolved from heating solid samples of dust deposits of Rocknest and fines from holes drilled into John Klein and Cumberland mudstones.” (Rocknest is a patch of sand that NASA selected as the likely location to first use the scoop on Curiosity’s arm. John Klein is a rock named after a deputy principal investigator for the mission who died in 2011. Cumberland is a rock similar to John Klein.)

Throughout the MSL’s first year on Mars, NASA scientists and engineers have been using the “SAM test-bed,” an Earth-based replica of SAM, to evaluate and validate experiments before sending instructions to the SAM instruments on Mars. NASA ran 357 test-bed experiments throughout Curiosity’s first year on the Red Planet, underscoring the critical dependence that robotic explorers still have on Earth-bound humans.

Atreya explained more about the SAM test-bed. “‘Don’t break SAM’ is the SAM team’s unwritten rule,” he said. “Taken a step further, the safety of MSL also depends on the proper operation of its payload. So, before running any experiment with the real SAM on MSL, an identical sequence of the experiment must be simulated with the SAM testbed at Goddard – every step that the SAM on MSL will carry out. If any part of the experiment sequence faults out, it must be fixed first before the experiment script is uploaded to MSL. Testbed runs are tedious and time-consuming, but essential. Not many of SAM experiments are routine, so testbed runs for pretty much everything SAM does at Mars – and there are many firsts – need to be carried out and repeated with whatever modifications are required from experience both in the lab and at Mars.”

The anniversary of Curiosity’s landing has given Atreya reason to reflect on the mission – past, present and future. “The first year of Curiosity and SAM on Mars has been extremely rewarding scientifically,” he said. “We can’t wait to explore the mysteries of Mount Sharp and what lies on the long trek to the mountain.”

What lies ahead for Curiosity might be a lot more than anyone currently expects. The rover has performed so well that NASA is considering an indefinite extension of the two-year mission, saying it could last as long as 55 years. The nuclear-powered rover has enough plutonium on board to last that long – perhaps longer. It might never get tired of performing as well as it has during its first year on the Red Planet.

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