A FRAMEWORK FOR ANALOG STUDIES OF MARS SURFACE OPERATIONS

Using the Flashline Mars Arctic Research Station

William J. Clancey, Ph.D.

Chief Scientist, Human-Centered Computing

NASA/Ames Research Center

University of West Florida

First Presented at the Mars Society Third Annual Conference
August 2000

Outline

Using FMARS as a research facility requires a framework for systematically defining and evaluating experiments at Haughton

- Research dimensions & contributions
- Characterizing fidelity
- A difference-based strategy for defining experimental protocols
- Likely scenarios
- Management recommendations

Problem Statement

- How can we exploit FMARS to prepare for living and working on Mars?
- **Do the environmental and logistic differences between Devon Island and Mars preclude transfer?**
- Is there a principled way of "analyzing away" the differences, to produce data that will be valid on Mars?

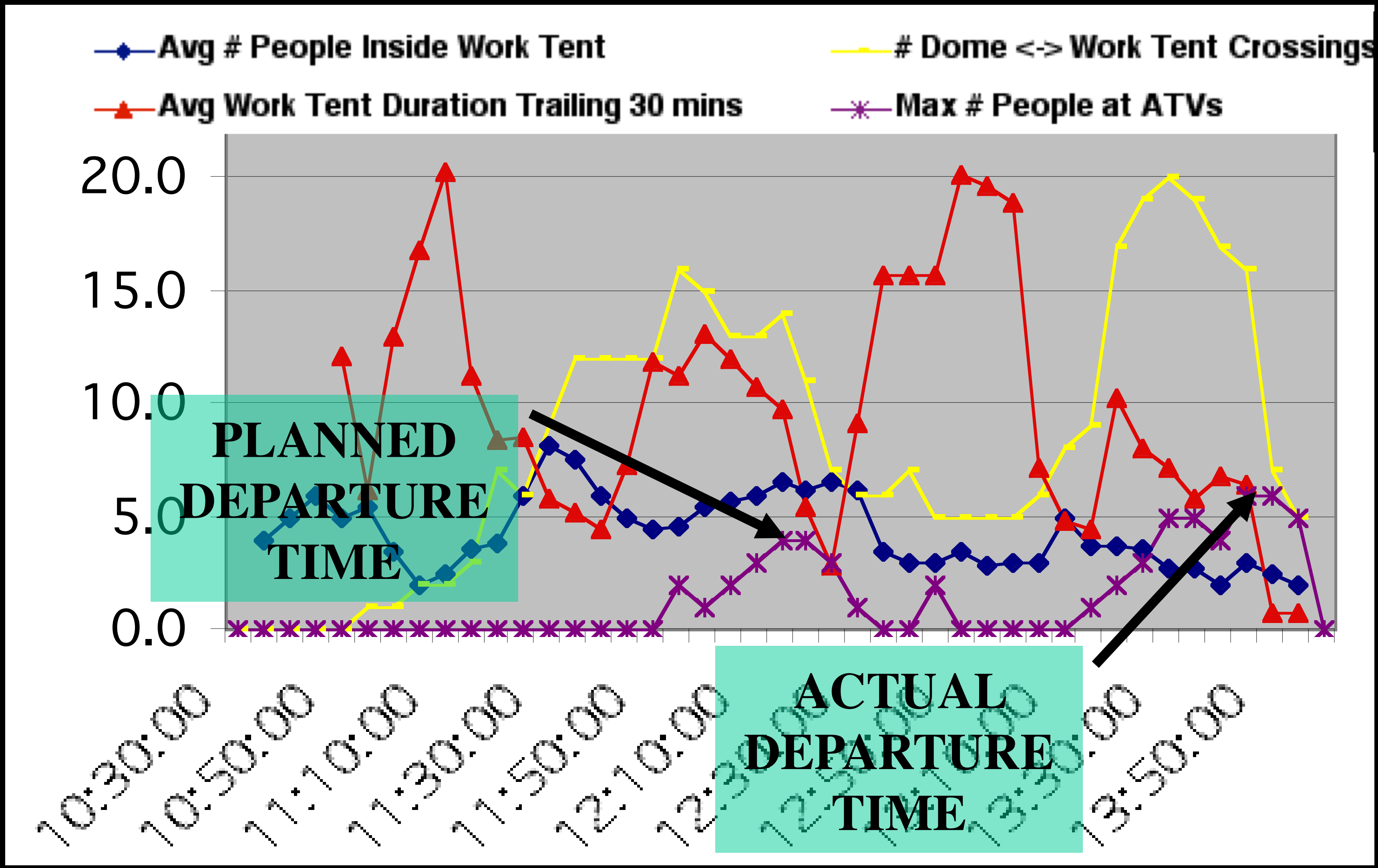
Analog Study Dimensions

- **Discipline:** Human factors, biology, sociology, geology, telecommunications, computer science, architecture, etc.
- **Work/Life Activity:** Data gathering/analysis, exploration, life support, recreation, planning, waste management, cooking & cleaning up, chores, retrieving/storing supplies, interaction with earth, sleep/eating/hygiene, etc.

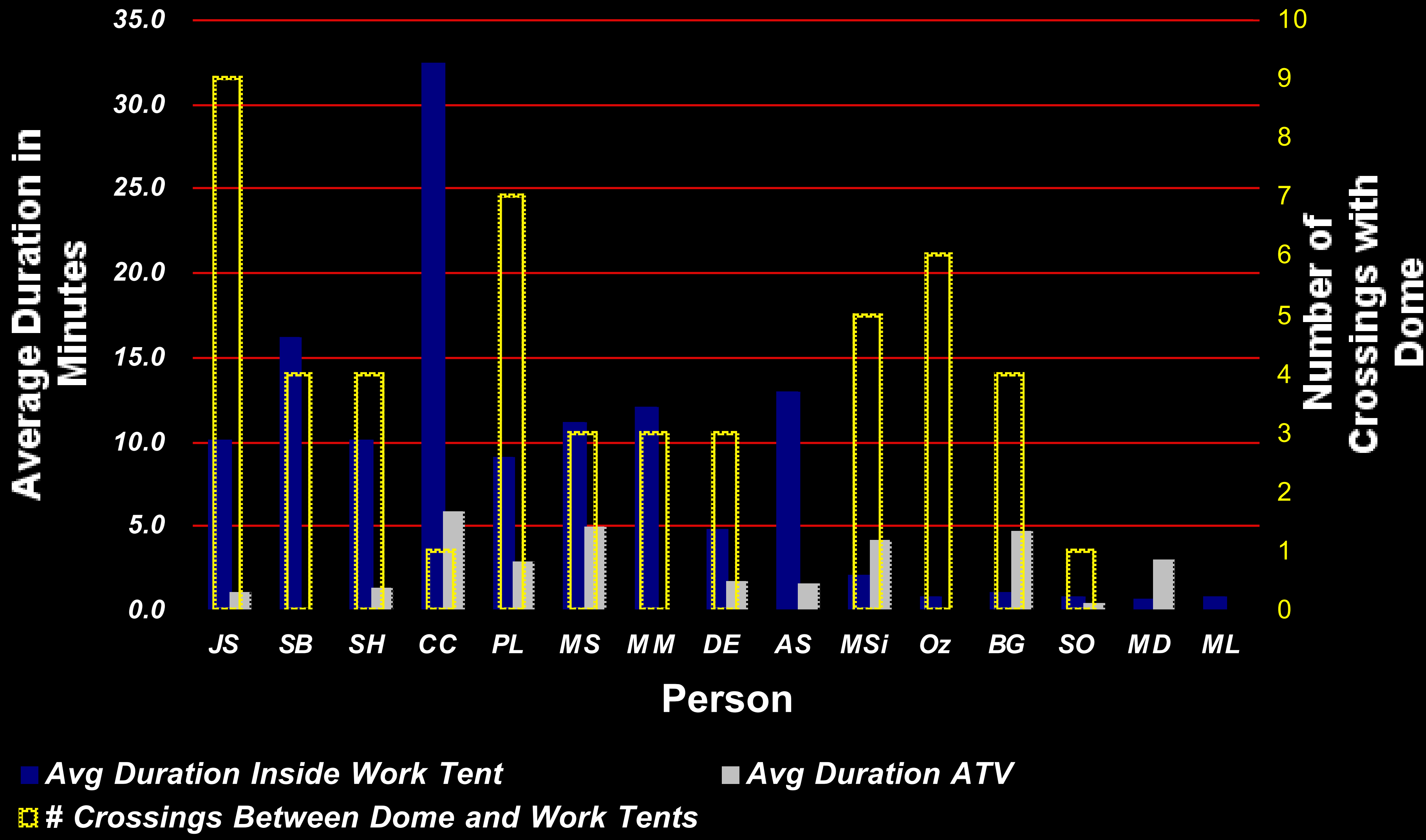
Time-Space Interactions

- Time lapse 3 hrs (11am-2pm)
- 3600 frames
- Movement between ATVs & shared tents
- Corresponds to two floors of habitat
- Shows effect of schedule changes on resources (ATVs)

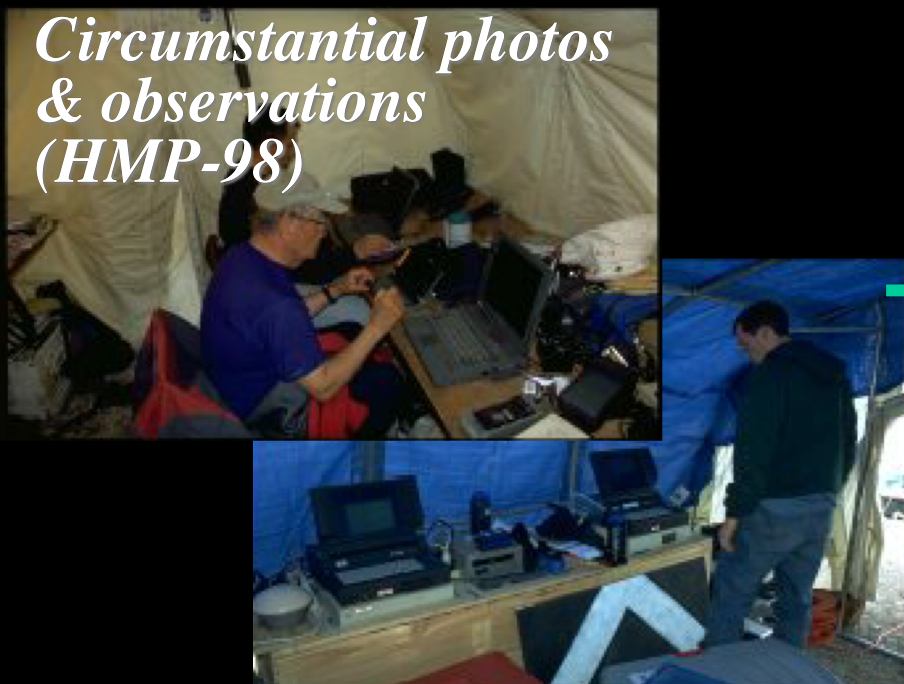
Time Lapse Analysis



Average Duration by Person
(with number of crossings)



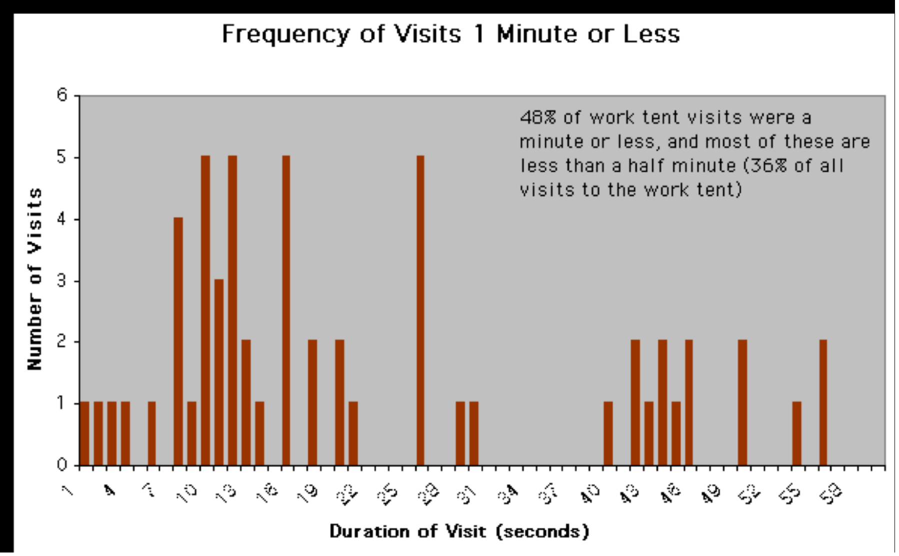
Analytic Progression



Circumstantial photos & observations (HMP-98)

Systematic setting-oriented record (time lapses, HMP-99)

Next: Account for frequency distribution —Triangulate systematic person and artifact-oriented records => time lapse + shadowing



Time Lapse Analysis

Log of inside work tent time

	A	B	C	D	E	F	G	H	I
1			**Work Tent**			trail 5 min	trail 30 min	In last 5 mins	trail 30 min
2	**TIME**	**PERSON IN**	**PERSON OUT**	**# INSIDE NOW**	**DURATION**	avg # inside	avg dur	Max # Inside	traffic
3	15:26:36			0					
46	15:27:19	JS		1					
47	15:27:20	SO		2					
48	15:27:21	PL		3					
104	15:28:17		PL	2	56				
207	15:30:00					0.5	56	1	
316	15:31:49	KS		3					
467	15:34:20	BC		4					
507	15:35:00					3.5	56	4	2
573	15:36:06		BC	3	106				
807	15:40:00					3.0	81	3	1
858	15:40:51		SO	2	811				
1107	15:45:00					2.0	324	2	1
1407	15:50:00					2.0	324	2	1
1707	15:55:00					2.0	324	2	1
2007	16:00:00					2.0	459	2	1
2076	16:01:09	RA		3					
2132	16:02:05	BC		4					
2158	16:02:31		BC	3	26				
2307	16:05:00					3.3	314	4	3

14,500 frames –(manual)–> Data sheet –(macros)–> Charts

Work Tent Visit Durations

First row has been cut in half to fit

```
 0 | 1 2 0 2 2 1 0 0 0 1 0 0 1 0 0 1 0 0 0 1 0 0 7 1 1 4 7 0 0 0 0 0 2 3 4 0 1
 1 | 4 0 4 6 6 2 8 1 2 2 0 1 2 4 1 1
 2 | 6 2 8 6 0
 3 | 0 1 7 0 8
 4 | 7 7
 5 | 4 0 6
 6 | 6 3 0 6
 7 | 8
 8 | 4
 9 |
10 | 8
11 |
12 |
13 |
14 | 3
```

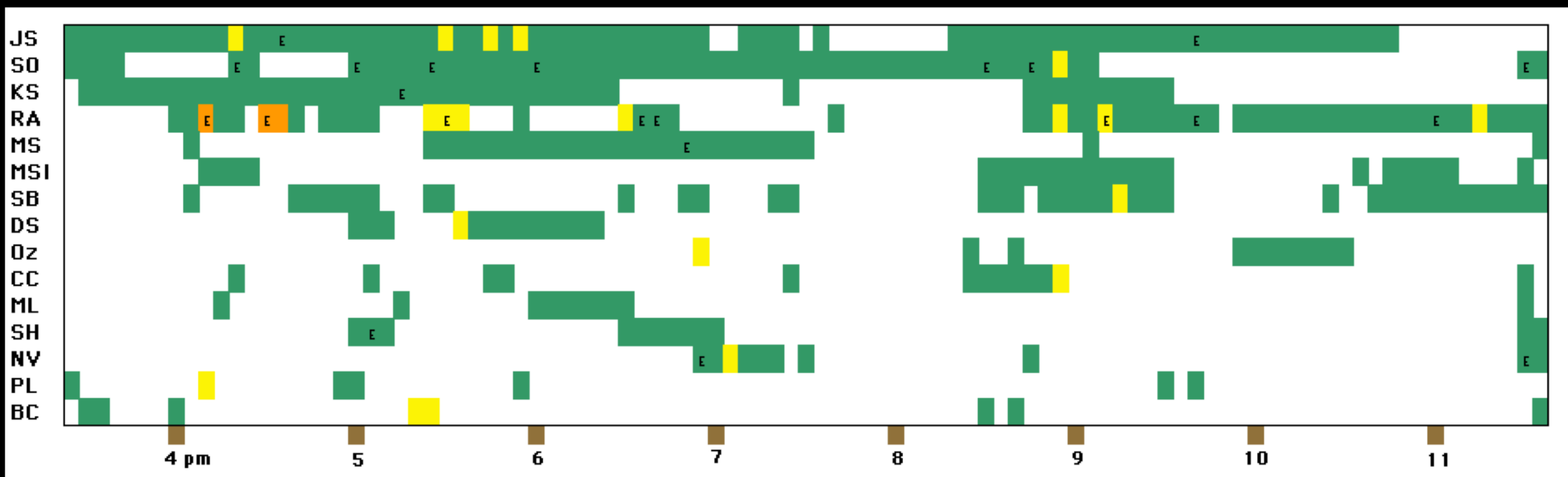
July 11, 1999 — 3:26 - 1130 PM

Duration in minutes, e.g., 14 | 3 = 143 mins

(after Tufte, split line chart)

Frequency and order of visits —50% under 10 minutes => storing & retrieving things

Tent Visits by Person



KEY:

Each cell = tent occupation during 5 minute interval

Green = present

Yellow = exit & renter

Orange = reenter twice

E = exit without return

Hab Time Lapse

First "formal" occupation
Second evening together
July 31, 2000 18:10-21:50

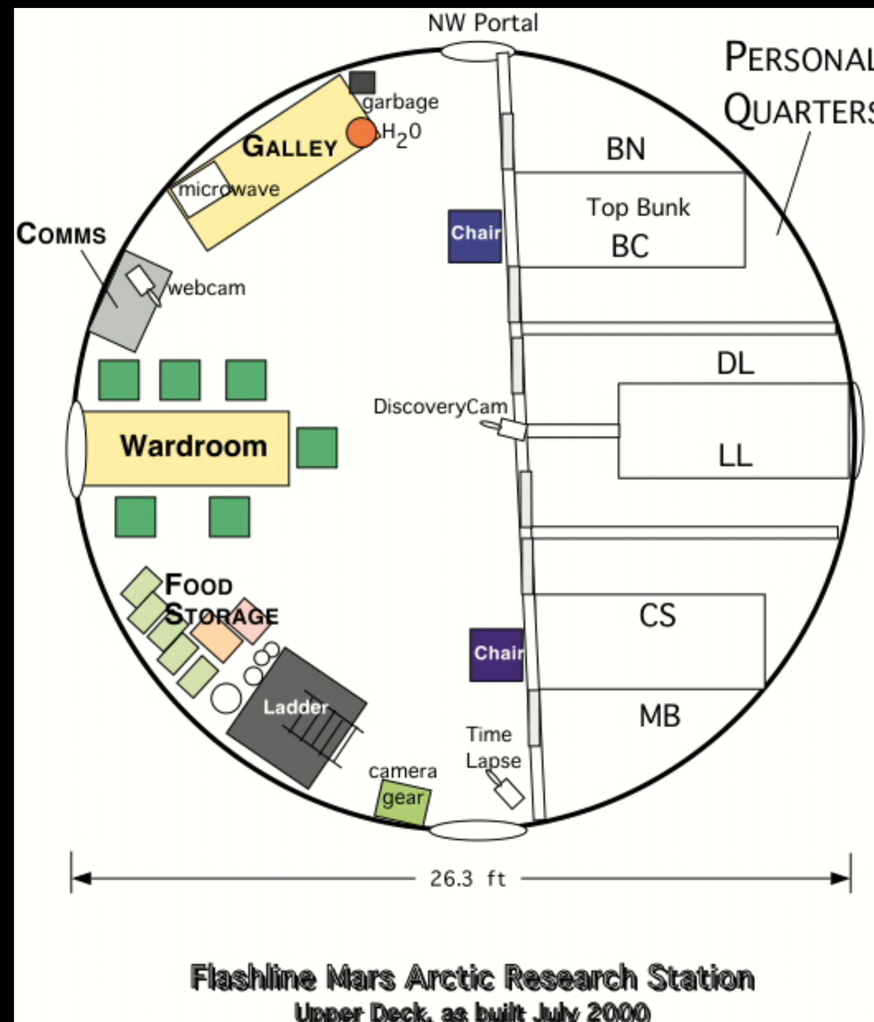
Analog Study Dimensions (cont.)

- **Mission Phases:** Preflight, landing, set-up, exploration, reporting, pre-departure, next crew
- **Engineering & Implementation:** Requirements analysis, design, documentation, validation, training
- **Known Challenges:** Atmosphere, gravity, radiation, dust, water, fuel
- **Technologies:** Communications, life support, automation,...

Need to coordinate research dims for synergy, balance, and systems integration

Expected Contributions

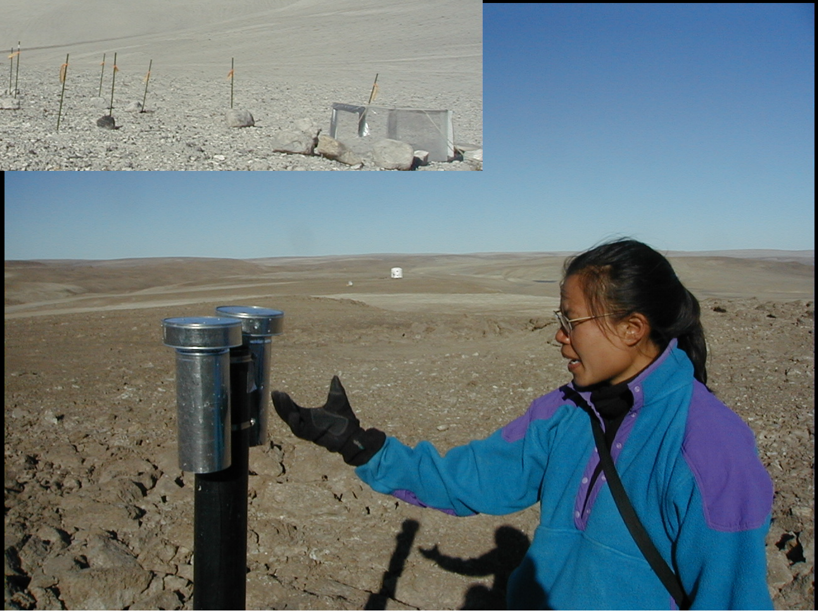
- Hab design
- Daily life schedules & procedures
- Crew selection



Flashline Mars Arctic Research Station
Upper Deck, as built July 2000

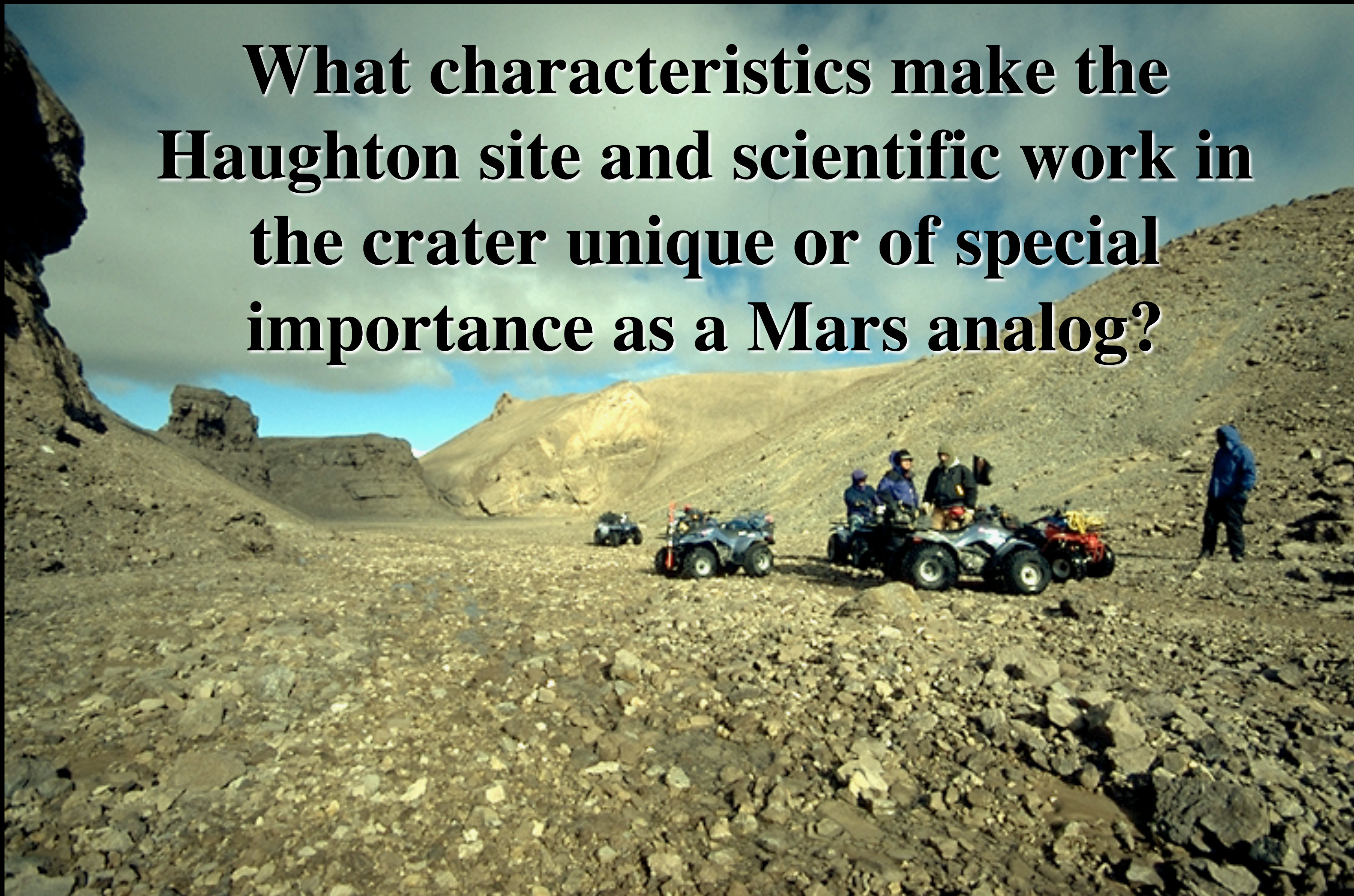
Expected Contributions (cont.)

- Space suit capability & durability
- Scientific instruments (types, deployment, monitoring)



Expected Contributions (cont.)

- Communication protocols (mission support, PIs, public)
- Telecommunication/ computer equipment (hab, rover, space suit, earth)
- Automation requirements (life support, rovers, science, & exploration)
- Telescience, medicine, training


What characteristics make the Haughton site and scientific work in the crater unique or of special importance as a Mars analog?

Fidelity Characteristics

- **Inherent high-fidelity** (e.g., authentic work to be performed and time constraints on being outdoors)
- **Imposed experimental** (e.g., wearing realistic gloves and coordinating with off-site investigators)

INHERENT HIGH-FIDELITY CHARACTERISTICS

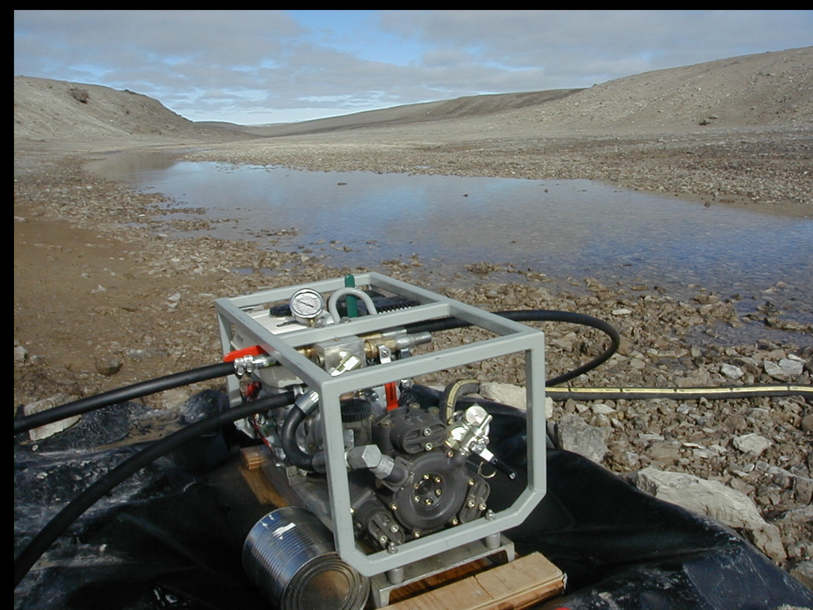
- Habitat with realistic dimensions and life support
- Work has ecological validity—field science in a cold, rocky, windy, dusty, periglacial environment
- Life support, power, transport, and instrument systems require regular monitoring, resource management, and maintenance
- Satellite data services (GPS, weather, communications) and local wireless networks are available and necessary
- Remote field instruments are deployed and monitored
- EVA sites must be revisited, but access is limited
- Distant sites provide logistic support (esp. Resolute)
- Local weather must be monitored for safety and planning
- Protective clothing is necessary

IMPOSED EXPERIMENTAL CHARACTERISTICS

- "Science Backroom" (perhaps distributed over the Internet) monitors and advises; provides tasks & training
- EVAs: Walkable return, use walkie-talkies, wear space suits, plan & monitor, video available at base camp & mission support
- Shared scientific database, reused and extended by multiple crews, downloaded to mission support; field dictations transcribed by mission support
- New crew members trained on systems, geography
- PIs at NASA centers and universities participate in data interpretation, instrument use, and EVA planning
- Robots serve as advance scouts, field assistants, caching
- Crews install additional equipment & upgrades

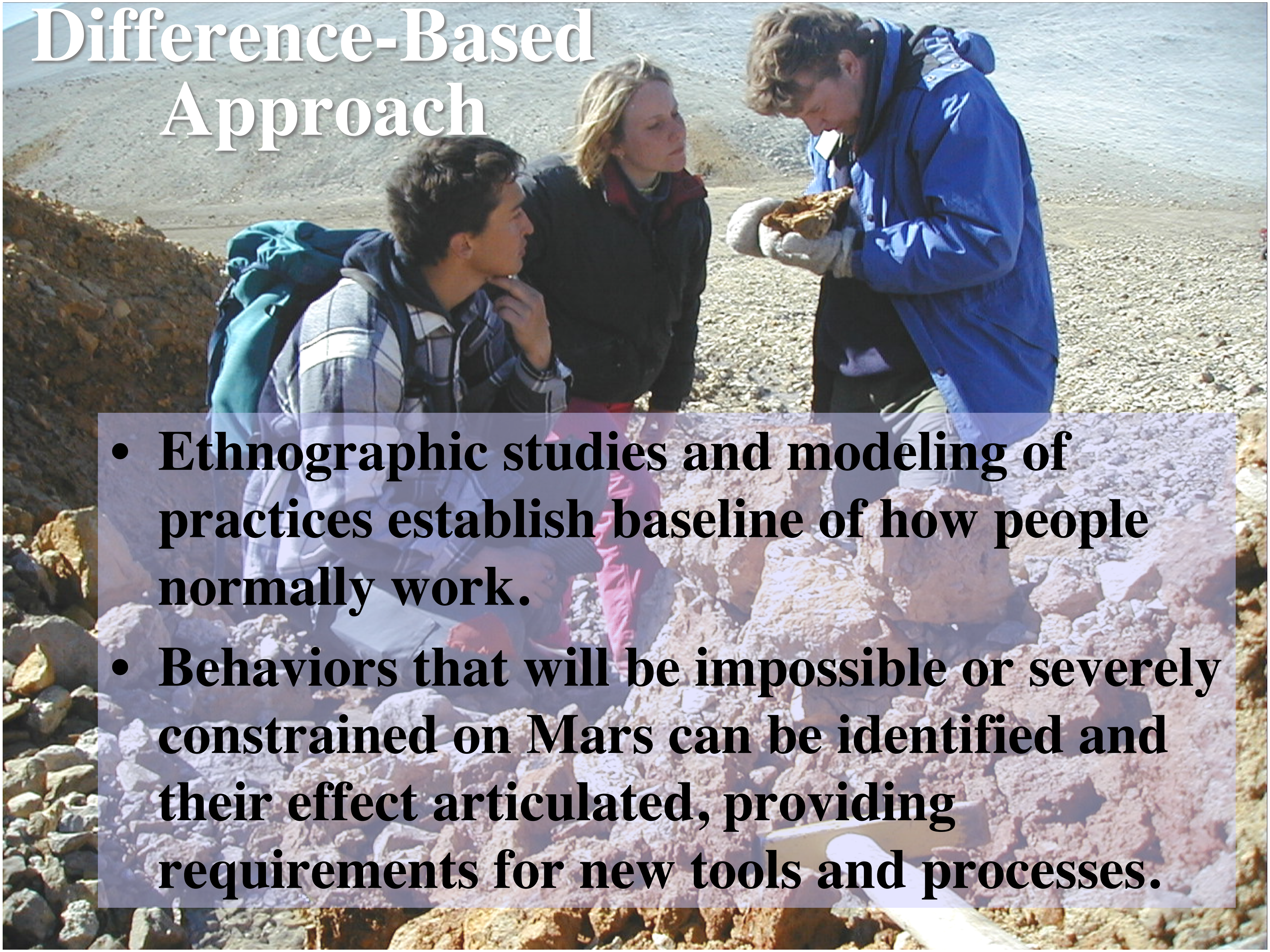
Key Differences: Devon Vs. Mars

- Atmosphere (pressurized suits)
- Surface water
- Food
- Fuel (power, ATVs)
- Medical care
- Time delay
- Sunlight
- Gravity



Analytic Approach

- Differences between Mars and Devon could be a primary driver for defining protocols
- Rather than viewing as reducing validity, understand their effects & ameliorate by design
- For example, how is a geologist's observation, interpretation, and memory changed if drawing on site is not possible, but restricted to annotating photographs after a traverse is complete (or in a pressurized rover)?



Difference-Based Approach

- **Ethnographic studies and modeling of practices establish baseline of how people normally work.**
- **Behaviors that will be impossible or severely constrained on Mars can be identified and their effect articulated, providing requirements for new tools and processes.**

LIKELY SCENARIOS

- Daily life in the hab
- Traverse planning, navigation, monitoring (& remote camp)
- Tending field instruments
- Communication with mission support, co-PIs, public
- Maintaining & troubleshooting equipment
- Mixed-initiative teleoperated exploration
- Analyzing data in the hab & researching related work

Key Opportunity

Experiments that test and exploit contextual interactions of the total system:

Facilities, crew roles, clothing/suits, instrumentation, operations, medical care, documentation, training, life support & exploration automation, external support, communications, etc.

FMARS
Principles of Operation

- Clarify the unique human abilities to explore Mars and how automated systems may complement them
- Exploit opportunity for total system design & evaluation
- Minimize role of aspects better treated elsewhere (e.g., duration)
- Treat Devon setting as the *mission*, preceded by *sims* that certify equipment and train the operators and crew
- Employ critical engineering analysis in scenario design & analysis. Let imagination evoke, not convince.
- Distinguish media show from engineering experiments. Don't overdo simulated "being on Mars" for the sake of the media.
- Manage by science committee with written policies & peer review, with overall long-term objectives in mind.


Finally, create an inspiring vision that relates engineering, science, history, and art...

"Make no little plans, they have no magic to stir men's blood. Make big plans, aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing asserting itself with ever-growing insistency."

Quoted by Charles Moore in *Daniel H. Burnham, Architect, Planner of Cities* (Boston, 1921)

For more information...

- Human Exploration Ethnography (2002)
- Visualizing Practical Knowledge (1998)
- Field Science Ethnography: Methods for being systematic and productive on an expedition (2001)

Make no little plans….

Available at:
https://billclancey.name/WJCMarsSociety.html