Field Science Ethnography: Methods for Systematic Observation on an Arctic Expedition

WILLIAM J. CLANCEY
NASA/Ames Research Center

The Haughton-Mars expedition is a multidisciplinary project exploring an impact crater in an extreme environment to determine how people might live and work on Mars. This expedition to the Canadian High Arctic seeks to understand and field test Mars facilities, crew roles, operations, and computer tools. The author combines an ethnographic approach to establish a baseline understanding of how scientists prefer to live and work when relatively unencumbered, with a participatory design approach of experimenting with procedures and tools in the context of use. This article focuses on field methods for systematically recording and analyzing the expedition's activities. Systematic photography and time-lapse video are combined with concept mapping to organize and present information. This hybrid approach is generally applicable to the study of modern field expeditions having a dozen or more multidisciplinary participants, spread over a large terrain during multiple field seasons.

During several field seasons, I have conducted research about the practices of scientists and engineers in Haughton Crater, with the objective of determining how people will live and work on Mars (Long 1999). Haughton is a relatively uneroded 23.4-million-year-old impact structure located near the western end of Devon Island in the Canadian Arctic Archipelago; it is the highest latitude terrestrial impact crater known (75° 22′ N, 89° 41′ W) (Osinski et al. 2000). The crater is approximately 500 miles north of the Arctic Circle and more than 100 miles from Resolute, the northernmost commercial airport on this planet.

This work originated within and has been strongly influenced by the activities of the Haughton-Mars Project (HMP) of NASA/Ames Research Center (Pascal Lee, principal investigator). Special thanks to Charlie Cockell, Gordon Osinski, and other members of the HMP for enabling my observation and opportunity to understand their work. I am also indebted to my colleagues in the Computational Sciences Division at NASA/Ames who have participated in this work in various ways over the past three years: Rick Alena, Brian Glass, Charlotte Linde, John O'Neill, Mike Shafto, Maarten Sierhuis, and Roxana Wales. Journal reviewers provided many helpful suggestions for preparing and revising this article.

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FIGURE 1
Base Camp of Haughton-Mars 1999 Expedition

The people living and working at Haughton provide a case study of human exploration in an authentic work environment, which is at the same time a physically evocative Mars-like landscape, logistically remote, and hazardous (see Figure 1). My investigation of field life and work practice is part of the Haughton-Mars Project (HMP) led by Pascal Lee, an astrogeologist. My approach involves systematic observation and description of activities, places, and concepts, constituting an ethnography of field science and engineering tests.

As a computer scientist seeking to develop new kinds of tools for living and working on Mars, I focus on the existing representational tools (such as documents and measuring devices), learning and improvisation (such as use of the Internet or informal assistance), and prototype computational systems brought to the field by my National Aeronautics and Space Administration (NASA) colleagues and university researchers (e.g., robot geologists). This work is viewed as a partnership in which field scientists and engineers actively contribute to my systematic findings and interpretations as I participate in their work and life.

After two field seasons, I came to characterize the objective of my study as determining how we will live and work on Mars. However, the original focus was more narrow, in terms of studying prototype computer tools in the field and revealing the contextual factors relevant to their successful operation. In the third year, the expedition expanded to a small village to construct a prototype Mars habitat; subsequently, it will contract back to a group of six people who will live in the habitat.

In the course of these changes, many research themes have developed. For example, how do scientists construct an understanding of their own productivity within the complexity of identities (see Bernard and Killworth 1974; Sheehan 1993), exploration opportunities, and logistic constraints of a short-stay inhabitation in a remote field site? Other issues relate to social scientists' studies of science in general and the public understanding of science. In this article, I focus on methods for making systematic observations, given the multidisciplinary, distributed nature of the expedition's activities. I especially consider how analysis of data, such as charts and conceptual maps, shapes further questioning and subsequent observation within and over field seasons.

After sketching the observational context and challenges, I describe my recording and data analysis methods in some detail. I conclude by discussing related work and the lessons of the HMP experience.

OBSERVATIONAL CHALLENGES

During the first field season in 1998, the size of the expedition and duration of visits was very limited. My ten-day stay in the crater (all that I was permitted) was insufficient for observing a dozen people, who were strewn over a twelve-mile area on a typical day. The wind made my outdoor video recordings virtually worthless. I was unable to access my cameras while riding all-terrain vehicles (ATVs), limiting the photographic record.

Consequently, the following year, I arranged to stay in the crater for most of the field season. I brought wireless microphones, plus an assistant who could help me cover the activities and people of the expedition (which had now doubled in size). Not coincidentally, I found that a biologist and geologist had also brought assistants—my first indication that problems for an ethnographer in studying the human activity of the crater were paralleled by scientists' difficulties in studying the crater itself. Indeed, in the second year we were all better equipped with digital cameras and laptops, a double-sized work tent, more time, and more hands and eyes to handle the work. Nevertheless, many challenges remained.

Most notably, observing life and work in an Arctic crater is fraught with physical difficulties, especially fatigue from driving the ATVs (typically three hours or more at a time on extremely rocky and often steep, slippery terrain), safety concerns (ATVs can fall over, a bear can arrive at any time), and weather dangers (icy wind that takes your breath away). Unlike the Antarctic, the weather is rarely below freezing during the summer, but heavy winter clothes with wool hats and gloves are frequently necessary. This gear makes it difficult to manipulate cameras and attach microphones. In such conditions, it is difficult to separate oneself enough from activities to photograph what is happening, let alone to look around and watch what others are doing.

Most work in the crater—the reason for being there—occurs during traverses, which are forays ranging from one to ten miles, taking more than an hour to most of the day (and into the darkless night). During a traverse, the group must stay together, with perhaps only a few moments at each stop to take a photograph or jot a note. Driving skills on the ATVs determine whether one can take direct routes or will be delayed by going around obstacles (hence falling behind). Most stops during a traverse are quick, and most recording equipment is packed to avoid damage should the ATV overturn on a breccia-covered hill or fall into a creek or the mud around a lake. Therefore, like the scientists, an ethnographer will only unpack and set up observational equipment for what I call a "full stop." Then engines are all turned off (making possible good audio recordings), and the group will spend perhaps thirty minutes to several hours on foot in one general location, such as a lake or mini-oasis (a patch of vegetated ground five to ten feet across).

FRAMING THE STUDY

Apart from the logistics and distributed nature of the expedition, the essential difficulty in observing the HMP was focusing on some subset of the wide variety of issues that are potentially useful for establishing a Mars base. I have found it useful to organize my ongoing study according to three broad perspectives that address the broader issue, "How will we live and work on Mars?"

1. Studying the nature of field science
    a. The nature of human exploration
    b. Scientific discovery in natural settings
    c. The nature of a modern scientific expedition
    d. Conceptual change in the group
    e. Mapping and naming the landscape
    f. Logistics planning and resource management
    g. Navigation (e.g., inventing and using landmarks)
    h. Reporting genres of scientific disciplines
2. Using the HMP expedition as an analog setting to formalize Mars mission requirements

   a. Habitat design and daily activities
   b. Mission support (including roles and communication protocols)
   c. Communications in the field with remote support, remote scientists, and the public
3. Doing computer science research with a participatory design methodology
   a. Mixed-initiative human-machine systems (e.g., exploration robots, instructional systems)
   b. Telemetry, data storage, analysis, and sharing (e.g., electronic notebooks and organizational memory)
   c. Multiagent simulations of expedition life (Clancey et al. 1998)

This provides some focus, but there are still many choices of whom, what, where, or how to observe. For example, consider the range of possible activities to observe and document relevant to computer tools: data collection during traverses, daily reporting to mission support, food inventory management, power system maintenance, and so forth. Notice particularly that the challenge is to go beyond a typical ethnographic record to understand technical procedures and equipment in enough detail to know how practices might be changed on Mars and how the overall system might be redesigned. For example, after observing a biologist's use of UV recording devices left at remote sites, I reviewed the supplier's online Web site to learn about other sensors. This prompted me to work with the weather station manufacturer to determine how the weather data might be transmitted directly to the habitat. Thus, field observations and technical design are interwoven by the overarching analog purpose of the expedition.

On balance, the three perspectives are all useful and constitute topics generally applicable to empirically based work systems design: What is the nature of life and work in this setting? What patterns are relevant to the (re)design of this work system? and What natural experiments are within my expertise for defining, observing, modeling, and evaluating?

As an analog of an expedition to Mars, perhaps the most useful ethnographic observations relate to practices that will be impossible or severely constrained on Mars. For example, one geologist routinely made pencil drawings while standing in front of rock formations. Drawing is an integral part of reflective inquiry (Schön 1987), influencing how the geologist examines and samples the rocks. If a space suit prevents or inhibits drawing dexterity, how would this affect the geologist's on-site explorations and the ultimate quality of the work? Thus, the question, "How do scientists live and work?" becomes more specifically, "What will be different on Mars, and what logistic differences will make a difference in the quality of human exploration?" With this information, mission and tool designers can begin to develop procedures and equipment that ameliorate the difficulties of living and working on Mars.

Framing my study as a multiple-year project significantly helped focus my efforts. In my second field season, I saw how other scientists were scoping their observations with the intention of returning for a third season (and perhaps many more). I realized that my own study of the expedition would benefit from the same long-term perspective of multiple visits with different methods and purposes. Thus, I studied the tent layout during 1999 as an analog of the habitat that was to be constructed in 2000. Then, in 2000, as a member of the habitat crew, I experimented with time-lapse setups that I might use when the habitat was more formally occupied in 2001 and later. My framing of the value of ethnographic observations during the HMP shifted from the broad themes of 1998 (the nature of field science) to the design-oriented issues of the Mars habitat and computer tools in 1999 and 2000.

RECORDING METHODS

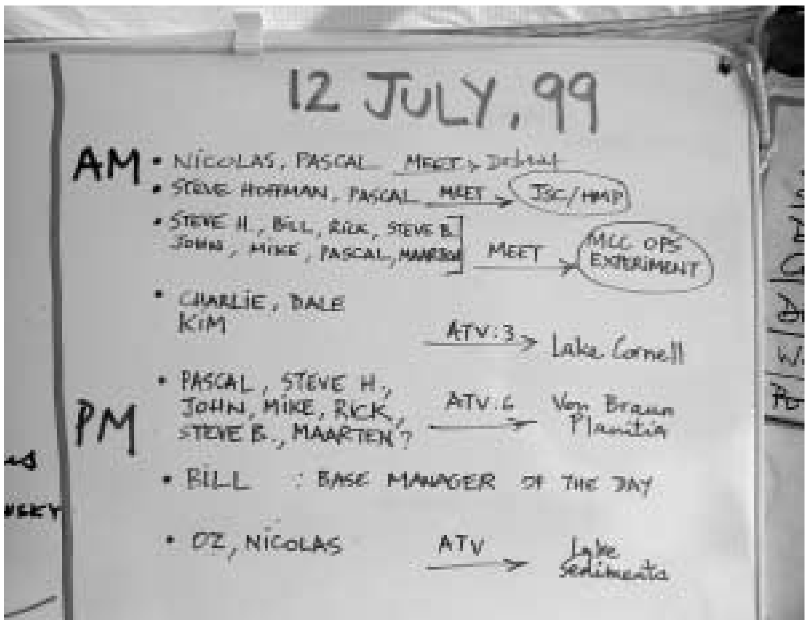
During several field seasons, I have developed a suite of methods for recording the expedition's activities. I will describe photography, video, time-lapse video, and written methods.

Photography Logistics

The best record keeper is a still photograph camera. Until digital cameras provide better than 5 MB resolution with professional lenses, I will continue to use a 35mm SLR for photos requiring high-quality, wide-angle, or telephoto magnification. I selectively digitized a third to half of the slides on a PhotoCD upon my return, making them accessible for presentations and publication. However, my preferred camera is a 2 megapixel digital camera. This produces a time-stamped record that is easily accessible in the field and provides photos that can be immediately shared and analyzed.

Photos were stored on a 32 MB Compact Flash™ card and transferred approximately every day using a PC card adapter to a laptop's 6 GB hard drive. They were stored there in dated folders and cataloged immediately using the Cumulus™ program. Photos were backed up to 100 MB ZIP™ cartridges; three of these stored the 750 images taken in one month. Photos were also backed up in the field to 1 GB JAZ™ cartridges. Four rechargeable batteries allow approximately seventy photos, and four batteries are always available as backup.

FIGURE 2
Typical Whiteboard Photograph



Systematic Photography

Besides the familiar methods of shadowing someone or observing a place (such as sitting in the work tent), one might take systematic photographs of an artifact or setting. For example, in the second field season I took photographs every day of the whiteboard in the dome tent, which was used for logging ATV assignments. The log indicated where individuals were going and how many people were on each traverse. By analyzing these photographs over the course of the month, I was able to discover patterns in how the crater was being explored[1] (see Figure 2).

On average, each person left camp on a traverse on 7.3 days (out of 21). If we knew whether people were satisfied with this (Was the weather frustrating attempts to travel more often?), we could begin to evaluate how often scientists would expect to leave the Mars habitat.

We are also interested in the pattern of site visits. On average, there were 2.7 traverses planned to each location; the place with the most number of planned traverses (12) was von Braun, the anticipated location of the Mars

Society's research habitat. There were more than 20 people during this phase of HMP-1999. Do people travel in large or small groups? On average, 3.5 people participated in each traverse. Tallying by discipline, we find that on average 1.4 participants per traverse were biologists or geologists and 2.1 participants were support scientists (computer, telecommunications) or media representatives. Given that a 6-person Mars crew can only send 2 to 4 people on a traverse, this will not be different from how people prefer to travel during an Earth expedition. Indeed, HMP observations indicate that it would be reasonable to suggest that 2 astronauts be accompanied on a Mars traverse by 1 or 2 telecommunications and support specialists.

But the whiteboard data also show that biologists and geologists rarely traveled together. Comparing a geologist and biologist who were both in camp for the entire month of July 1999, we find that both left camp on twenty-one occasions, but the biologist went to eleven sites, while the geologist went to nineteen sites. The biologist visited only three of these sites once, while the geologist visited fourteen of his sites once. The geologist visited thirteen sites not visited by the biologist. Strikingly, the most common location for the biologist was not planned by the geologist at all—and vice versa. More detailed examination and charts further reveal the sequence in which sites were visited during the month, showing that the biologist's search is depth first (completing a study of one place before moving on), while the geologist's search is breadth first (sampling a wide variety of sites before returning for a long stop at one place). Given this information, we can define protocols that will constrain how the scientists work during future HMP expeditions and study how Mars-like constraints on working together affect their performance and morale.

Video Logistics

I have found it useful to have two video cameras. One, a conventional Hi-8 camcorder, is left mounted on a tripod and used for time-lapse photography and interviews at camp. The second, a Sony PC-1 MiniDV camcorder, fits into a "Napolean" pocket in my outer jacket, so it is always available. I found two ninety-minute batteries to be quite sufficient (charging them each day).

For outside recordings, a zoom "wind" microphone is necessary but often inadequate. Instead, I usually give people wireless lapel microphones that transmit to a dual-channel Azden receiver mounted on the MiniDV camcorder. This allows stereo recording (one person per channel) or, as is more often the case, the chance to select which channel is transmitting more clearly and picking up the other participant from the side. With this arrangement, I made very successful recordings from as much as 100 meters away, including conversations between biologists in a boat on a lake and geologists who were walking well ahead of me or standing on another hillside.

Wearing headphones attached to the camcorder, I was able to monitor these conversations and selectively turn the camcorder on and off. As any ethnographer using video knows, one learns to anticipate when good conversations will occur. In general, the most fruitful recordings involved a biologist and an assistant or a biologist and a geologist coming together after a period of independent exploration.

Inside a tent and out of the wind, built-in camcorder microphones were sufficient. However, I also brought a wireless hand-held microphone, which the group passed around during some evening debriefings of the day's work. Some of these conversations were only audio recorded, using a digital (MD) recorder, when it was inconvenient or awkward to set up a camcorder in a crowded tent. With the small size of the MiniDV camcorder and ability to hold it down to one side while talking to someone (checking the picture on the LCD out of the corner of your eye), video recording has become almost as unobtrusive as audio and offers all the advantages of capturing facial expression and the surroundings.

Recording meetings in the group tent was, of course, productive; I sometimes regretted not having a camera going all the time (e.g., on one pull-out day, we had at least ten briefings where logistics were replanned—a series I did not anticipate and that would have been ideal to document). At the other extreme, I learned a great deal from exit interviews, when I would take someone aside before they were flown out of the crater to review their time in the field. Indeed, I discovered that midpoint interviews would be more useful to find out what people were doing and discover other facets of the expedition I might be tracking. For example, during an exit interview, a robotics specialist told me about material he wished to convey to someone who would be joining the expedition after he left. I used this opportunity to codify his work (using a tool described below), then used the representations as a conversation piece when the second person arrived. Thus, while learning of their interests and methods, I was simultaneously prototyping a tool we might use for facilitating crew handovers on the International Space Station or for lunar or Mars expeditions.

Lessons learned concerning video documentation are the following:

- The most difficult aspects of video documentation are good sound and a proper mixture of close-ups, focused shots on speakers, and group/contextual shots.

- Use a zoom wind mike on all outside shots if there is any wind at all, aim at the speaker, monitor the sound, and in general keep recordings short if the conversations cannot be heard clearly.
- Use two wireless mikes if two people are together.
- Include voiceover narration when starting a scene if the location is new.
- Always ask people on camera what they are doing, why they are stopping, where they are going, and so forth.
- Use the digital still capability of the video camera to take photographs of equipment, tools, written materials, and close-ups of people.
- If the camera is handheld, follow someone; don't jump around like a kid in a candy store. Ask yourself what you are trying to observe.
- If people are working or sitting in one place, use a tripod to hold the camera unobtrusively to the side.
- Log all videos in the field (at least put dates on the tape cartridge and case).
- Document a few types of events, particular places, or people well.

Time-Lapse Video

The use of time-lapse recordings deserves special mention. During the 1998 season, we had two work tents separated by fifty meters—one shared by all, the other devoted to a subgroup of three people from a university. Visiting these tents at different times, I determined that they were used in quite different ways, but was frustrated by not being able to be in both places at the same time or to view activities when I was busy on a traverse or talking to someone outside. So, the following year I used time-lapse recordings, hoping to capture what was happening in my absence and perhaps to discover patterns in the use of different spaces.

For example, in the most successful experiment in 1999, I placed a camera outside between the (now expanded) shared work tent, the (new) natural sciences tent, and the (new) large dome tent, with a view of the ATVs parked on the terrace in front (see Figure 3). A twenty-foot S-Video cable connected the camera to the laptop computer inside the work tent. By this placement of the camera, the resulting video logged occupation and motion between four key areas of the base camp, as well as capturing use of some personal tents. The layout was of special interest because motion between the work and dome tents corresponds to the top and bottom floors in a proposed layout for a Mars habitat.

During a three-hour period (11 A.M. to 2 P.M.), quarter-size video frames (320×240 pixels; see Figure 4) were directly captured to computer disk every three seconds using a digitizing PC Card and Adobe Premiere. This produces approximately 300 MB, which was backed up to a JAZ 1GB drive and later copied to a CD-ROM for convenient access. Frame size and period-

FIGURE 3
Example Placement of Camera for Time-Lapse Video
(records entry and exit from dome and work tents, plus
the central staging area used for traverse preparation)

icity is a compromise between storage and visible information. By comparison, a video inside a work tent, covering a much smaller area, was adequately captured by 160×120 frames, producing about 600 MB during eight hours. Today's expansion bay hard drives are 20GB or more, allowing many such recordings to be made.

The resulting video was saved as a Quicktime™ file and coded in a spreadsheet, indicating the times when someone entered or left the tents and ATV area. Duration of visits and number of people occupying each area were calculated using Visual Basic macros in Excel. Averages and totals were graphed to show correlation (see Figure 5). One unexpected result is that the data allow measuring the effect of a schedule change (delay in departure of a traverse by 1.5 hours) on both individual and group occupation of the different areas. For example, movement between the dome and work tents (the two "floors") peaked each time occupation at the ATV area peaked and reached a minimum during the delay period.

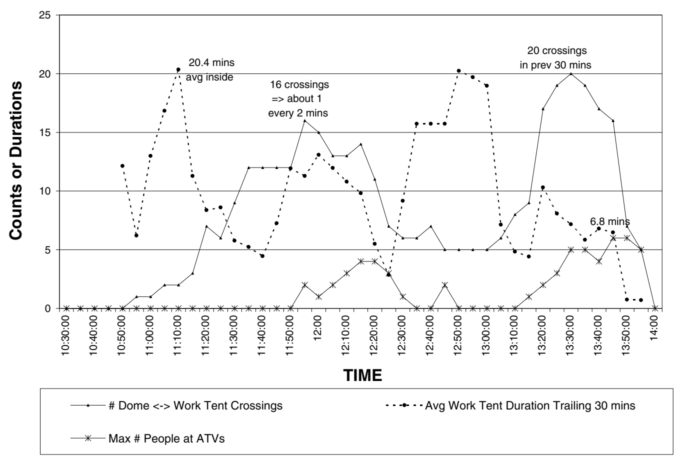
Factoring the analysis by individuals (see Figure 6) shows a great variation that can be best explained by considering the actual activities of individ-

FIGURE 4
Example Time-Stamped Frame (shows an exit event from work tent and people at the all-terrain vehicle staging area)

uals and their roles in the camp. For example, the person who occupied the work tent for the longest total duration during this three-hour period also crossed between the work and dome tents the most number of times, passing behind people who were attempting to work without interruption.

In general, the time-lapse videos provided far more information than I had anticipated. Invisible patterns appeared, and many questions were raised about what people were doing. For example, analysis of the work tent in 1999 during eight hours shows that more than half of the visits were under two minutes. Before that, I had not realized that people were coming and going so quickly—in fact, they were using the tent to store items (or trying to find someone). Then I realized that in subsequent studies I would need to log the reasons for visiting the work tent. Although the category might seem obvious, I had not thought to systematically study this activity until I saw the unexpected statistical pattern (Clancey 1988). Observing the tent as a participant, one thinks of the work tent activity as "people working on computers for long periods of time, with other people coming and going." Again, a focus on what is thought to be "the work" makes other events, no matter how fre-

FIGURE 5
Place Occupation over Time



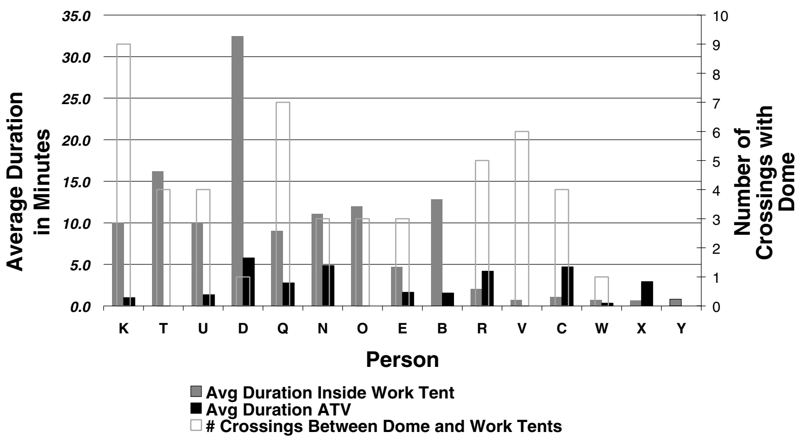
NOTE: ATV = all-terrain vehicle. Figure shows the average number of people inside work and dome tents and at ATVs, showing correlation at noon and 1:40 P.M. expected EVA departure times. During intervening wait, work tent duration increased dramatically and crossings between tents dropped.

quent, incidental. Time-lapse photography has proved to be an immensely valuable way of being able to extend my observations to places where I am not present or too immersed in the activity itself, while providing a log that is relatively easy to review for patterns (8 hours of 3 seconds/frame reduces to 5.3 minutes of video).

Written Notes

Of course, written records are essential. In this respect, I found the best combination of tools to be a water-resistant pocket notebook, which I could access at a moment's notice (even while paused on an ATV), plus a word-editing program on my laptop in the work tent. I spent several hours in the work tent each day, either organizing my thoughts using an "outline" mode or writing observations that were sent as e-mail to selected colleagues in my work group at NASA. Perhaps the most innovative experience involved sending photographs to an anthropologist in my group and receiving questions by return e-mail. This was rewarding, as she pointed out items that I had taken for granted (What is that poster in the dome tent? Who put it there?). I found myself racing around to check out places to reexamine what was so

FIGURE 6
Average Duration by Person (with number of crossings)



NOTE: Individuals on X-axis are sorted by decreasing total time inside work tent, showing variability in crossings and duration at the ATV dependent on individual activities and roles. For example, K was in the tent the longest during this period, but was responsible for different tasks at many locations, so crossed between tents the most often. V was looking for someone, so crossed often, but didn't stay in the work tent. D was working relatively undisturbed, not leaving his seat in the work tent.

strange to this remote observer. Thus, digital photography, e-mail, and a satellite connection enables distributed, collaborative observation and analysis during the field season itself. In fact, public expedition reports are posted on the Internet while we are still in the field (see http://www.marssociety.org).

DATA ORGANIZATIONS

With so many themes, events, and computer media to relate, methods for organizing data in the field are as important as the means of recording them. Besides outlining and tables, computer folders, and a photography database already mentioned, I explored the use of domain analysis frameworks and a "concept mapping" tool.

One way of systematically organizing observations is to classify them according to a framework of relations. I used a domain analysis framework suggested by Spradley (1980) (see Table 1). The relations are illustrated with two examples—one relatively mundane (corresponding to explicit knowl-

TABLE 1
Domain Analysis Relations and Examples Illustrating Kinds of Knowledge

General Relation	*Explicit Knowledge Example*	*Tacit Knowledge Example*
Kinds of	Rocks	Traverses
Steps in	Setting up a computer on the local network	Getting started in the morning
Places to	Practice the shotgun	Leave the all-terrain vehicles (ATVs)
Reasons for	Arrival of a plane	Walking by the river
Parts of	An ATV	The dome tent
Things	In the kitchen tent	That can fall off an ATV while moving
Ways to	Dress	Participate during dinner
Times of	The expedition	The day (e.g., breakfast time for late risers)

edge, which people typically mention in their conversations, e.g., kinds of rocks), the other not typically explicated in everyday conversations (tacit knowledge, e.g., kinds of traverses during an expedition).

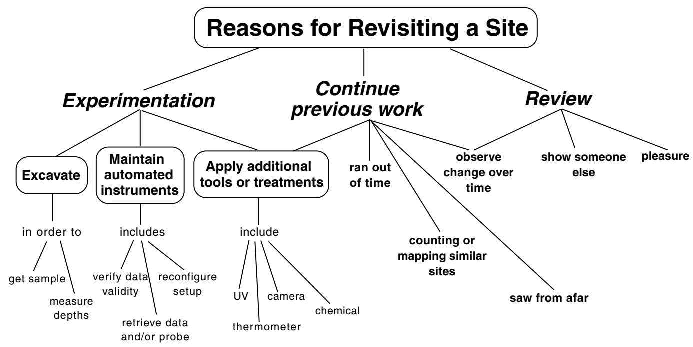
Each of the relations can then be represented as a root of a hierarchy, with one tree corresponding to each relation and covering concept. For example, parts of an ATV is a relatively complex but obvious hierarchy of parts. Some of the other relations, which are not often explicated in discourse during the expedition, may also be complex. For example, there are many reasons for revisiting a site (see Figure 7).

Another central aspect of work practice at Haughton can be characterized as stages in a traverse:

- planning the activity,
- organizing at start (e.g., gathering at the ATVs),
- launching into the activity (e.g., leader departs, others follow),
- punctuated events (e.g., full stops),
- regrouping (bringing the group back together),
- ending the activity, and
- following up (action items).

Although I have emphasized the design focus of my observations, many patterns such as stages in a traverse were documented a year or more before I realized their special value for Mars missions. In this case, the stages in a tra-

FIGURE 7
Reasons for Revisiting a Site



NOTE: Diagram implemented using Cmap, a tool for representing and sharing concept maps. The tool is provided by the Institute for Human and Machine Cognition, University of West Florida.

verse might be formulated as voice commands for orienting a robot to what people are doing. Or one might develop computer programs for recognizing these stages.

Cmap diagrams were especially useful for communicating my observations to the rest of the expedition during our evening debriefing sessions. The diagrams provided easy-to-read summaries that prompted further observations by the group. For example, when I first showed the "reasons for revisiting a site" diagram, people were reminded of their own experiences—recovering a rock sample left behind on a previous visit and looking for a lost tool. These diagrams also appeared to delight the group, who took pleasure in seeing their everyday work elevated to art forms.

CONTRAST WITH RELATED WORK

My application of ethnography in a field science setting has been strongly influenced by business anthropology, the study of corporate life for the purpose of redesigning work systems, including especially computer systems (Greenbaum and Kyng 1991; Clancey 1993, 1995a, 1995b, 1997; Bowker et al. 1997; Horgan et al. 1999). In turn, this work originates in the sociotechnical systems research of the 1950s (e.g., see Emery and Trist 1960), which forms the basis of my study of scientists and engineers working at Haughton.

Only a handful of anthropologists have studied scientific work in the field (Bernard and Killworth 1974; McGreevy 1994; Goodwin 1995; Latour 1995; Roth and Bowen 1999). To be sure, an expedition like the HMP is not a culture in the traditional sense because of its temporary nature (lasting a few weeks or at most a few months) and its often transitory membership (of the more than forty-four participants in HMP-99, on average only twelve were in the field at the same time).

An expedition is a kind of short-term project that brings together people from different organizations with common support and living arrangements. In practice, the expedition is multidisciplinary and hence forms small work groups in the field (typically two or three people spending most of the day together). Nevertheless, as in all human endeavors, there is a cultural aspect to such expeditions, largely derived from the broader and now blended communities of practice (Wenger 1998) to which these scientists and engineers belong. In particular, e-mail communications with outside collaborators, which will be the only conversations that the Mars time delay will allow, are important to study.

Different studies of expeditions are, of course, possible. My concern with the nature of human exploration focuses on the geologists' practices and tools for mapping the crater, as an analog for exploring Mars. Other studies might consider more broadly how Devon Island has been explored over the past decades or the historical study of Arctic expeditions seeking to find a Northwest Passage. Indeed, many lessons for planning extended space missions can be gleaned from historical analogs (Stuster 1996; Ituzi-Mitchell 1999). However, in contrast with voyages of discovery, a modern scientific expedition tends to work from a base camp (rather than moving over hundreds or thousands of miles). The sense of exploration at Haughton is not a discovery of entirely unknown landscapes (although ice-bound islands were still being discovered as recently as twenty years ago), but is a more detailed exploration of already photographed and mapped terrain, such as ravines in the crater.

Many analog studies have been conducted with an eye toward future, long-duration space travel. The focus has been primarily on the effects of isolation and confinement (e.g., Johnson and Finney 1986). Winter-over stays in Antarctica have been considered (e.g., Harrison, Clearwater, and McKay 1991), as well as crews on submarines and Skylab (Connors, Harrison, and Akins 1985). However, few of these studies have considered the nature of extensive surface exploration or how an isolated crew will work with a remote support team.

In contrast with my study, ethnomethodological analysis of how scientific descriptions and diagrams are created, adapted, and interpreted (e.g., Lynch and Woolgar 1993; Latour 1995)—another aspect of the study of scientific practice—is much narrower. Focusing on representations, including creation of notations, tool adaptation, and meaning construction, is relevant to the design of new tools and may be easily applied to Haughton. But my concern is necessarily broader, including how life and work are interwoven in shared space and how the expedition communicates with the outside world.

Finally, an outdoor expedition is not a typical office setting. My previous understanding of workplace studies (see Greenbaum and Kyng 1991; Jordan 1994) at first biased me to focus on the work or the representations, ignoring issues I later termed *logistics*. For example, in studying a typical office environment, an ethnographer would usually take for granted how electricity is supplied to the building. But in a Mars analog setting, such logistic concerns are always central and include food inventories; use of batteries; assembling, testing, and reprovisioning instruments; packing and storage methods; and so forth.

CONCLUSIONS AND RESOLUTIONS

I have described my experience, methods, and lessons learned from multiple field seasons during the HMP in Arctic conditions as a member of a team exploring how people might live and work on Mars. Although this is a special constellation of concerns and constraints, the range of observational challenges, recording methods and data organization tools, and ways of being systematic are applicable to studying other scientific expeditions in remote settings, as well as for participatory design in office settings. The following considerations are influencing my ongoing work on Devon Island.

- Ample power, work space, laptop computers, and a satellite Internet link made it possible to analyze data on site and communicate with colleagues. But I might have devoted too much time to analysis that could have been done later, rather than making more pertinent observations in the work tent around me. In the comfort of the habitat in 2000, I found it possible to sit in a chair along a wall and use the more routine practice of watching everything, as one might in an office environment. A special discipline is required to do this in a wind-blown tent when your feet and hands are cold. I wish I had exerted that discipline a bit more in the first two field seasons.
- The complexity of the expedition and logistic problems highlighted the well-known problem of being systematic (Jordan 1991, 1994; Johnson and Sackett 1998). Events from day to day are not repeated, as people with different disciplinary foci and methods come and go. Time-lapse recording is the best tool for extending one's observational reach.

- The risks and costs of the expedition during multiple years require defining for oneself and others how ethnography could be useful for Mars missions "requirements analysis" and what specifically is being studied. After three years, I developed the role of weather specialist, with the specific focus as a computer scientist on weather telemetry (wireless transmission and storage of data). Thus, I defined for the expedition a key problem and role (enabling my participation as an observer in the habitat's six-person crew) and formulated an experiment involving time-delayed distributed work (between the crew and a weather specialist on Earth). In short, participant observation during a costly field expedition may be facilitated by defining a significant role within the organization.
- The false dichotomy between work and life, although well-known to me, repeatedly biased what events were salient, and went so far as to render invisible the use of the 1999 work tent as a place for storing things. Although an ethnographer might be just an observer on an expedition's traverses, he or she is never strictly speaking just as an observer in camp. Activities in camp are in a protected place, conceptually apart from the landscape being studied; we share a place to eat, sleep, record data, and prepare for the next traverse. Consequently, an observer has to work harder at studying camp life instead of just living it.

Finally, the experience of living and working with a small group of people in an extremely isolated environment (with few signs of other life and no roads, buildings, etc.) highlights the amazing variety and complexity of human interests and behavior. In a handful of people with some high-tech equipment, we find far more ideas and activities than even a dozen people could adequately describe. An observer is humbled by this complexity and must adopt a limited, practical role. For just as the brilliant sun of Haughton's summer requires goggles to sleep, one must periodically turn away from the ever-present cacophony of the expedition and rest.

NOTE

1. E-mail interviews later established that the only modification that occurred in practice was that more visits occurred than were planned (e.g., opportunistic stops).

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WILLIAM J. CLANCEY is a senior research scientist in the Institute for Human and Machine Cognition at the University of West Florida, Pensacola. Since February 1, 1997, Clancey has held a joint position at the NASA/Ames Research Center, Computational Sciences Division, where he is chief scientist for Human-Centered Computing. He developed some of the earliest artificial intelligence programs for explanation, the critiquing method of consultation, tutorial discourse, and student modeling. Clancey's work on heuristic classification has been influential in applying and teaching the methods of formal qualitative modeling. His recent books reexamine the relation of descriptive cognitive theories to human experience and neural processes: Contemplating Minds: A Forum for Artificial Intelligence *(1994),* Situated Cognition: On Human Knowledge and Computer Representations *(1997), and* Conceptual Coordination: How the Mind Orders Experience in Time *(1999).*