

# Principles for Integrating Mars Analog Science, Operations, and Technology Research

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## ***Abstract***

During the Apollo program, the scientific community and NASA used terrestrial analog sites for understanding planetary features and for training astronauts to be scientists. Human factors studies (Harrison, Clearwater, & McKay 1991; Stuster 1996) have focused on the effects of isolation in extreme environments. More recently, with the advent of wireless computing, we have prototyped advanced EVA technologies for navigation, scheduling, and science data logging (Clancey 2002b; Clancey et al., in press). Combining these interests in a single expedition enables tremendous synergy and authenticity, as pioneered by Pascal Lee's Haughton-Mars Project (Lee 2001; Clancey 2000a) and the Mars Society's research stations on a crater rim on Devon Island in the High Canadian Arctic (Clancey 2000b; 2001b) and the Morrison Formation of southeast Utah (Clancey 2002a). Based on this experience, the following principles are proposed for conducting an integrated science, operations, and technology research program at analog sites:

1. **Authentic work:** The single, most important aspect of integrated research is involving human factors and technology developers in actual work settings, where planetary scientists are confronted with significant logistic difficulties. Thus real issues are identified and prioritized, and work system design is treated holistically (not just as a technology problem).
2. **PI-based projects:** Experience at FMARS and MDRS suggests that use of analog facilities be organized around projects led by independently funded principal investigators. Each "rotation" pays for its own operations and shares facility overhead. Over time, institutional committees might actively seek to shape the facility and attract particular kinds of research (e.g., include a greenhouse and waste water recycling system).
3. **Unencumbered baseline studies:** Human exploration research begins by living and working with scientists who use conventional tools and methods, to identify practices that may be hindered in planetary environments, and hence identify issues requiring new work practices (e.g., the inability to draw maps when wearing spacesuit gloves).
4. **Closed simulations:** Research stations at analog sites (e.g., FMARS, MDRS) enable simulations in which a crew lives and works in isolation (only email contact) over extended periods, doing authentic, PI-based work, in both baseline and encumbered modes (e.g., wearing heavy suits with gloves). Thus, a integrated study is possible with a mix of maintenance tasks, sampling and laboratory analysis, reporting, recreation, etc., so the interactions of available space, schedules, roles, tools, etc. can be studied.
5. **Observation and documentation:** The basic method of study is observing as a participant ("participant observation," Greenbaum & Kyng 1991), combining field notes, photography, surveys, interviews, and systematic recording using time-lapse video, audio, movement tracking, etc. (Clancey, 1999; 2001a; 2002c).

Following these principles, we have been integrating field science, operations research, and technology development at analog sites on Devon Island and in Utah over the past five years. Analytic methods include work practice simulation (Clancey 2002c; Sierhuis et al., 2000a;b), by which the interaction of human behavior, facilities, geography, tools, and procedures are formalized in computer models. These models are then converted into the runtime EVA system we call “mobile agents” (Clancey 2002b; Clancey et al., in press). Furthermore, we have found that the *Apollo Lunar Surface Journal* (Jones, 1999) provides a vast repository for understanding astronaut and CapCom interactions, serving as a baseline for Mars operations and quickly highlighting opportunities for computer automation (Clancey, in press).

A beneficial side-effect of planetary, social, and computer scientists living and working together—confronting real logistic difficulties in evocative landscapes—is the development of a multidisciplinary community with shared experiences and intuitions, and thus an ability to collaborate on real missions. By including graduate students in these expeditions, we promote our long-term goals of human exploration and incorporate the latest methods and technologies.

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