"Working on Mars"

Understanding How Scientists, Engineers and Rovers Interacted Across Space and Time during the Mars Exploration Rover Mission

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Mars Exploration Rover Mission (MER)

- **Science Mission**
  - **Launched: June/July 2003**
  - **Landed: January 2004**
  - **Run for NASA by Jet Propulsion Lab (JPL) in Pasadena, CA. Ames contributed to the mission.**
  - **Mission run on Mars time (Martian sol = 24:39 in Earth time)**
    - **Solar powered rovers**
    - **Sunlight and daytime temperatures for cameras and other instruments**
    - **Objective: search for evidence of past water**
- **Work Cycle**
  - **Activity Planning for rover work and batch of commands sent every sol for rover execution on the next sol**
  - **Nominal mission lifetime 90 sols per rover, spanning four months January thru April**

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Overview

- Description of
  - Ethnographic Methods for MER
  - "Mission" Ethnography
  - Assessing a Work System
- Overview of a MER work day
- Scientists, Engineers and Rovers Working "on" Mars
  - Facilities
  - Communicating with a rover on Mars
  - Earth time, Mars time and Keeping track of time

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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

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"Mission" Ethnography at NASA

Rules of Mission ethnography:

1. If you have a badge and are taking up room in meetings or tests, you must contribute and add value.
2. Launch, landing and surface operations will meet the mission timeline whether you contribute or not.
3. Feedback that is late is useless; input on software development, systems integration and training must meet the above timelines.
4. Mission personnel will remember if you contributed or not and this will influence their future interactions with you. (See 1 above)
5. Processes and Procedures will be re-worked into the mission. They are the only thing that does not have a freeze and change control limitations.

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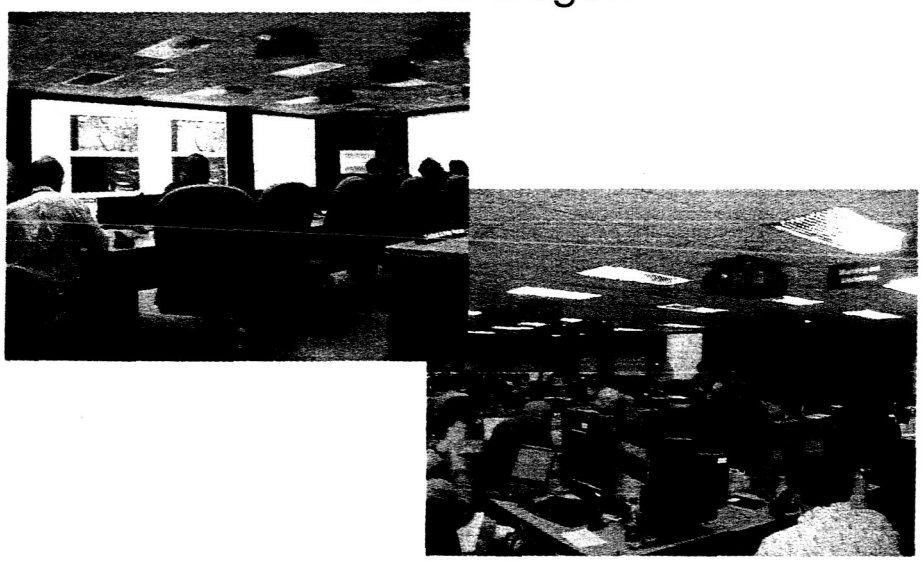
Assessing a Work System: Where to Begin?



Assessing a Work System: Where to Begin?

- Work System Analysis
  - What is the organizational structure? How do people access, display and share information?
  - What tools do people use?
  - What's in the software? What should be in the software?
  - How do people communicate?
  - What are the described processes (work process) vs. actual work (work practice)
  - What are the breakdowns and disconnects? What is the re-work?
  - When and where are decisions made? Who is responsible for what?
  - How do the facilities support the work?
    - Rooms, work stations, tables, chairs, printers, projection screens
  - What is missing?
    - Minimal support of standard information sharing formats: ex: Copiers and Printers not easily accessible, etc.

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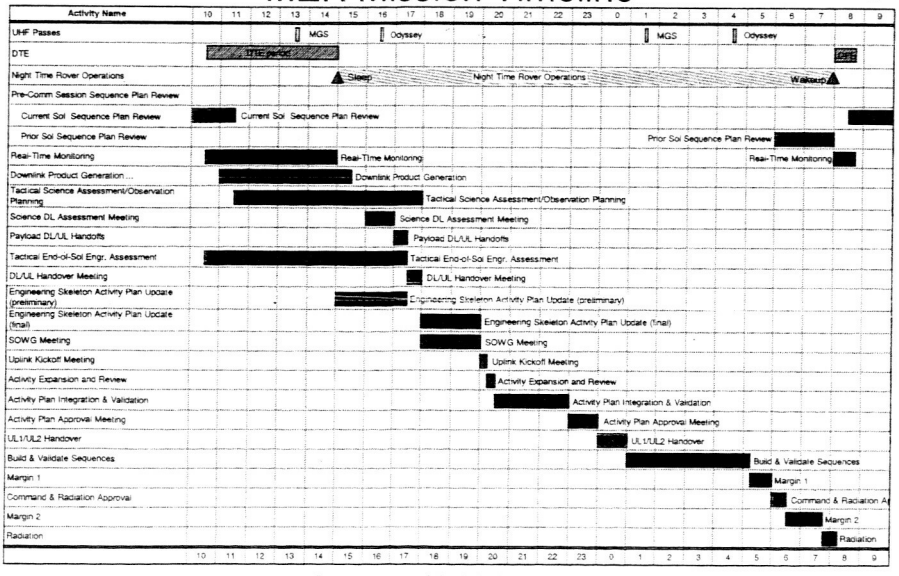
MER Mission Timeline



Courtesy of MER Mission
Jet Propulsion Laboratory

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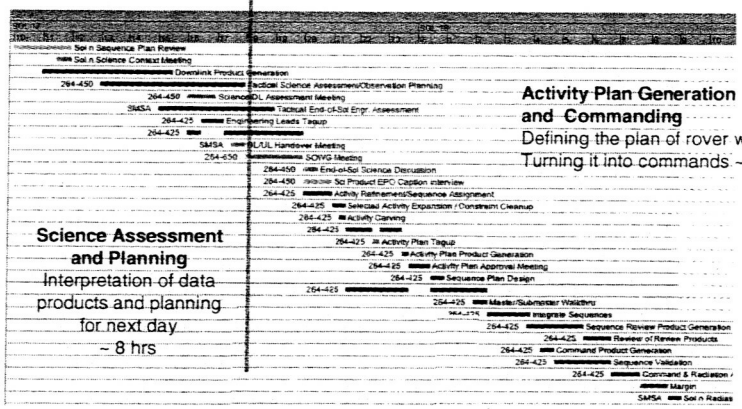
Daily/ "Soly" Timeline for Work, Planning and Commanding

- Day/Sol split into two phases:

Downlink: Receive data from the rover, do health validation and data product generation. Decide on and generate science plan requests

Uplink: Prioritize, constrain, plan rover activity. Generate, validate, and transmit commands to the rover



Science Assessment and Planning
Interpretation of data products and planning for next day
~ 8 hrs

Activity Plan Generation and Commanding
Defining the plan of rover work and Turning it into commands ~ 14 hrs

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Facilities Design

- Where is this work done?
- How do you support tele-robotic science that must know what is happening on Mars?
- How do you support collaboration?
- What are some of the more interesting ways in which the facilities contribute to the work?

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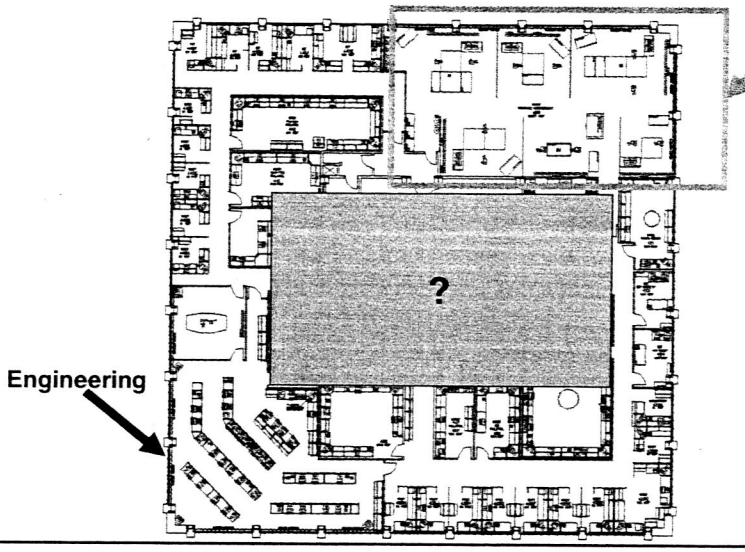
Facilities: Mission Support Area (MSA)-Bird's Eye View



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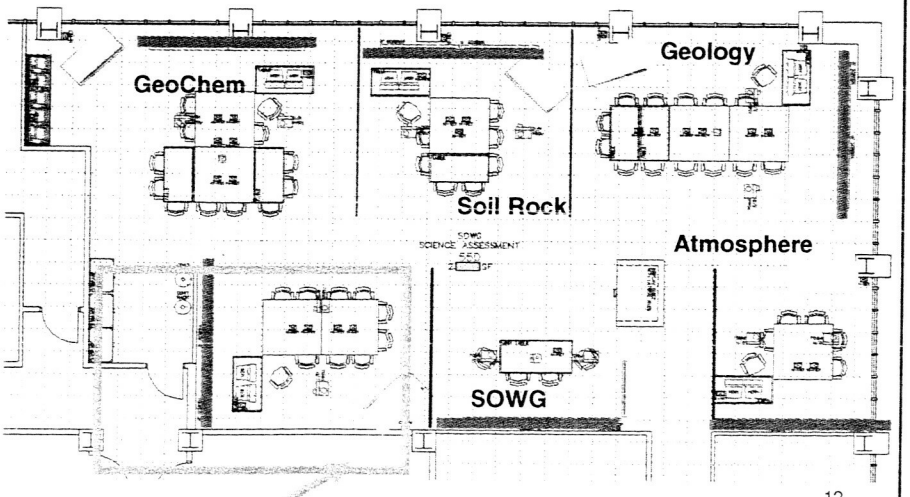
Facilities: Science Assessment Room

Five Theme Groups- Planning for collaboration and work



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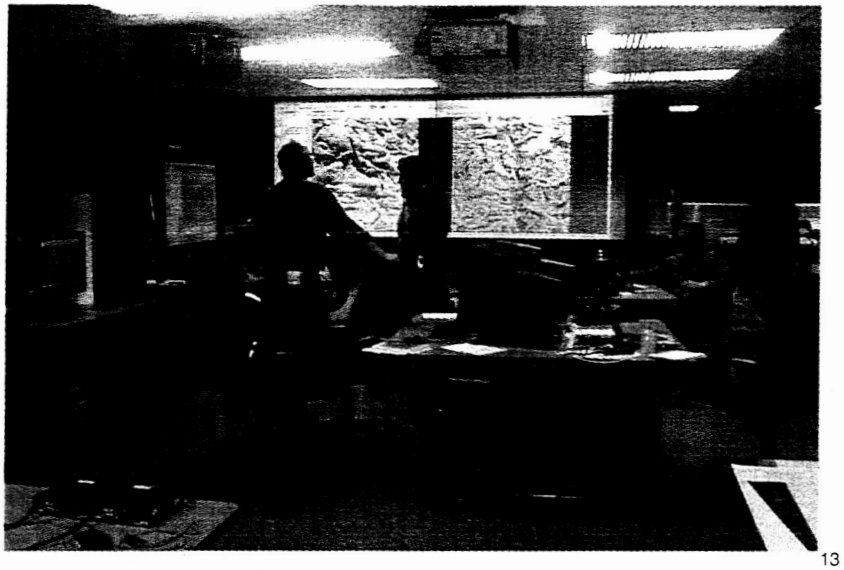
Long Term Planning Area



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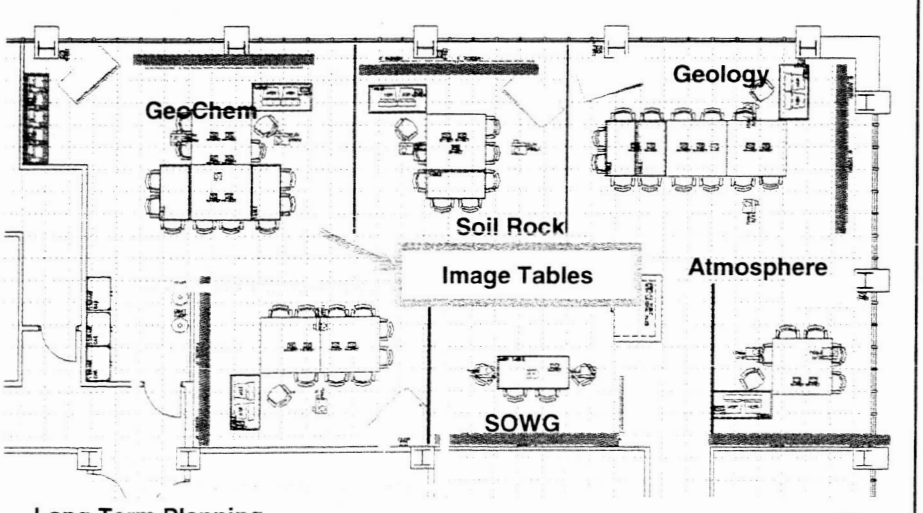
Facilities: Science Assessment Room



Long Term Planning

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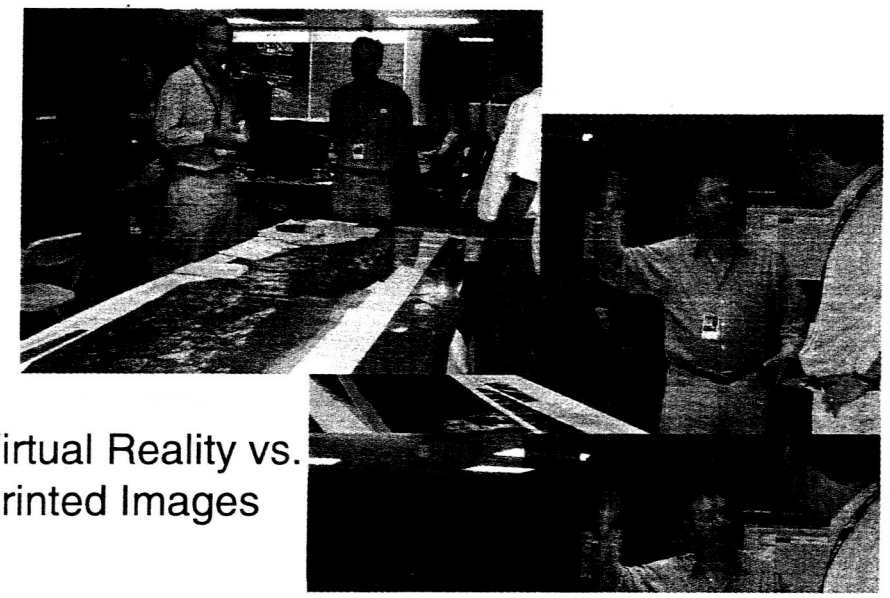
Image Tables: A "Window" on Mars



Virtual Reality vs. Printed Images

Communicating Across Teams and with the Rover-The Problem

- Problem: how do you convey information across teams and to a rover, when:
  - participants speak different technical languages
  - focus on different issues
  - have different tasks
  - use different software tools
  - must communicate from humans to a robot
- Not just an academic exercise, the answer influenced mission software design

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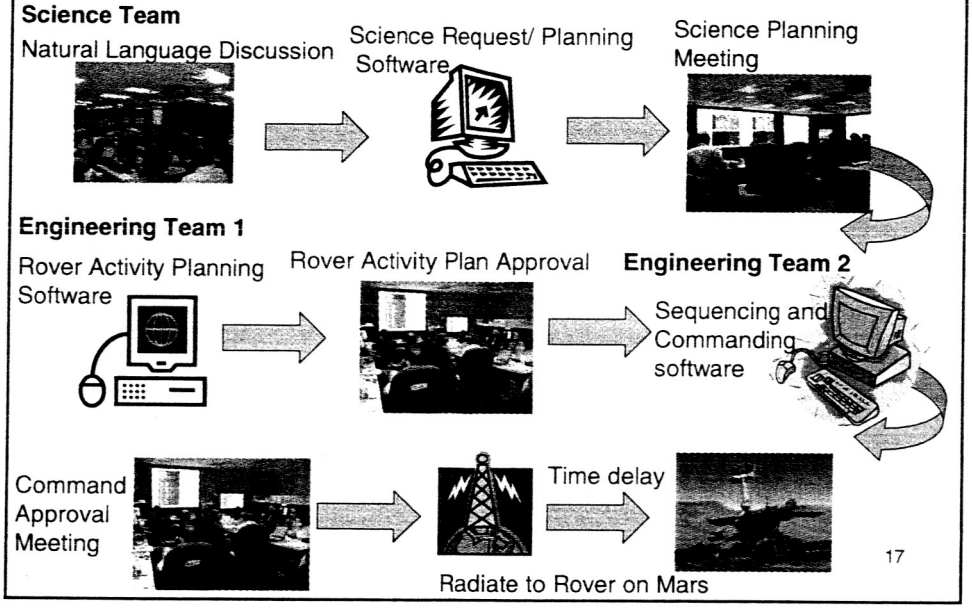
Communicating Across Teams and with the Rover- the Problem



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Communicating Across Teams and with the Rover- An Answer

- Answer: Identify a naming convention that describes the work and
  - allows for natural language discussion
  - identifies components that are relevant to all teams Ex: instrument such as Pancam or RAT
  - identifies both the activity and the object on which the work will be done Ex: Pancam on Feature
  - identifies formalized concepts Ex: kind of activity
  - carries across software tools
  - can be translated into work for the rover
  - Ex: Pancam_surveyaround_Adirondack

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Earth Time, Mars Time, Keeping Track of Time

- Martian sol = 24:39 minutes in Earth time
- Mission works on Mars Time
- Participants report at the same time on every Martian sol: 12:00 hrs.
  - But to do that they have to keep track of ever changing Earth date, hour and minute
  - Report to work 39 minutes later every day in Earth time: 12:00, 12:39, 13:18, 13:57, 14:36 etc
  - Schedules help keep track

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Earth Time, Mars Time, Keeping Track of Time

MER A				
Date [PDT] @ PDL Shift Start	1/5/04 15:08	1/6/04 15:48	1/7/04 16:27	1/8/04 17:07
Approx. Sol	3	4	5	6
Pancam PEL	JBe	JBe	JJo	JJo
Pancam PDL	MLe	MLe	RMo	WFa
Pancam PDA	JSo	FSe	FSe	MJo
Pancam PDA2	MWo	WFa	MJo	JSD
Pancam PUL	JPr	JPr	HAr	HAr
Pancam PUL2	EMc	MBM	JPr	MBM

Courtesy of MER Pancam Team and J. Bell

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Earth Time, Mars Time, Keeping Track of Time

- Keep track of time meant knowing:
  - LST for each mission (local solar time on Mars at each site)
  - Relationship between LST A and LST B (twelve hours *and* 20 sols apart)
  - Relationship between LST and PST (what time it is in the "outside" world)
  - UTC (Universal Time Coordinated for radiating commands to Mars)
  - Military time (for aligning Earth and Mars time work within the mission)
  - Time in other Earth time zones (for scientists working with people at home institutions)
  - Relationship between Sol (1, 2, 3) and Earth date (1/5/04)

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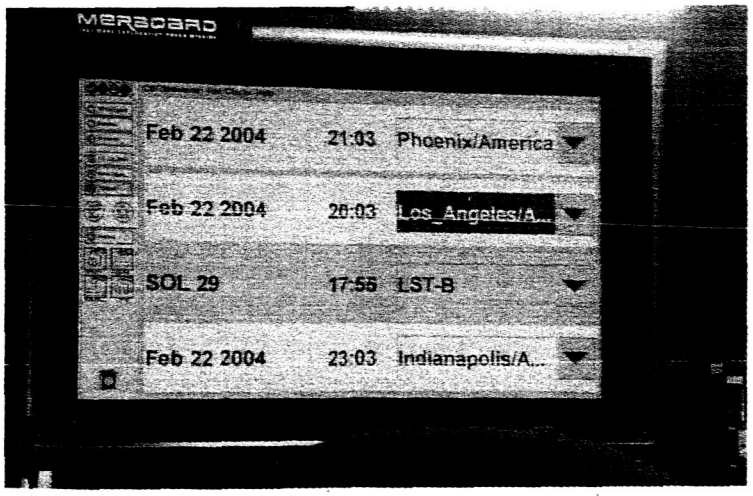
Earth Time, Mars Time, Keeping Track of Time



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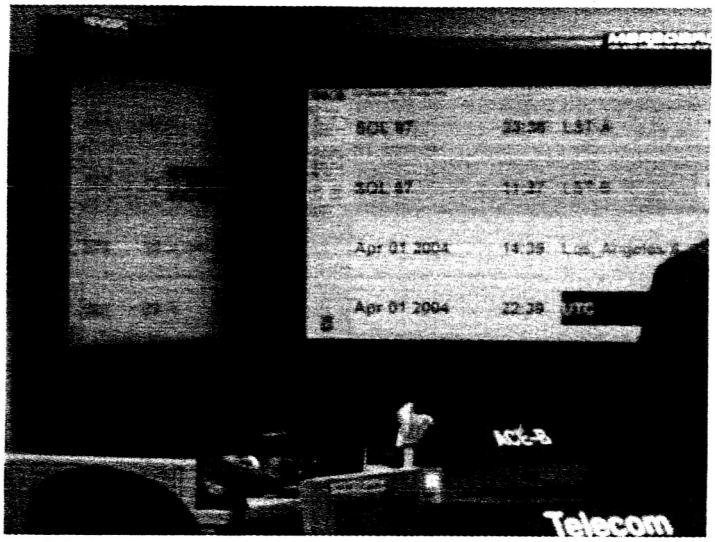
Earth Time, Mars Time, Keeping Track of Time



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Earth Time, Mars Time, Keeping Track of Time

Quote found written on white board by MER participant :

What time is it in reality?

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