BASALT: The Future of Mars, on Earth Today

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SOMEDAY, HUMAN EXPLORERS will walk on the planet Mars.

But, as young children and older space exploration enthusiasts often lament, “someday” doesn’t seem to be getting much closer.

In one sense, that’s a blessing. To carry off a successful Mars expedition, we must solve a daunting array of technical problems, including regenerative life support, improved in-space propulsion, Mars surface power, use of martian resources, and landing of heavy payloads. Seen through the lens of these challenges—many of which will take 10- or 11-digit budgets to overcome—“someday” can seem all too close.

The problems a Mars expedition will face include the limited bandwidth and long latency time of the communication link back to Earth. In modern life, upload and download speeds of megabits per second can seem barely adequate. Our existing communication satellites can manage rates like that. But take a communication satellite to the Moon, and its data rate drops by a factor of 100. Take it to Mars, and the rate drops by a factor of 100 million. Communication between Earth and Mars also means coping with up to 40 min of round-trip speed-of-light latency between asking a simple question and getting an “immediate” answer.

Under those conditions, how can a large team of specialists on Earth best advise a small group of generalists on another planet? How can the home team keep aware of what their distant collaborators are seeing and doing? How can their recommendations arrive “just in time” rather than tens of minutes late? And how can both teams work together to make the best possible scientific decisions?

Some of those problems can be addressed today, on Earth, with a modest budget. Dozens of space exploration “analog” projects have made progress in solving the communication challenges of future exploration. Many “analogs” have included field work, but the science has often played second fiddle to operational and engineering objectives.

Over the past 4 years, the BASALT (Biologic Analog Science Associated with Lava Terrains) team has taken the next great step in analog mission fidelity. BASALT conducted real science investigations, with real sample collection protocols and real consequences if those protocols were broken—all while employing Mars-realistic communication bandwidths and latencies, with “extravehicular astronauts” in the field and “intravehicular astronauts” communicating with them in real time to help with science questions, navigation, and procedural protocols. In a separate “Mission Control” room, a team of engineers worked with two-way delayed communication streams to monitor and maintain a complex data architecture and a suite of scheduling, mapping, and situational awareness (including augmented reality) tools. “Mission Control” also hosted a science team with broad, deep expertise. The scientists analyzed the flood of voice calls, imagery, and instrument data coming in from the field to make decisions on a tight schedule, so that they could deliver sampling priorities to the field team on time, rather than many minutes too late.

The team members faced variable weather, volcanic fumes, rough and unstable terrain, and heavy loads. They mastered inevitable frustrations with real-time work re-planning, delays for weather and equipment failure, and confusion registering field imagery to real landmarks at the site. The work was hard, but the team’s efforts have paid dividends. After reading this Special Collection, which presents the scientific, operational, and engineering insights gained by the BASALT team during their intensive field activities and thousands of hours of postmission analysis, we hope you will agree.

For this participant, a planetary scientist and veteran of one space flight, two seasons in Antarctica, a half dozen NASA “analogs”, hundreds of hours in mission control, and a career focused on exploration, BASALT was a chance to work in the amazing future that scientists and engineers are now creating, a future in which the Earth is just one of many worlds for people to explore and understand. “Someday” won’t come soon enough for me to fly to Mars myself. But

projects like BASALT give a taste of what planetary exploration will become, while doing meaningful science and blazing the trail for the men and women who will make the trip for real. It is hard to imagine more rewarding work. It'd be greedy to ask for more...but I hope they invite me back.

Author Disclosure Statement

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Abbreviation Used

BASALT = Biologic Analog Science Associated with
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