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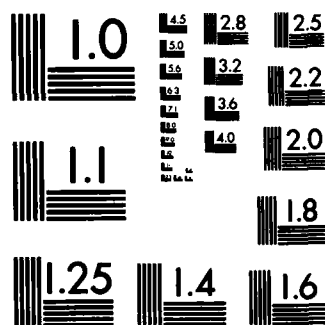
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This document reports the results of a test conducted under a test plan published as Volume I. A statistically significant difference was observed in the time required to extract tactical information with and without a military map background was not present. Display size and presence of a map background had no significant effect on the other measures. Assessments of user compatibility, however, indicated a consistent preference for a map background.		

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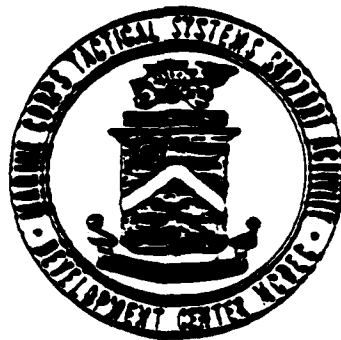
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GRAPHICS DISPLAY TEST

VOLUME II

TEST REPORT



MCTSSA

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Graphics Display Test

Volume II

Test Report

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ABSTRACT: This document reports the results of a test conducted under a test plan published as Volume I. A statistically significant difference was observed in the time required to extract tactical information with and without a military map background. More time was required when the map background was not present. Display size and presence of a map background had no significant effect on the other measures. Assessments of user compatibility, however, indicated a consistent preference for a map background.

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5 March 1982

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Tactical Systems Development Branch
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SECTION 1

INTRODUCTION

In October 1981, the Analysis Section of the Tactical Systems Development Branch (TSDB) at MCTSSA conducted a concept test to determine if a proposed work station mix for an automated battalion level combat operations center (COC) was excessive (see "Battalion Combat Operations Center (COC) Test Report", MCTSSA Document No. 22T001/U-TRP-01 dtd 8 Feb 1982). During the conduct of this test it was noted by test observers that a significant number of the test participants elected not to use the map background on the automated graphics display terminals used for the test (the participants had the ability to select or deselect the map background at will). A number of comments made by the participants at the conclusion of the test indicated that the rationale for not using the map background fell into two general categories. Some of the participants indicated that the map background simply was not necessary for the functions they were performing. Other participants indicated that the map background was not used because its presence, together with all of the overlay symbology, caused a clutter problem.

This unexpected but interesting finding suggested that a follow-on test, designed to investigate the functional utility of the map background, should be conducted. If it could be

determined that the map background does not significantly increase the effectiveness of the display then it might suggest that less sophisticated, less expensive, lighter weight equipment could be provided for the automated CQC at the battalion level.

The primary aim of the Graphics Display Test, then, was to determine whether or not there is a statistically significant difference between the functional utility of a graphics display with a map background and a graphics display without a map background. As a related question, the Graphics Display Test also investigated the effect of display size as it relates to the functional utility of a graphics display.

SECTION 2

DESCRIPTION

2.1 REFERENCE. For a more detailed discussion of test design, test procedures and data analysis methodology, see "Graphics Display Test Plan" (MCTSSA Document No. 22T001/U-TP-01 dtd 1 Feb 1982).

2.2 PURPOSE. The purpose of the Graphics Display Test was to assess the effects of the presence/absence of a map background and of display size as they relate to the functional utility of the graphics display for the battalion level Tactical Combat Operations (TCO) supported Combat Operations Center (COC).

2.3 PROCEDURES

Four display types (designated type A, B, C and D) were tested. Type A was a large display (approximately 10-3/4" by 10-3/4") with a map background. Type B was a large display without a map background. Types C and D were small displays (approximately 4-1/2" by 4-1/2") with and without a map background respectively. Each display type was utilized for twelve test iterations so that each level of the two factors (map background and size) were tested twenty-four times.

Test participants consisted of twenty Marine Corps and four U. S. Army officers holding primary ground combat MOSs and/or current or recent tactical experience by virtue of

formal schooling or billet assignment. Each participant went through two test iterations utilizing two of the four display types.

Each test iteration was conducted against one of two scenario variations (a different scenario was required for each iteration that a particular participant performed). Both scenarios involved a reinforced infantry battalion conducting independent operations within an assigned tactical area of responsibility (TAOR).

2.4 OBJECTIVES

Two objectives were established for the test; evaluation of the effectiveness of the four display types in providing assistance to the commander and assessment of the user compatibility of the various displays.

Effectiveness evaluations involve measurements of observable phenomena and produce numerical results which are directly obtainable. Two effectiveness indicators were measured during the Graphics Display Test:

- Cumulative time required to obtain six pieces of tactical information
- Total score received on the answers to six tactical questions as a function of the graphics display utilized

Compatibility assessments involve elicitation of test participant appraisals/opinions and do not always yield quantitative results. In those cases where quantitative results are obtained, it is usually through indirect means. Two compatibility indicators were used during the Graphics Display Test:

- Participants' ordinal judgements of the displays
- Subjective comments/opinions expressed by the participants

2.3 GENERALIZED TEST FACILITY. The capabilities of the graphics display equipment utilized by an automated battalion CDC were simulated by MCTSSA's Generalized Test Facility (GTF). Although the GTF graphics terminals do not physically resemble the hardware envisioned for MTACCS, they can be configured/controlled to closely simulate key characteristics of this hardware. For this test, a high resolution digitalized map was utilized to simulate the presence of a paper map inserted behind a transparent graphics display. Additional graphics capabilities of the GTF equipment was utilized to produce monochromatic red overlays consisting of standard military symbology for units and control measures. The symbology for applicable units was made to move across the display in near real-time (simulation of PLRS) in accordance with the scenario

being utilized. The size of the display was controlled through use of masking overlays and the digitalized map was displayed or suppressed in accordance with the display type being tested.

SECTION 3

RESULTS

3.1 GENERAL

This section describes the results used to satisfy the objectives stated in Section 2. The data, together with summary statistics and interpretations as to the statistical significance of the data, are presented.

In order to facilitate the presentation, the following definitions and conventions are appropriate. Analysis of variance (ANOVA) is a common statistical technique which tests the hypothesis that there is no statistical difference between the mean value of data drawn from two or more populations. The ANOVA procedure results in a statistic called the F-statistic. Corresponding to the F-statistic is a P-value (or significance level) which is an expression of the probability that, if the hypothesis is rejected, you are rejecting the true case. Rejection of a true hypothesis is called "type I error". It is important to realize that the probability of type I error is a conditional probability, i.e., it only has meaning if the hypothesis is rejected. It is not correct to say that, if the hypothesis is not rejected, you have a probability of one minus the P-value of being correct.

For the purposes of this discussion, a difference between the measures of performance for the four display types will be considered statistically significant only if the probability of type I error is equal to or less than one-tenth. In other words, the hypothesis will be rejected only if there is no more than a ten percent chance of being wrong in doing so.

3.2 EFFECTIVENESS RESULTS

Two measures of performance (MOP) were utilized to evaluate the effectiveness of the displays in providing assistance to the commander. The first measure (MOP 1a) was the total amount of time (in seconds) required to obtain six pieces of tactical information from the display. The second measure (MOP 1b) was the total score achieved on the answers given to six tactical questions as a function of the display being utilized.

The results of these measures are contained in Tables 3-1 and 3-2 respectively.

For both measures of performance, three hypotheses were established. The three hypotheses were; that no statistically significant difference existed between a large and a small display size, that no statistically significant difference existed between a display with and a display without a map background, and finally, that there was no significant interaction effect between display size and the presence or

TABLE 3-1
TOTAL TIME REQUIRED TO
OBTAIN TACTICAL INFORMATION
(MOP 1a)

Large Display with Map Backgrnd	Large Display without Map Backgrnd	Small Display with Map Backgrnd	Small Display without Map Backgrnd
342	338	310	577
314	370	295	478
155	487	253	409
256	206	464	566
373	331	191	267
288	452	278	274
485	694	310	460
388	234	222	352
422	581	346	576
353	645	708	610
434	401	257	260
380	484	508	370
Averages:			
349	428	345	433

Average with Map Background: 347

Average without Map Background: 431

Average for Large Display: 389

Average for Small Display: 389

Overall Average: 389

Std. Deviation: 134

Note: Times are to nearest whole second

TABLE 3-2
TOTAL SCORE ON
TACTICAL QUESTIONS
(MOP 1B)

Large Display with Map Backgrnd	Large Display without Map Backgrnd	Small Display with Map Backgrnd	Small Display without Map Backgrnd
28.7	49.2	44.0	31.5
30.6	47.7	53.1	45.6
37.5	26.7	47.0	36.9
31.6	22.5	39.6	45.7
45.4	33.5	38.5	36.0
41.5	32.3	42.5	45.6
33.8	38.4	35.0	34.8
32.9	42.2	49.5	33.2
48.3	37.3	39.4	37.6
47.0	36.7	55.4	38.9
45.7	31.0	42.2	46.3
24.9	49.0	13.5	31.1
Averages: 37.3	37.2	41.6	38.6

Average with Map Background: 39.5

Average without Map Background: 37.9

Average for Large Display: 37.3

Average for Small Display: 40.1

Overall Average: 38.7

Std. Deviation: 8.4

Note: Range of possible scores was 6 to 60

or absence of a map background. Table 3-3 contains the ANOVA Table for the first measure of performance and Table 3-4 is the ANOVA Table for the second measure of performance.

Based on the convention stated in paragraph 3.1, only one statistically significant difference between display types was indicated. Specifically, a statistically significant difference, as measured by the mean time required to obtain tactical information (MOP 1a), was found to exist between the display with and the display without a map background. The presence or absence of the map background was not a significant factor when measured by total score received (MOP 1b). Display size was not a significant factor when measured by either of the MOPs and in both cases there was not a significant interaction effect.

3.3 COMPATIBILITY RESULTS

Two measures of user compatibility were utilized. The first measure (MOP2a) was the ordinal judgments of the participants as to their assessment of the compatibility of the four displays. The second measure (MOP 2b) was the subjective comments/opinions expressed by the participants.

TABLE 3-3
ANOVA TABLE FOR MOP 1a

<u>Source</u>	<u>Deg. of Freedom</u>	<u>Sum of Sqs</u>	<u>Mean Square</u>	<u>F</u>	<u>P-Value</u>
Size	1	15.0	15.0	.001	.97
Map	1	84008.5	84008.5	4.84	.03
Interaction	1	222.5	222.5	.013	.91
Residual	44	763644.0	17355.5		

TABLE 3-4
ANOVA TABLE FOR MOP 1b

<u>Source</u>	<u>Deg. of Freedom</u>	<u>Sum of Sqs</u>	<u>Mean Square</u>	<u>F</u>	<u>P-Value</u>
Size	1	97.8	97.8	1.375	.25
Map	1	29.9	29.9	.416	.52
Interaction	1	25.7	25.7	.356	.55
Residual	44	3169.7	72.0		

The first measure was quantified by constructing an interval scale from the ordinal judgements (see "Graphics Display Test Plan" for details). The ordinal judgements are summarized in Table 3-5 and resulted in the following interval scale:



The two obvious groupings are display types A and C at the high end of the scale and display types B and D at the lower end of the scale. This result indicates that the participants felt that the displays with a map background were more compatible than the displays without a map background and that within each of these groupings, the large display was preferable to the small display. An additional observation is that the interval between C and B is greater than either of the intra-group intervals. This is additional evidence that the participants considered the map background to be the dominant factor in determining the user compatibility of the display.

The Kendall coefficient of concordance was utilized to test the hypothesis that the participants were inconsistent in establishing their ordinal rankings. The results were that this hypothesis can be rejected with near certainty (P-value less than .0001).

TABLE 3-5
PARTICIPANTS' ORDINAL JUDGEMENTS

This table reflects the number of participants who ranked display "i" above display "j"

j	i =			
	A	B	C	D
A		1	3	2
B	22		20	6
C	21	3		2
D	22	15	21	

Note: When cross diagonal elements do not sum to 24, either a tie or a failure to draw a comparison is indicated

The second measure of user compatibility was quantified only to the extent that percentages of participants expressing a common opinion were identified. The following paragraphs are a summary of the participants' written comments. They are presented in descending order of the frequency with which the comment was made.

The most frequent comment made was an expression of a strong preference for a display with a map background. Approximately sixty percent of the participants expressed this opinion. Of those who gave a rationale for this opinion, the most frequent was the difficulty of correlating information between the display (without a map background) and the paper map.

Approximately twenty-five percent of the participants expressed the opinion that the "ideal" display would give the user the ability to call up or eliminate the map background at will.

Approximately twenty percent of the participants objected to the monochromatic red overlays. The most frequent rationale given was the tendency for the red overlay information to blend into the map colors. One participant felt that the red symbology would present a serious problem in a red light environment during night operations.

A strong preference for the large display size was expressed by sixteen percent of the participants.

Approximately eight percent of the participants expressed a strong preference for a display without a map background. The rationale was that a map background is not usually necessary for fire support coordination related functions and that when detailed terrain study is necessary, it is easier to perform using a paper map.

One participant (approximately four percent) expressed the opinion that a display that could present only a few map highlights, i.e., key terrain, roads, etc., would make it unnecessary to have a detailed map background. The rationale was that a few map highlights would make the correlation of information between the display and an accompanying paper map much easier to accomplish.

SECTION 4

DISCUSSION

4.1 EFFECTIVENESS EVALUATIONS

The analysis for Objective 1 uncovered a statistically significant difference in the amount of time required to extract tactical information from a display with a map background as compared to a display without a map background. This was true irrespective of the size of the display.

It is important to understand that the term "statistically significant difference" means that there is strong statistical evidence that the measured difference in the mean time to extract information is a true difference as opposed to a random occurrence. That the difference is statistically significant does not necessarily mean that the difference is operationally significant. Additional analysis may aid the reader in making a determination as to the operational significance of the results.

The difference in the measured mean time required to extract information from the map background display as compared to the no map background display was eighty-four seconds or a

twenty percent decrease in time. A two sided, ninety percent confidence limit for the difference between the two mean times is:

$$\text{Probability (19 sec } < \text{ True Difference } < \text{ 149 sec)} = .9$$

This represents a range of reduction in time of between four percent and thirty-five percent when compared to the mean time for a no map background display. Stated another way, the probability that the presence of the map background results in a time reduction of between four and thirty-five percent is nine-tenths. The maximum likelihood estimate for the time reduction is twenty percent.

The data analysis for Objective 1 found no other statistically significant differences between display types. That is to say, the statistical evidence is that all other observed differences were random occurrences and do not reflect any true difference. The implication is that, while the test participants were able to work faster with the display types that included a map background, they were not able to work any more accurately with one display as compared to another.

4.2 COMPATIBILITY ASSESSMENTS

A high degree of consistency existed between the two measures of performance utilized for an assessment of the user

compatibility of the displays. Both the ordinal judgements and the written comments of the participant indicate the belief that the presence of a map background on the graphics display enhances the user compatibility of the display.

4.3 LIMITED SCOPE OF TEST

This test was conducted as a follow-on test to the Battalion Combat Operations Center (COC) Test and was designed to address the specific issue stated in paragraph 2.2 of this report. Within the limited scope of this test, the results indicated some advantages of a graphics display that has the capability of including a map background. Issues such as cost, system development time, system mobility at the battalion level and many others were not considered.

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