

Language, Space, Time: Anthropological Tools and Perspectives in the Scientific Exploration of Mars

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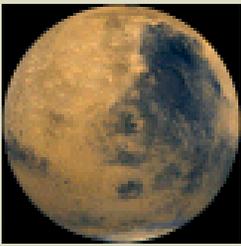
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Mars Exploration Rover Mission (MER)



- ▶ Objective: Search for evidence of past water on Mars
- ▶ Landed: January 2004 (launched July 2003)
- ▶ Run for NASA by Jet Propulsion Lab (JPL) in Pasadena, CA. Ames Research Center contributed various teams to mission-including work practice evaluation.
- ▶ Mission run on Mars time (Martian sol = 24:39 in Earth time) for four months
 - Solar powered rovers- sunlight and daytime temperatures for cameras and other instruments
- ▶ Work
 - Planning for rover work across science and engineering teams with commands sent to the rover on every sol for execution on the next sol



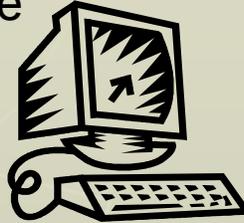
Work on Earth that Results in Work on Mars

Science Team

Natural Language Discussion



Science Request/ Planning Software



Science Planning Meeting



Engineering Team 1

Rover Activity Planning software and Approval



Engineering Team 2

Sequencing and Commanding software



Command Approval Meeting

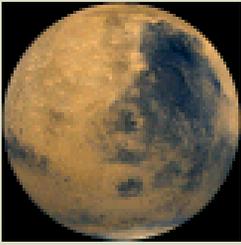


Radiate commands to Rover on Mars



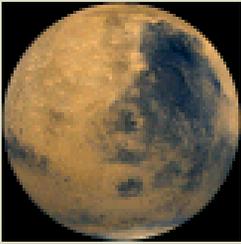
Time delay





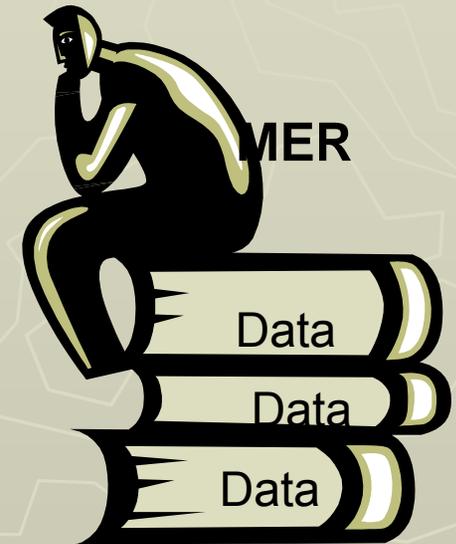
What is Needed to Support this Work?

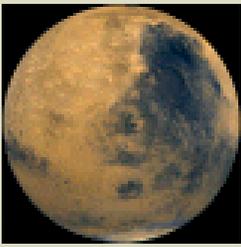
- ▶ Can anthropological tools and perspectives contribute to scientific exploration on Mars?
- ▶ Yes
 - Ethnographic methods, “mission ethnography,” grounded theory
 - Relevance of the concepts of Language, Space and Time in understanding domains and cultures
- ▶ Developed:
 - A **Language** to communicate the specifics of the work across the multiple teams and to the rover
 - A **Space** in which to work
 - A way to negotiate the differences between Mars **time** and Earth **time**



Ethnographic Methods for MER

- ▶ Data collection and analysis of:
 - field notes from in-situ observation and participation
 - video and photos
 - documents and artifacts
 - information created in software
 - system interactions between tools
 - information exchanged in meetings
 - nature of individual and group work
 - Interviews (formal and informal)
 - Email information and exchanges
- ▶ Research time- full time for three and a half years (2001 to 2004)





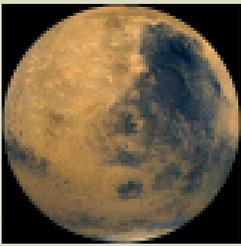
“Mission” Ethnography

- ▶ Participants in mission design process
 - Badged and taking up “real estate” in meetings and design sessions
 - Had access to personnel
- ▶ Expected to deliver recommendations to improve the mission design
- ▶ Data collection, assessment, analysis, recommendations had to meet mission time lines
 - Tests and trainings
 - Software and system freezes
 - Launch and Landing
- ▶ Decisions would be made with or without our recommendations
- ▶ Engineering and Science brought real world practicality and deadlines to the ethnographic process



Devising a Language for Work on Mars

- ▶ Scientists underestimated the complexity of language that was needed to convey their work
 - Early mission scientists' concept of a name to identify work:
 - Target = "Pilgrim"
- ▶ Ethnography identified the need for an expert "language" for Martian work; grounded theory supported the development of that language
 - Mission names incorporating identifiers and relationships of objects.
 - Observation Level = **IDD_Post Scratch_Plymouth Rock**
 - ▶ Take several different kinds of in-situ (IDD) measurements of feature Plymouth Rock, after scratching the rock with the RAT
 - Activity Level = **Red single Pilgrim**
 - ▶ Take a single frame image of the target spot pilgrim on Plymouth rock, using the red filter of the Pancam



Examples of Instrument Names, Methods and Other Identifiers/Constraints for use in the Formalization of a Science and Engineering Language for Mars Work

Instrument

- APXS
- Haz
- MB
- MI
- MiniTES
- Nav
- Pancam
- RAT
- Rover
- IDD (shorthand for two or more in-situ instruments in one obs)
- PMA (shorthand for two or more remote sensing instruments in one obs)

Note: PMA and IDD activities belong in separate observations.

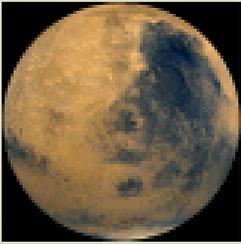
Method

- Accordion
- Approach
- Blind (for MiniTES activity without a supporting image or Pancam activity without a target)
- Comparison
- Drive
- Drive camera use methods "quick look", "rubber neck", "systematic"
- Movie
- Rat
- Scratch
- Sniff
- Surveys: Survey around, between, covering, from . . . to, including
- Sweep
- Tau
- Trench

and/or

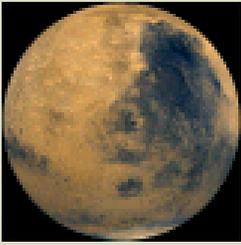
Other Identifiers/Constraints

- Afternoon
- Around
- Between
- Contiguous (identify whether Mast Relative or Time relative in notes field)
- Elevation
- Location/reference to a region or area
- Long
- Morning
- Morning after
- N, S, E, W (directions)
- Pre
- Post
- Short
- Soil



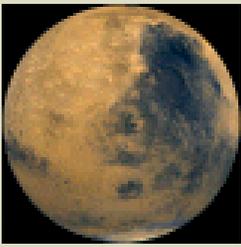
Mission Examples of a Language for Work on Mars

	Mid Mission – two months into mission	End of Nominal Mission- four months into mission
Temporal Constraints	13:30 LST Midday Anytime Post MB Prebrush Sol 46 PreMGS Ultimate/penultimate/antepenultimate	Before 14:30 Post backup Plan A, IF Dist GT .085m Overnight science Pre or Post ODY
Methods	Traverse clast survey Mini-MiniTES Stutter step	Super clast survey Ground Stare 3x1x255 Stares
Purposes	Recon Transient Temperature Doc	Dust Devil Finder Phobos Set
Features	Trex cheek Ejecta blanket IDD work volume	Crater floor Heatshield



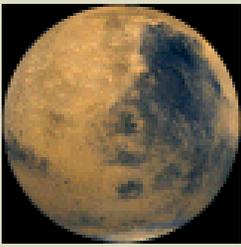
A *Space* for Work “on” Mars

- ▶ How do scientists and engineers do work “on” a planet that is 350 million miles away?
- ▶ Design team members knew what they wanted as functionality (computers, tables, chairs, LAN access), ethnography identified requirements based on the work that was being done.
- ▶ Following work needs identified:
 - The configuration of the space of collaboration
 - A meeting space to suit everyone’s needs
 - The conjoining of a “window on Mars” with an electronic virtual world



Devising a **Space** – Collaboration on Earth and in a virtual Mars World





Devising a **Space** – Hard copy of a Mars virtual world



“A window on Mars”

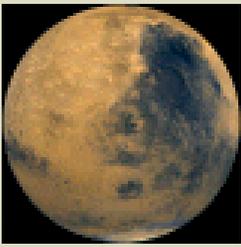
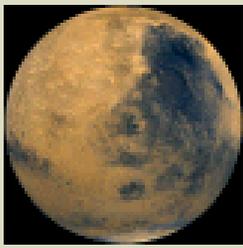


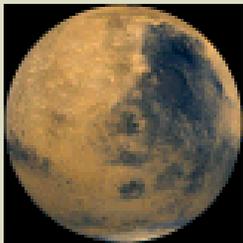
Image Tables: Multiple "Windows" on Mars





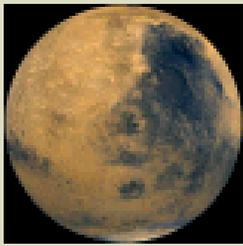
A **Space** for Science and Engineering To Meet and Share Artifacts





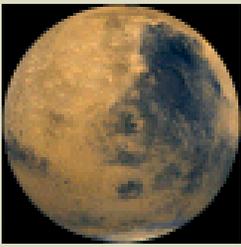
Keeping Track of "Time"

- ▶ What does it mean to coordinate Earth time and Mars time?
 - Isn't it like time zones- just know the differences?
- ▶ Mars sol = 24:39 in Earth time
- ▶ If Mars time (MT) is constant (people are working on Mars time), Earth time (ET) is always shifting
 - Monday MT= 11:00 ET = 18:00
 - Tuesday MT= 11:00 ET = 18:39
 - Wednesday MT= 11:00 ET = 19:18
 - Thursday MT= 11:00 ET = 19:57
- ▶ To understand complexity: substitute EST (eastern standard time) for MT and PST (pacific standard time) for ET above, then decide best time to call someone in PST two weeks from now.



Keeping Track of “Time”

- ▶ Engineers’ and Mission Manager’s pre-mission concept of Mars and Earth time tracking?
 - A standard Earth time clock on the wall and “schedules”
- ▶ Ethnography identified other human relevant “times”:
 - Mars Time - Local Solar
 - 24 hr/military time- meetings at 1300 hrs Mars Time
 - Elapsed mission time
 - Universal Time Coordinated (UTC)
 - Earth time zones
 - Days vs. sols



Keeping Track of “Time”

- ▶ Anthropological understanding of the importance and relative-ness of time allowed us to identify and predict “time” confusion
- ▶ Humans must shift back and forth across “times” within the mission:
 - Two missions on Mars, one on each side of the planet- 12 hours and 20 sols apart
 - Shift between Mars work and the world of families and Earth-time responsibilities
 - Working across Earth time zones –university partners, families, friends, travel

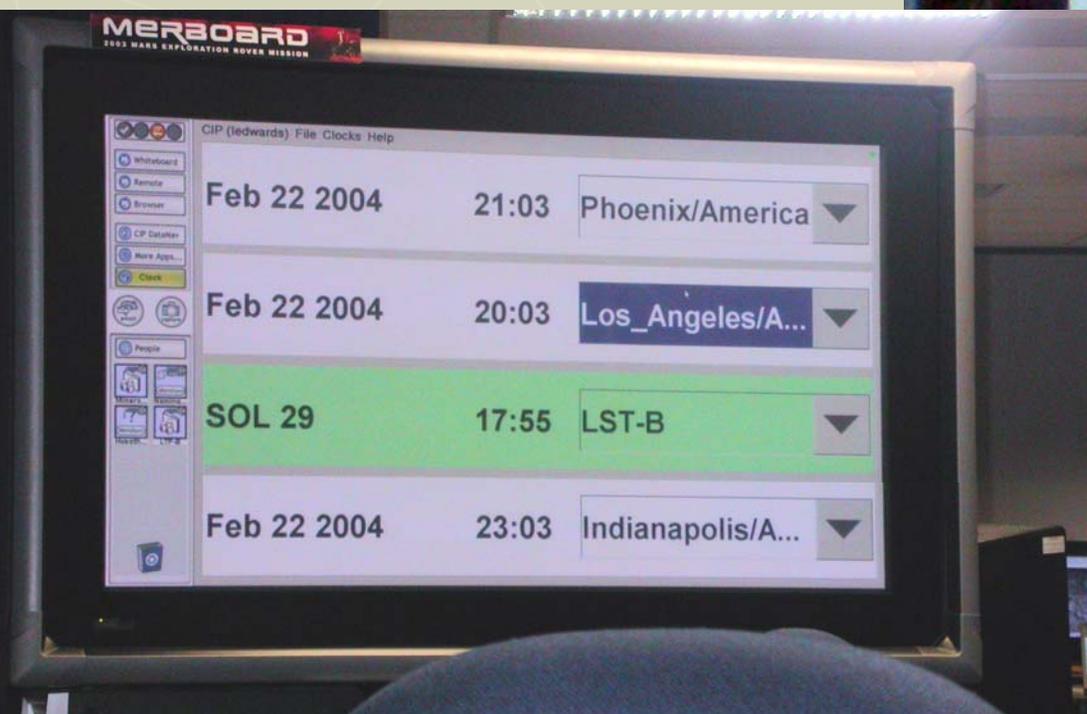
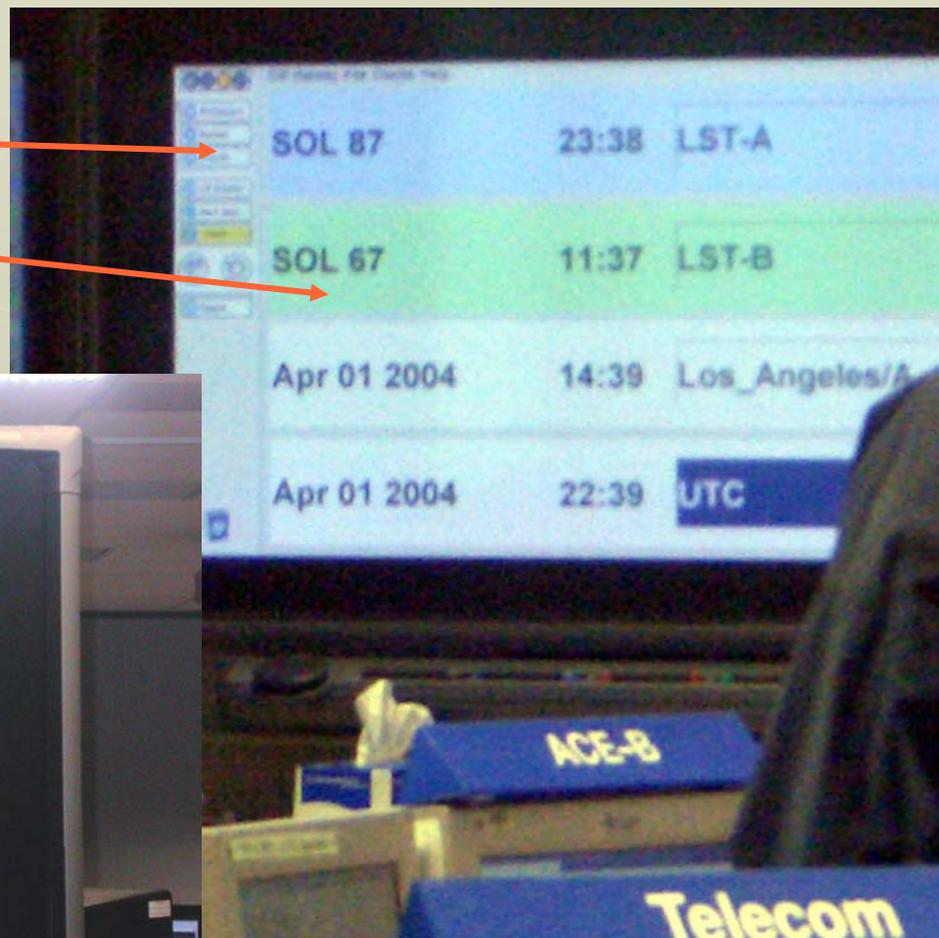


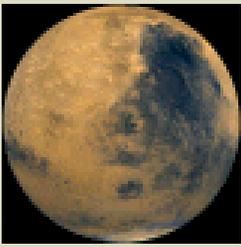
Keeping Track of "Time"

Clocks for Mars Work

Spirit Mission A

Opportunity Mission B





Conclusions

- ▶ “Mission Ethnography”, Anthropology, Science and Engineering each brought a different and necessary perspective to the design of the MER Mars Mission.
- ▶ **Language** once extracted from the domain of work, was applied and developed sophistication over period of mission.
- ▶ **Space** of interaction was spread across two planets and the work and information in those spaces had to be understood.
- ▶ **Time** as an organizer was relative, sequential, circular, delayed, and simultaneous.
- ▶ Mission participants came to respect what social science had to offer. We gained a healthy respect for the complexity of Mars engineering and the work of scientific exploration.
- ▶ Open question: Is this the first “field work” on another planet?