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# Evaluating the MER Display Ecology

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Figure 1. MERBoards, projectors, laptops, and workstations in the work environment

## Introduction

In January of 2004, the National Aeronautics and Space Administration (NASA) landed two unmanned vehicles on the surface of Mars for the purposes of collecting scientific information regarding the terrain, composition, and atmosphere of the planet. The Mars Exploration Rover (MER) mission has continued for the past 20 months, with the two rovers, Spirit and Opportunity, continuing to transmit data to Earth as they traverse the surface.

The actions of the rovers and the data that they collect are guided by mission scientists and engineers, and the mission is based at NASA Jet Propulsion Labs (JPL) in California. To coordinate their activities, scientists and engineers employ a variety of displays for collaboration and information sharing. In the group workspaces designed specifically for the MER Missions, shared displays, including large projection screens, large interactive plasma displays, and shared workstations with multiple monitor setups, are ubiquitous. Together, these surfaces form a “display ecology,” in which the uses of individual displays influence the roles of others, despite not having been designed as a unified, seamless system. Of particular interest to us is the MERBoard [1, 2, 3].

In this position paper, we focus specifically on how the display ecology supported the specific task of daily Rover activity planning. We consider how the physical aspects of the displays affected their use in this task, how the affordances of different applications such as PowerPoint

and SolTree supported the task on different displays at different points in time, and how the changing nature of the collaboration and the task itself affected scientists' choice of displays and tools.

### The Sol Planning Task

MERBoard provided a tree-building tool called SolTree (Figure 2) to support this task; it allowed the scientists to visualize all possible paths for the Rovers and annotate them as necessary. Despite the availability of this tool on the MERBoard, scientists also used other displays and tools for planning as the task and collaboration evolved. Used regularly during the first 70 Sols (Martian days) of the MER missions for planning activities, SolTree was the primary planning tool early in the mission.

The use of a structured scaffolding tool on a shared display surface entails several assumptions; it assumes that the task that it supports will be done by a group of people, rather than an individual. It assumes that collaboration will be synchronous and co-located in such a way that a shared visual surface will be beneficial. Additionally, the design of this tool assumes everyday or near-everyday use during the mission, since it was intended to support planning on a Sol by Sol basis. We found that these assumptions did not hold throughout; the nature and timing of the Sol planning task evolved over the course of the mission, as did the type of collaboration used to accomplish the task. The evolution of task and practice caused Sol planning to migrate off of the MERBoard onto laptops and projection screens, as the scaffolding and the shared visual surface offered by the large display ceased to fit the task as the mission progressed.

*Migration to projection screen for large meetings:*  
Although MERBoard was well-suited for the planning task

early in the mission, images of SolTrees were often exported as images or transcribed into PowerPoint for the purposes of displaying them on the projectors during meetings when the plans were being presented to larger workgroup. The size and resolution of MERBoard were well suited for small group authoring, but were not sufficient to make MERBoard a valuable presentation tool for this type of viewing.



Figure 2. Scientists collaborating on a plan using SolTree

*Tool structure supports early collaborative work:* Most of the LTP scientists appreciated SolTree's ability to keep track of all of the possible branches and options, especially in the earlier parts of the mission. Others praised the fact that SolTree imposed a structure on brainstorming options; it required planners to think down each linear path and consider and annotate all of the possibilities. User of the tool said that it "forced explicit logic," "offered scaffolding," and required the scientists to consider all possible ramifications.

This was important because the process that was still new to the scientists and not yet routinized.

*Persistence and evolution of plans:* Though the general perception of the SolTree tool among scientists is that it was provided for interactive planning for Rover activities, their descriptions of use illustrate a broader value of the tool as a persistent information display for community awareness. SolTrees were often left open on the MERBoard even after the planners had completed their planning for the day, as a way of maintaining awareness of the planned activities and options. The persistence of the artifact created continuity from day-to-day between the various planning teams.

*Tasks migrate to other displays as collaboration changes:* The planning process evolved during the course of the mission, shifting gradually from unfamiliar and exploratory to familiar and proceduralized. As mission goals solidified, planning became more tactical, and scientists generally confined their planning to the consideration of a few potential options rather than a full-blown exploration of all possible next steps. The decision making process became increasingly streamlined. The method of visualizing these plans evolved as well, as did the subsequent use of the multi-display environment. Additionally, the planning process became predictable enough that scientists no longer needed to create them together; it was sufficient for an individual to create the plan on his own and get it approved by the group later. As a result of this evolution of the task, the group use of the SolTree tool on MERBoard for planning eventually gave way to the individual use of PowerPoint on laptops for creating “Sol Paths” that were afterwards shown ambiently on the MERBoards for awareness. As MERBoard’s value for synchronous active collaboration

decreased, it continued to be used for passive information display.

## Implications for Multi-Display Environments

In looking at the use of the NASA MERBoard over time, several patterns emerge across the various applications. These patterns demonstrate the evolving role of the system in the context of a dynamic work environment, and a complex ecology of displays:

- *Changes in the collaboration style over time* – MERBoard’s value for collaboration was that it supported synchronous sharing of artifacts; users could engage in viewing and authoring material simultaneously. The fact that procedures became familiar and routinized meant that responsibilities could be divided up and tackled individually, thus reducing the need for a shared work surface for synchronous collaboration.
- *Changes in the tasks of the scientists over time* – MERBoard’s value for interaction was primarily as a ramp-up tool that allowed users to conduct exploratory work, especially when procedures or tasks were unfamiliar, and scientists benefited most from doing them together to see and learn how the problems should be addressed. Over time, workgroups found less need for the shared exploration afforded by MERBoard.
- *Other displays and applications available in the environment* – MERBoards were one of many display technologies available. Other means of displaying information that also could be used for sharing, such as laptops and shared workstations for very small collaborations and projection screens for large meetings allowed tasks to migrate off of the MERBoard as necessary.

Taking these factors into account in evaluating the changes in MERBoard use during the mission and pre-mission, we identified some implications for display ecologies and large interactive displays for supporting group work:

- *The transition from interactive use to ambient display* – Designers of large displays should expect that the interactive use of displays may not be constant over time, but that users may continue to find value in the ambient display capabilities of the systems. Applications should not be designed only with interactive use in mind; attention should also be paid to how applications might be support passive use, what kinds of content to support while the displays are not being used interactively, and how that content should be displayed.
- *The dynamic use of multi-display environments* – Large interactive displays in multi-display environments are by nature group-owned and flexibly appropriate; constant, steady use need not be the primary measure of success. Multi-display environment designs should be flexible and dynamic and perhaps easily reconfigurable. They should support the fluid migration of tasks among various display surfaces.
- *Support for undefined tasks and proceduralization* – Systems such as MERBoard support exploratory tasks and tasks that do not have a set procedure, becoming less necessary when work becomes streamlined and routinized over time. Designing for continuity by making data products easily accessible and movable between displays will make transitions in work processes smoother, and help ensure that artifacts continue to be valuable as work progresses.

### Implications for Evaluation

The “success” of a large interactive display within a display ecology cannot be measured solely by whether a steady state of use is reached. Because people appropriate these shared displays as necessary, there may be a natural ebb and flow of use that does not correspond to success or failure, but rather to the dynamic nature of collaborative work processes. Success may also be found in the ease and extent of support that

such displays provide when tasks call for a shared visual display or interactive work surface.

In the realm of large interactive display research, a decrease in interactivity is often viewed as a failure of the system to support workgroup practices, but the interplay between interactive and passive use proved to be an important aspect of the support that MERBoard offered. We observed a migration from interactive use to equally valuable ambient information display. We believe that success should be assessed by looking both at interactivity and the value of the display in passive uses.

Finally, in the greater context of a display ecology, it is misleading to evaluate the isolated use of a single system; the existence of other displays in the environment means that it is important to understand how the ecology functions as a whole, not just how individual displays are used. In evaluating displays in such multi-display environments, we believe it is better to examine how well and fluidly the ecology as a whole supports the work tasks than to assume that disuse of a tool is a failure of the technology to support the task.

### Citations

- [1] Huang, E.M., Mynatt, E.D., Trimble, J. Displays in the Wild: Understanding the Dynamics and Evolution of a Display Ecology. Proc. of Pervasive 2006 (to appear).
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- [3] Trimble, J., Wales, R., Gossweiler, R. NASA's MERBoard: An Interactive Collaborative Workspace Platform. In Public and Situated Displays (2003), O'Hara, K., Perry, M., Churchill, E., Russell, D., (eds.), 18-44.