The Mobile Information System: A Hands-free Procedures System

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NASA is investigating a "paperless" environment for new, 21st-century spacecraft-related procedures. A work environment with "hands-free" procedures/instructions promotes efficient operations. Giving an astronaut the ability to use both hands during a task will undoubtedly make that crew member's work easier; however, it could add complexity to the task and discomfort if the system is not properly designed.

We employed the Johnson Space Center Usability Testing and Analysis Facility to conduct a five-phased evaluation of a near-eye, head-mounted display (HMD) system – the Mobile Information System (MIST) – to examine its usability for future space and planetary exploration missions. With MIST, we then completed two pilot studies using simulated International Space Station maintenance procedures, two parabolic microgravity flights, and one long-duration study. This paper describes the last three phases of the program. The current components of the system include a miniature camera, a microphone, a tablet computer, a touchpad, batteries, and cables.

Two parabolic flight studies on board NASA's C-9 aircraft provided opportunities to evaluate MIST under simulated microgravity. Both test flights were part of a NASA Langley Research Center (LaRC) microgravity fabrication experiment that provided an opportunity to test MIST hardware and software in a real-world, operational environment using LaRC's experimental procedures displayed on the HMD. Researchers provided their observations on the MIST microphone. Our general objective in performing these evaluations was to assess the operability and functionality of MIST and its components. On the first microgravity flight study, two participants wore the MIST for half of the parabolic flight (figure 1, left). For the second microgravity flight study, we used the same experimental procedures with three LaRC flight members and the addition of voice recognition (figure 1, right).

We found that the mobility and compactness of the display were very desirable features to the LaRC flight team. MIST facilitated the tasks and enhanced the team dynamics, allowing the capture of more information than is typically captured under the same flight conditions

Fig. 1. *Usability Testing and Analysis Facility evaluator assisting LaRC crew member.*

without MIST. Furthermore, we discovered that using a touchpad rather than voice recognition was sometimes more efficient in the environment of the C-9 aircraft. Effects on the human voice, especially during 2g pullouts, led to an error chain in the voice recognition software; thus, further investigation is needed to understand and solve this issue.

These studies only tested MIST in short-duration settings ranging from 20 minutes to 1.5 hours. Most space and planetary exploration missions have procedures that can last up to 8 hours or longer. This prompted us to review literature on HMD usage lasting longer than 1.5 hours. A search of previous studies found that the average time the HMD technology was used was less than 30 minutes. Thus, a long-duration test of the MIST prototype was developed. We conducted this study to evaluate the comfort, usability, and impact of MIST during long periods of human performance. Two participants wore the system for approximately 4 hours each while performing task activities; e.g., assembling a second MIST, glovebox operations, and inventory data entry. Procedures were displayed on the HMD and controlled with voice recognition (figure 2).

Fig. 2. *Assembling MIST (left), glovebox (right).*

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continued

We collected several human factors measures, including: a modified Cooper-Harper Quality Performance Scale, measuring the level of compensation needed to meet performance objectives; a Discomfort Scale; the NASA Task Load Index to assess the physical and mental workload of the task; task time; and post-evaluation questionnaires for assessing system usability, user fatigue, and adaptability to the system. Cooper-Harper scores revealed controllability of the system to be acceptable, with minimal to no operator compensation needed to perform task goals. Participants wore and interacted with MIST for an average of 3 hours and 51 minutes each, with little to no physical discomforts being reported (figure 3). Usability and adaptability to the system were highly rated, with participants commenting they would recommend this type of system to assist in two-handed operations. Few issues of eye fatigue, headaches, or motion sickness were reported, indicating that a person could wear and interact with the near-eye display with no physical impairments. This study helps fill a gap in the literature concerning long-duration use of a near-eye display. Overall, the use of MIST to support procedures in microgravity and for long-duration operations was successful, with high acceptability from the user perspective. The study yielded valuable insights for development of guidelines for design revision and system enhancements.

While additional evaluations are necessary to further our understanding of the advantages and disadvantages of the system in various environments, these studies have shown that an HMD system such as MIST is a feasible technology for space operations. Future designs and enhancements will help increase system viability in terms of mobility and ease of use.

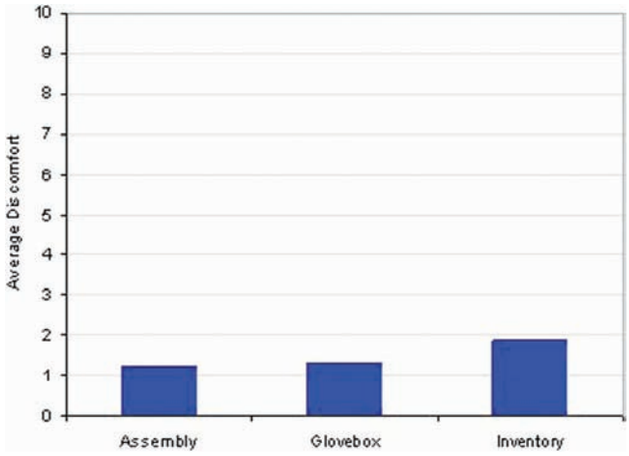

Fig. 3. *Average ratings of discomfort across tasks.*

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