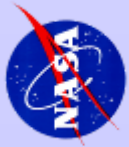


Maintenance Procedure Display – Head Mounted Display (HMD) Evaluations

Usability Testing and Analysis Facility
Habitability and Environmental Factors Division
NASA – Johnson Space Center

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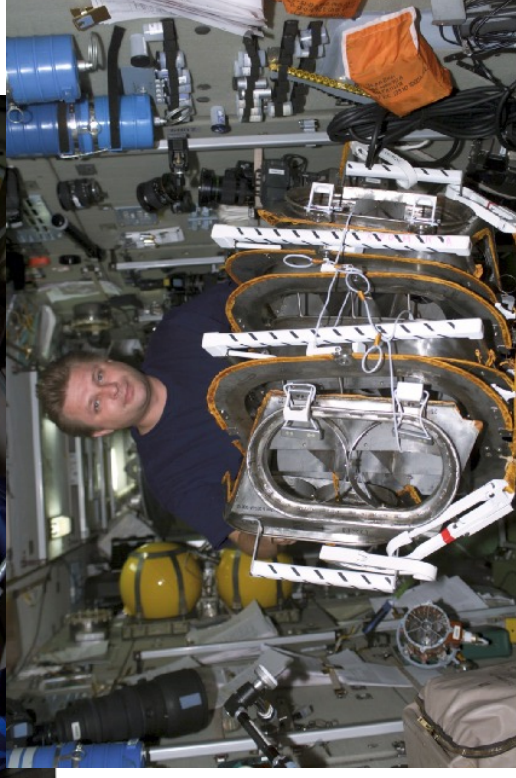
Maintenance Procedures Display

Problem Definition

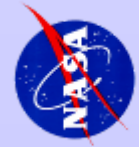
- International Space Station (ISS) maintenance tasks currently consume approximately 60-70% of ISS crew time
 - Roughly 260 maintenance procedures and 90 maintenance callouts
 - Maintenance procedures are presented on a laptop that must be temp mounted near the worksite



ISS004E6630



ISS004E6429



Study Goals

- Phase 1 - Evaluate three commercial HMD integrated systems (e.g., HMD, hard control/switch, small laptop) using low fidelity, ISS-like, characteristic procedures to determine best system performance (e.g., task time, errors) and usability (comfort, color and font readability, image quality, etc.).
- Phase 2 - Evaluate best HMD integrated system (e.g., HMD, small laptop) from Phase 1 against the current baseline process (electronic procedures on laptop) and presentation via an e-book reader.



Near Eye Displays (HMDs)

Liteye 500 SVGA HMD



Resolution: 800 X 600

Icuiti M920 Display



Resolution: 640 X 480

MicroOptical SV-6 PC Viewer

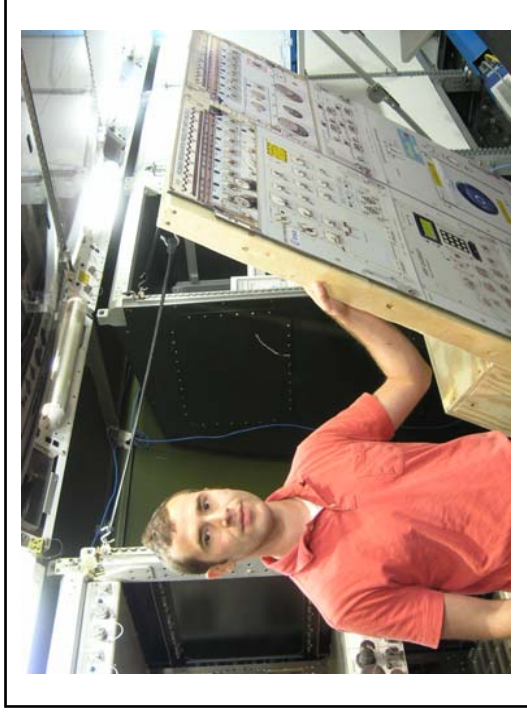


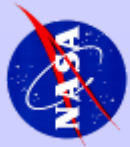
Resolution: 640 X 480
800 X 600
1024 X 768



Design

- Space Station Mockup and Trainer Facility (SSMTF) located at the NASA JSC is a full scale, high fidelity replica of the pressurized portions of the International Space Station. It is used for crew training, mission support, engineering evaluations, and assessments. The Payload Development Lab (PDL) II, in the SSMTF, encompasses a set of standalone racks and was used for this evaluation.
- Built an additional ISS-like (light weight) rack and integrated it the PDL II
- Within subjects design with counterbalancing of three HMDs

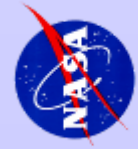




Phase I - Evaluation Methods

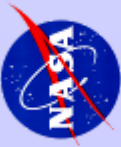
- 12 Test participants
- Don HMD and perform two maintenance procedures
- Video
- Questionnaire for each HMD
- Questionnaire for comparison of HMDs
- Debrief





Phase 1 Results

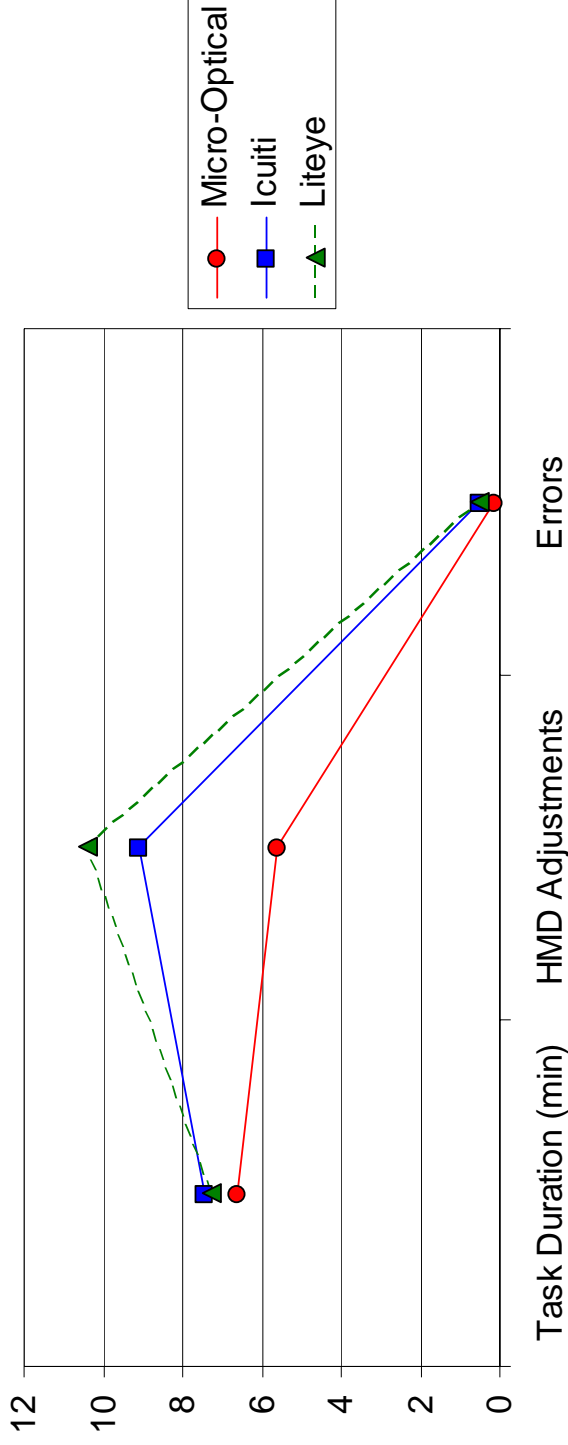
- A conflict surfaced between display size, visual surround, and stability.
- Some participants preferred a larger, crisper display area for presentation of the procedures; however, a clear need surfaced for being able to see the visual surround (work environment) with the eye that was reading the text.



Phase 1 Results

- **MicroOptical SV-6** > Liteye 500 > Icuiti M920

HMD Performance Measures

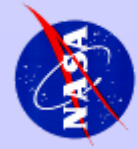


- The MicroOptical SV-6 HMD system had the least average errors, fewest average adjustments, and shortest average task duration time.

Phase 1 Results

- The results for HMDs that were evaluated in this study are consistent with the perceptual grouping effects: Liteye HMD had a display area that was over three times larger than the MicroOptical HMD while the Icuiti HMD was only a little over 60% larger. Thus the user's vision was reduced or obstructed much more for the Liteye HMD than the other two HMD systems.
- Therefore, the ability to view surrounding work area was more unsatisfactory for the Liteye than the other two HMDs ($p=.02$; Krusal Wallis ANOVA).

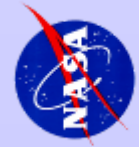




Phase 1 Results

Display Areas for HMDs

HMD	Display Horizontal (mm) x Vertical (mm)	Display Area (mm ²)
Liteye	23.88 x 19.24	459.45
Icuiti	18.87 x 11.96	225.69
MicroOptical	13.81 x 9.94	137.27

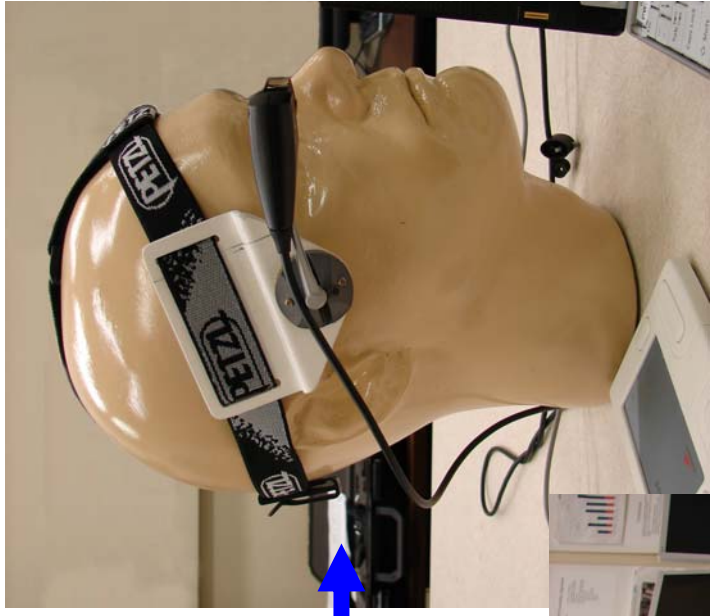


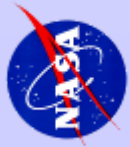
Phase 1 Results

- Literature results suggest that these displays are usable when the background is static (as in the current procedures in this study) and a relatively small performance decrement is acceptable (Laramée & Ware, 2000). That decrement may be primarily caused by the parallel processing of objects in one perceptual group (the HMD) and transitioning to another perceptual group (the rack work environment) requiring a shift in spatial attention (Treisman, 1982).
- Overlapping images for both eyes were more of an issue when the near-eye display filled the user's field-of-view for that eye.
- Further some investigators suggest that future HMD designs should attempt to remove cues that cause the visual system to segregate the HMDs from the world view (McCann et al, 1993; Ploys et al, 2005; Woods et al, 2002).
- As for the stability of the HMD, participants often voiced comments about the need for a stable display for operational use.



Improved HMD Mounting





Phase 2 - Evaluation Methods

- 12 Test participants
- Use each of three electronic displays (Laptop, e-book reader, HMD) and perform two maintenance procedures
- Video
- Questionnaire for each electronic display device
- Questionnaire for comparison of three electronic display devices
- Debrief

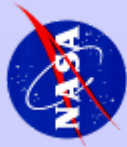




Phase 2 Preliminary Results

- A key observation from the evaluation was each device influenced the way participants performed the maintenance procedures task.
- For example, for the current method of using a laptop in the simulated ISS module, the participant had to continually move back and forth between the work area and the device, sometimes carrying material back to the computer display.

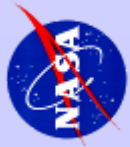




Phase 2 Preliminary Results

- The HMD permitted the participant to move into the work area, and work at the same time as reading the procedural steps.

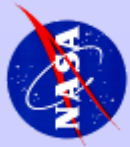




Phase 2 Preliminary Results

- Similarly, with the e-book reader, the participant carried the device, attached it near the work area, and referred back to the e-book display while working at the location.
- Both the HMD and e-book reader provided a better economy of motion in performing the task than the current laptop method.



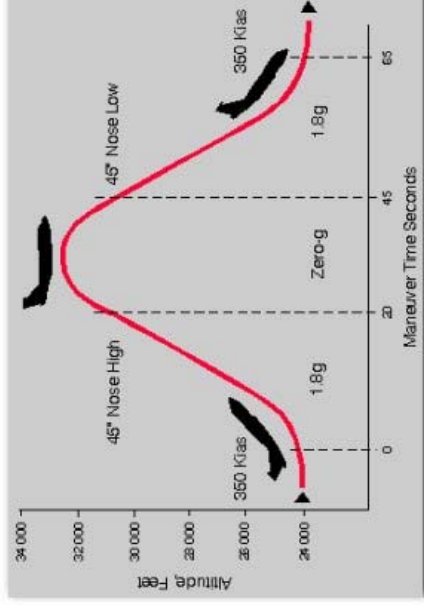


Phase 2 Preliminary Results

- Portability was a benefit of both the HMD and the e-book reader, as compared to the laptop.
- Additionally, viewing the full page of procedures with the e-book reader was much preferred to the display of scrolling procedures in the HMD.
- This was surprising since others have shown that the smaller monocular type of HMD display has minimal impact of visual fields, making them a reasonable choice to wear in non-immersive conditions.
- Additional evaluations of both the questionnaire data and video performance data are currently in progress to further understand the advantages and disadvantages of HMDs and other hand-free technologies for presenting maintenance procedures.

Next Steps

- Enhanced HMD design
 - Voice input
 - Cameras
 - Other technologies
- Collaboration with LaRC stereolithography project microgravity flights - laptop scripts on HMD and verbal recording of observations and comments on customized microphone
- Collaboration with GRC HMD evaluation, incorporating voice input
- DOD Human Factors Technical Advisory Group (TAG) - splinter meeting on Advanced Technologies for Supportability





Summary

- Potential human factors issues to consider when refining the design of the HMD as derived from these evaluations:
 - Ability to view the surrounding work area
 - Comfort of the head mount
 - Stability of the HMD display
 - Ease of adjustment of the HMD display
 - Optimizing the presentation in the HMD display
 - Intuitiveness of the cursor control mechanism
- The information obtained from these evaluations will be important in the development of hands-free technology requirements for future exploration missions.

Thank You

