TIMING IS EVERYTHING:
ISSUES OF DISPARATE TEMPORAL REGIMES IN SPACE OPERATIONS

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MARILYN DUDLEY-FLORES
THOMAS GANGALE

This is a work-in-progress

and is just another steppingstone in a tentative trail of literature suggesting that the issues of the mission control environment be studied more in depth.

As the gulf widens both spatially and temporally between astronaut crews and their mission controllers -- to the point that mission control is but a “help desk” function, the help that mission controllers provide had better be the best help available in this or on any other world.

We approach the issue of Mars mission controllers trying to keep time by two planetary clocks from the dual standpoint of:

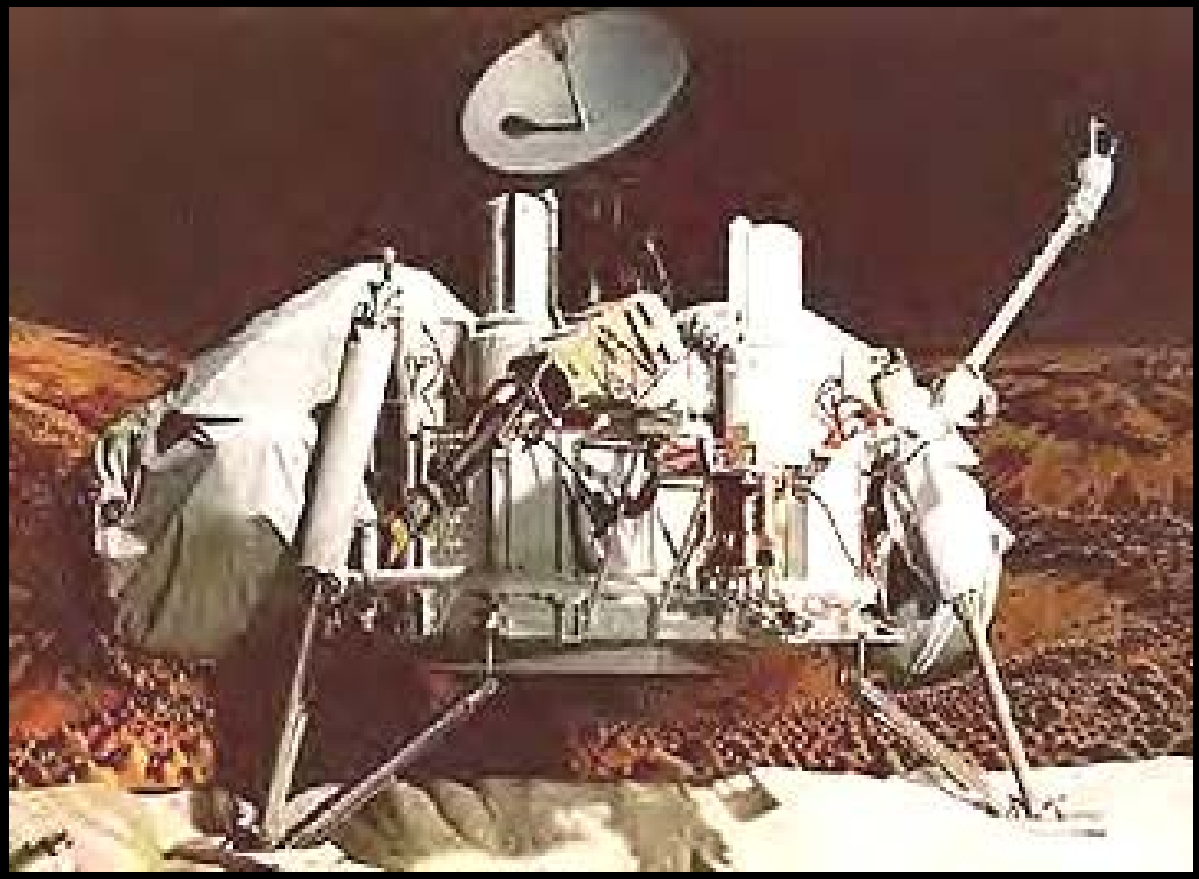
- Having made psychosocial investigations of astronaut and cosmonaut crews; and
- Having made investigations of what it would be like to keep time on Mars

Distressing Anecdotes

In 2004, when anecdotes began to come to our attention from among space industry workers that robotic Mars mission controllers and their families had suffered because of the effects of Mars timekeeping on Earth, we searched the literature. What was *not there* painted a large signature.

How Did the Viking Lander Controllers Cope?

For example, no compiled record of the unique stressors of the mission controllers of Mars surface operations exists from the Viking Lander era till now. It has yet to be compiled.



Our Involvement -- 2004

In the wake of the anecdotes that we heard from space industry workers, we and several colleagues were asked to pitch a study by NASA and NASA contractor members of the AIAA. The thrust of our effort was to have matured the research on mission controller issues as they connect to working shifts according to two planetary clocks. End products would have been optimal crew shift schedules minimizing health/safety risks. The funding did not emerge.

Deborah Bass, Roxana Wales, and Valerie Shalin

However, a smaller team, largely comprised of NASA employees, did manage to obtain some NASA funding around the same timeframe as our effort, and *they* were able to conduct a study that focused on the advantages and disadvantages of using “Mars-Time” during the Mars Exploration Rover (MER) missions of *Spirit* and *Opportunity* for 90 Martian days each (Bass, Wales, and Shalin 2004).

Anecdotes and Interviews

The way they approached the problem was not dissimilar to how we had planned to investigate it – by probing the anecdotes and conducting interviews with *Pathfinder* and MER mission controllers. They had an additional advantage of participant-observation.

Still, others have touched on the dual planetary clocks problem through their concerns for non-astronaut space industry workers and the way that NASA apprehends the utility of psychology.

NASA and Psychology

Social psychologist Peter Suedfeld wrote in 2005 that It was important to study ground personnel, who share in the successes and failures of the space mission. “Televised pictures of the exultation on their faces at the successful completion of a mission, and their dejection when something goes wrong, are clear evidence of their total involvement.”

Suedfeld pointed to the mission controller responsibilities for the mission, on top of the fact that they were often away from their families -- in their total involvement with the mission.

Four Phases of Space Psychology

Suedfeld outlined four phases concerning the evolution of the interface between NASA and the psychological research community: 1) invulnerability, 2) coping, 3) salutogenesis, and 4) integration. These different phases are exemplified respectively by the following statements.

1) Astronauts are invincible.
2) We made do with what we had.
3) I am a better person for the experience.
4) A great many factors motivated me and many others contributed and were affected.

The Fourth Phase – Integration – Is Yet to Occur in How NASA Uses Social and Behavioral Scientific Knowledge

Meanwhile, back in Pasadena

1) Mars mission controllers were *not* invincible.
2) They made do with what they had, but….
3) Were they really better people for their experiences?

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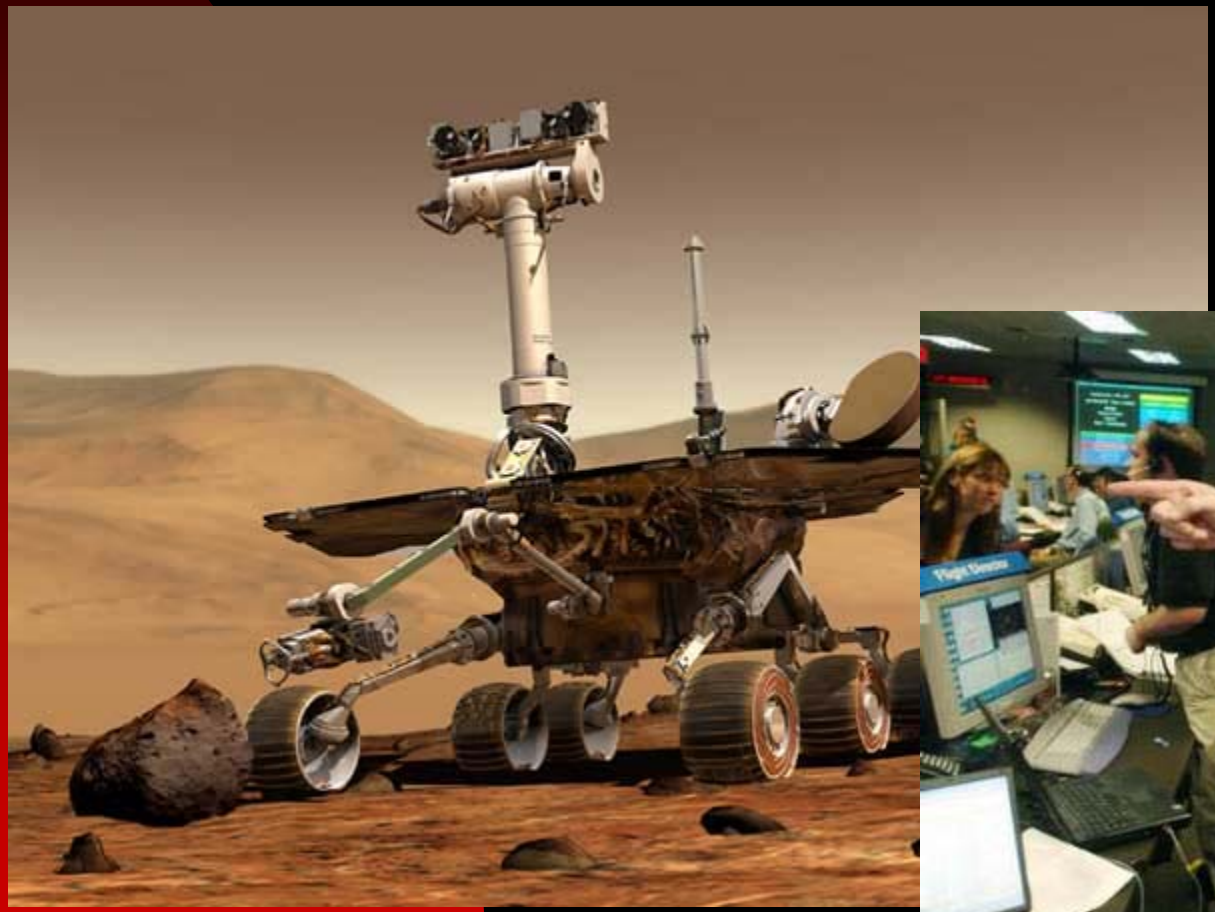
From the integration standpoint: What were the many factors that surrounded them as they attempted to keep time on two worlds and how were others affected?



Mission controllers trying to keep track of time on two worlds reminded us of our previous psychosocial studies of astronauts

The anecdotal accounts of dysfunctional, deviant, and conflictive behaviors among Mars rover mission controllers during the course of their duties remind us of the astronauts' stories of their stressors. But, mission controllers are not the "rock stars" of the space industry. Their issues fly low under the radar. But, it is not a quantum leap of logic to understand that the effects of mission requirements on mission controllers could impact missions, including future human-crewed Mars missions.

From our other studies concerning timekeeping on Mars

We suspect that astronauts on Mars will have very little trouble physiologically adjusting to the length of the Martian sol as they locally go about living and working there. Submariners, explorers, and those who engage in deep caving expeditions and Antarctic winter-overs seem to have little trouble adjusting their diurnal cycles to the unique features of their environment. To put it metaphorically, it will be those future Mars astronauts' shift-working mission controllers back on Earth who will face the discordant "music of the spheres" as they find themselves trying to read off the song sheet of the astronauts.

Whatever suffering of human crews to Mars that is yet to come

part of that suffering may derive from mistakes made by their mission controllers as they struggle Earthside to stay in touch, to stay alert, to stay focused, and to perform according to the Martian clock -- while being very much ensconced in the 24-hour Earth day.

But, with study and foresight, suffering on human missions to Mars may be minimized by

attending to the structure underpinning the conflict, deviance, and dysfunction experienced by Mars rover mission controllers caused by the disparate temporal regimes between the two worlds. And, in the meantime, the suffering of mission controllers can be minimized as they carry out ever more advanced robotic Mars surface operations. This is the significance of the studies that we urge be conducted.

Our Methods

We think that advocating a hard look at the issue is a kind of method in itself, in order to recruit more eyes to study the issues of mission controllers attempting to work according to how time is told on two worlds.

Our ongoing research draws from the slim data from JPL Mars rovers' mission controller experiences, from severe and extreme environments records (including the space exploration record), and from the astrodynamics of various scenarios. From these data, we demonstrate that the issues of disparate temporal schedules of mission controllers and robotic rovers and human space crews is a safety/health concern that will acquire larger importance as humans freight longer-duration space exploration - particularly to Mars.

Mars Mission Controllers – A Sparse Documentary Record

In the documentary record of the few television coverage and scientific papers available, the issues and considerations of mission controllers of Mars surface operations do not paint a large signature. The way these issues and considerations are depicted in that documentary record rank at the level of coping and salutogenesis (*i.e.*, we made do and it was a rewarding experience) in the Suedfeld space psychology phasing schema.

Living and Working by Mars Time: Road Rage and Domestic Violence

But, the anecdotal record suggests that not everyone coped well or found their experiences especially rewarding. What about those stories that leaked out within the aerospace community during mid-to-late 2004 -- that some mission controllers on the Mars Exploration Rover missions were involved in incidents as severe as domestic violence and road rage? Snippets over television documentaries about the MER mission control at JPL did not mention *those* incidents.

Perhaps the worst anecdotes were exaggerations

But, in our prior investigations of polar and space expeditionary records we have found anecdotes indicative of factual events, if not altogether accurate. Myths and legends quite often tell the archaeologist where to dig, and likewise, anecdotes can guide social psychological investigations.

Disparate planetary diurnal interfaces

There are several types of temporal concerns that affect mission controllers of Mars surface operations – and which will concern mission controllers and crews when humans go to Mars. Some of these involve types of transmission latency phenomena, which we will discuss below. We would like to expound on two other types of temporal concerns at this juncture. One is the length of the Martian day (sol) that is approximately 39 minutes longer than the Earth day. The other consideration is the time window between Martian sunrise and sunset when solar-powered rovers can execute their uplinked commands.

Starting work 39 minutes later each work day

If a JPL mission controller comes in at the same Mars local time each day – let us imagine the first day of his shift begins at 12 noon Pacific – he soon finds out that his Earth work day start time has marched ahead by about 39 minutes each successive day: 12:39, 13:18, 13:57, etc. The typical MER mission controller did not keep time to the Martian clock in a continuous way for weeks on end. After four successive shifts on Mars time, such controllers were given several days off to recover. That scheduling decision was made as a result of two NASA Ames studies following the *Pathfinder* mission conducted by their human factors personnel.

Night as Frontier

Mission controller shifts beginning and ending in pre-dawn hours in Pasadena, California meant that JPL controllers were coming and going to work during low traffic hours on California freeways. At those hours, quite likely they were also still trying to wake up to begin their day or else tired from their shifts. While they avoided the gridlock of those thoroughfares typical at other times of the day, they found themselves at odds with the daily “first shift” schedules typical of upper middle-class families and the hours of business common to most stores and service providers in their communities – such as food services. In sociological terminology, controllers working shifts that began or ended in the evening and in the dark early morning hours were “colonizing the night.” For them, Mars was not the only frontier -- night was frontier.

From the “local” routine to living and working by the Mars clock

Bass, Wales, and Shalin found that those mission controllers “local” to the Pasadena area had more trouble than those controllers who temporarily moved to Pasadena for the life of the mission. Those who found living and working by Mars time particularly distressing were those who had child care, elder care, and pet care issues.

Bass, Wales, and Shalin wrote:

"The number of necessary, relevant time conversions at each point of work in the Earth day and Martian sol was complex." While there were advantages for the MER missions to staff according to the Mars clock, Bass *et al.* concluded that, depending on the characteristics of Mars missions that it may not be necessary to work on Mars time, and that extensive staff cross-training could facilitate round the Earth clock support of long-duration Mars missions. While the Bass, Wales, and Shalin analysis certainly points out these certainties, adding humans on Mars into the equation further complicates matters. On that note, we would like to turn to some transmission latency issues that will come to complicate life for Mars mission controllers.

The harsh reality of the speed of light

As the distance increases between Earth Mission Control and astronauts outbound to Mars, near-instantaneous two-way communications between them become impossible. At the greatest distance between Earth and Mars it takes more than 20 minutes for a communiqué from Earth to reach astronauts, then it takes more than 20 minutes for the response communiqué from the astronauts to reach their mission controllers. By necessity, under such circumstances, such long-duration space missions will require a level of autonomy not yet experienced in the space endeavor. More autonomous missions mean that Mission Control is relegated to the position of a help desk function. But, it had better be the best help they can provide when long-duration astronauts need help.

Mars Solar Conjunction and Third-Quarter Phenomenon

It is easy to talk about robotic missions and equipment on Mars in terms of "data receipt" and "data return" events, but adding a human crew on Mars mean that lives hang in the balance between data receipt and return. Transmission latency issues such as the one-way light time travel delay between Earth and Mars and the delay created by having to wait for Mars satellites to reposition themselves are challenging enough. Another type of transmission latency problem looms like an elephant in the living room.

A communications blackout for weeks at the worst possible moment

Mission controllers and human crews on Mars will not be able to communicate, up to about three weeks during Mars solar conjunction with Earth, occurring every 780 days on average. This communication blackout would occur as the third-quarter in mission elapsed time (MET) was beginning on conjunction class missions by Hohmann Transfer -- just as a human crew is halfway through Mars surface operations. Given what we know about a psychosocial nuisance known as third-quarter phenomenon that has plagued extreme environmental expeditions from their mid-points in their METs till the beginning of their final quarter, a communications blackout for several weeks would be still another critical juncture for mission controllers and their counterparts on the surface of Mars. It could spell disaster.

Preventing the Blackout

Dorothy Byford, James Goppert, and Thomas Gangale have touched on this issue in "Optimal Location of Relay Satellites For Continuous Communication With Mars" (2008). In that paper, they present some of their latest investigations for a satellite relay system to avoid communication interruptions between Mission Control and human crews on Mars. You can hear their presentation Thursday at 3:30 (1530) in Room 33C.

Discussion and Conclusion

Bass, Wales, and Shalin pointed out that sociocultural issues are at least as problematic as physiological and cognitive considerations for Mars mission controllers. MER controllers ran the risk of missing out on the social interfaces that supported them in their normal daily round. And, on the other side of the coin, they were absent from those social interfaces where they supported others.

Discussion and Conclusion, continued

The problems of mission control work on the Mars clock are not unlike problems seen everywhere among professions that depend on overnight and long shift work. In some respects these problems can be seen in work where field teams several Earth time zones away must do their work in conjunction with a base operation, as in military operations and military contract work. So, the problems of mission control work according to two planetary clocks are “normal” in light of those examples. What will emerge as different and out of the ordinary will occur when human crews deploy to Mars. If a “Mars-on-Earth” schedule is staffed among mission controllers it will be in effect preceding the mission, for the duration of that mission, and afterwards – perhaps in preparation for the next human crew.

Final Words

The length in duration of that mission and the criticality of humans further from Earth than any have ever been will make the two-clock timekeeping issue a human frontier for mission controllers in its own right. They will work to the ticking of a Martian clock for far longer than 90 Martian days. Much will be tied to solar-powered infrastructure that will precede the human crew, that will function during Martian daylight hours while they are there, and that will continue to function as they are outbound. This may be inferred from Humans-to-Mars mission plans that have much riding on *in situ* resource utilization where robotic events occur on the surface of Mars before and after the human crew gets there.

Attention to the functioning of a larger group

Much more needs to be done to improve the functioning of a larger group on Mars time than 200+ Mars mission controllers. That larger group would be the astronauts and their loved ones, the mission controllers and their loved ones, and other support staff and significant others. We think that this will be a good thing for the human ecology – getting a larger group of widening circles of Earthbound humans invested in a temporal regime beyond the Earth, to induce an outward-looking mindset that envisions human potential outside the Earthly box. We think that Peter Suedfeld's space psychology integration phase, where psychosocial sciences would be fully integrated into the space enterprise, will emerge as a result of plotting courses of action for long-duration space endeavors and will feed back in positive ways to the ventures "on the ground."

Contact

Dr. Marilyn Dudley-Flores, OPS-Alaska, 2262 Magnolia Avenue, Petaluma, California 94952 USA, 816-214-1934, md-r@ops-alaska.com

Thomas Gangale, OPS-Alaska, 2262 Magnolia Avenue, Petaluma, California 94952 USA, 707-773-1037, teg@ops-alaska.com