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TELEOPERATOR HUMAN FACTORS STUDY

Prepared for George C. Marshall
Space Flight Center, Alabama 35812

Contract NAS8-35184

Report Period

September 7, 1985 through October 6, 1985

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(NASA-CR-176310) TELEOPERATOR HUMAN FACTORS STUDY Progress Report, 7 Sep. - 6 Oct. 1985 (Martin Marietta Aerospace) 6 p HC A02/MF A01 CSCL 05H
N86-11854
Unclas
G3/54 27614

INTRODUCTION

This document summarizes the progress made on the Teleoperator Human Factors Study program during the period of September 7, 1985 to October 6, 1985. Technical and programmatic problems that have been encountered are discussed along with activity planned for the following month. The main portion of the report has been separated into four sections: Work Performed, Future Work, Problems Encountered, and Cost Information.

WORK PERFORMED

This section outlines progress made under each of the major study task elements. An overall summary of the work completed and in progress is discussed. Reports have been completed on Task 1 through Task 5 and work effort on Task 6 has continued in accordance with the scope of work received in the change order from NASA.

Task 1 - Define Reference Set of Teleoperator Tasks

Task 2 - Define Technology Development/Design Options and Issues

Task 3 - Survey and Assess Previous Studies

Task 4 - Define Missing Elements

Task 5 - Develop HFRP Requirements

Task 6 - Define HFRP Implementation

At the close of the last report, testing was in process to determine operator performance under various viewing and lighting conditions. Details concerning these tests are included in the attached study update report and summarized below.

The overhead camera view was deleted from the baseline test set-up since it would not be a likely configuration, at least for realistic early servicing missions, due to the necessity for a separate manipulator to place it in the proper viewing perspective. The two camera views used were the 45-degree peripheral video camera and the fiber optics link to the end effector camera. Each of the four operators completed five repetitions of the baseline test (module removal/insertion) under different lighting conditions. Lighting conditions were high, high, medium, low, and shadow.

Preliminary data results indicate that removal of the overhead camera hampered performance little, if any. Formal data analysis is in process and will be included in the interim reports as available. Also, the fiber optics setup is such that reduced light levels seem to be hardly noticeable in that video system, since automatic compensation was evidently in effect. The operators seemed to rely more on that image as the peripheral camera image dimmed.

The test set-up will be checked prior to the next runs.

Scheduling problems during September in the Robotics laboratory precluded conducting more than the single set of tests identified above.

FUTURE WORK

Work planned for the month of October includes more software upgrading, continuation of data analysis and preliminary time delay testing. Also, a demonstration by Tektronix of their stereo vision system using an LCD polarizing shutter is scheduled at MMC on October 7. Assessment of stereo vision systems is continuing for potential future utilization in this study.

PROBLEMS ENCOUNTERED

None

COST INFORMATION
(As of 9/25/85)

1)	Total cumulative cost incurred:	$323,769
2)	Estimate of cost to complete:	$ 35,037
	Contract value:	$358,806

INTEROFFICE MEMO

October 15, 1985

TO: K. Bradford
CC: C. Hartley, C. Schanker
FROM: J. Yorchak
SUBJECT: Teleoperator Human Factors Study Update

During our most recent visit to MSFC in early September Chris Schanker and myself used the baseline task (described below) to test operator performance under a range of lighting conditions. In addition, only two camera views were provided to the operators.

Due to the extreme difficulty of implementing an overhead camera in space operations the overhead view used in earlier baseline testing was removed from the operators' console. In previous baseline tests this camera provided an overhead view of the plane of the task board. With this view it was relatively easy for operators to: align the module during insertion and removal, open and close the door, and move the module around the task board. By removing this camera view we felt that a more "realistic" operational environment was created, since a third camera on a spacecraft like the OMV would be unlikely, and even if it were possible to have three camera views, an overhead view of the operational environment would require a manipulator arm to hold and position the camera.

With the remaining two camera views---the 45 degree angle camera and the fiber-optic camera---each of our four operators completed five repetitions of the task under different lighting conditions. Their first trial served as a warmup and utilized high intensity lighting (the brightest light available from the two xenon lamps). (All overhead lights in the PFMA lab were turned out for this testing.) In addition to the high intensity condition, operators completed trials under medium and low light, and a shadow condition created by having the light nearest the 45 degree angle camera on medium brightness, and the left light off. As you might imagine, this created some interesting shadows. These settings were accomplished by turning down the intensity of the lights with a control on the front of each lamp. Foot/candle intensity readings were taken for each of the light conditions through the use of a light meter aimed at the task board. In this manner, the meter registered the light reflected off the task board just above the compartment handle. The readings were as follows:

HIGH	2.5 ft/cdl or 250 lux
MEDIUM	1.0 ft/cdl or 100 lux
LOW	0.6 ft/cdl or 60 lux
SHADOW	0.8 ft/cdl or 80 lux

TESTING

Subjects completed one "warmup" trial under high intensity lighting, and then completed a second high intensity trial followed by three additional trials under the other lighting conditions. Each subject completed two or three trials, depending on how quickly they worked, and then were given a short break before completing the remaining trials. The order of the trials was counterbalanced, after the subject completed the warmup trial. We did experience a few minor breakdowns of the hand controller during the testing but Elaine was able to make quick repairs and get us going again with a minimum amount of wasted time.

BASELINE TASK

As mentioned previously, the task defined for the baseline testing and the future research is much more complicated than the peg-in-the-hole task which was used for operator selection. The task required subjects to open a small door which covered a compartment that contained a module (12" X 12" X 18") with a handle attached to it (this module simulated a satellite battery pack). Once the compartment was opened, subjects had to grasp the handle, remove the module from the compartment and then place it on the floor inside a 14" X 14" X 2" cardboard box a few feet to the left of, and in front of the compartment. After placing the module in the box, they were instructed to move the grippers to a point above the compartment and touch a piece of tape with the grippers. After touching the tape they retrieved the module, reinserted it in the compartment, and closed the door.

The complete baseline task described above actually consisted of nine subtasks that were timed separately by the experimenter. A table describing these subtasks, and the control motions required to perform them is provided below.

Baseline Subtasks

SUBTASK #	DESCRIPTION	MOVEMENTS REQUIRED
1	Move from the starting position to the task board and grasp the door handle of the compartment.	X, Y, and Z translations, as well as pitch and roll movements. In addition, the grippers had to opened and closed.
2	Open the door a few inches, and then release the handle and push or bump the door to a fully opened position.	X, Y, and Z translations and yaw movements.
3	Grasp the handle of the module.	X, Y, and Z translations and some pitch and yaw movements.
4	Pull the module from the compartment.	-X and some Y or yaw movements were required, as well as some pitch movements.
5	Once extracted, the module had to placed inside a 14" X 14" x 2" high cardboard box on the floor.	All six degrees of motion were required.
6	After dropping the module in the box, the subject was required to touch a piece of tape with the end effector. The tape was placed over the compartment.	All six degrees of motion were required.

7	After touching the tape return to the module and grasp the handle.	All six degrees of motion were required.
8	Reinsert the module in the compartment.	All six degrees of motion were required.
9	Close the door of the compartment.	X and Y translations and yaw movements.

Table 1. Subtasks of baseline task.

For many of these subtasks, the completion of the task was not always apparent to the subjects. In these instances, the experimenter told them when they had completed the subtask (this was done with subtask's 1, 8, and 9).

SUBJECTS

The subjects used for this test were our four "best" subjects as determined through earlier baseline testing.

RESULTS

Preliminary analysis of the data indicate that lighting was not as critical to task performance as first believed. Also, removing the overhead camera view does not appear to have hampered performance. (Formal data analyses will be forthcoming on these results.)

The effect of reducing the light level in the lab seems to have been attenuated by the ability of the fiber-optic camera to intensify the light that was available. If the operator used the fiber-optic view to work the task, his/her view of the scene was not effected to any significant degree by the various lighting levels. It seems that the fiber-optic hardware works in an all-or-none fashion, whereby, above certain minimum levels, the video looks identical for all light intensities. On the other hand, the image from the Vidicon camera changed dramatically when lighting levels were reduced, but the operators were able to compensate for this by relying more on the fiber-optic view.

ANALYSIS OF TWO CAMERA SETUP

By comparing the task times from the baseline trials with the task times from the lighting trials it will be possible to get a rough idea about the effect of removing the overhead camera view from the operator's console. However, this analysis is unavailable at the present time but will be conducted shortly.